SANTA BARBARA CHANNEL RISK MANAGEMENT PROGRAM

Prepared For

CALIFORNIA COASTAL COMMISSION
SAN FRANCISCO, CALIFORNIA 94105

This publication was prepared with financial assistance from the U.S. Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, under the provisions of the Federal Coastal Management Act of 1972, as amended, and from the California Coastal Commission under the provisions of the Coastal Act of 1976.

Prepared By

U.S.DEPARTMENT OF COMMERCE MARITIME ADMINISTRATION
NATIONAL MARITIME RESEARCH CENTER
KINGS POINT, NEW YORK 11024

APRIL 1981

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LEGAL NOTICE

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EXECUTIVE SUMMARY

GENERAL

The Santa Barbara Channel Risk Management Program was carried out to determine means to minimize risks to facilities and to the environment resulting from offshore oil and gas resource recovery and vessel traffic in the Channel. The Program has been under the direction of the California Coastal Commission, using funds in the Coastal Energy Impact Program (CEIP). The principal agency performing the analytical and experimental work was the National Maritime Research Center (NMRC), Kings Point, New York a part of the U.S. Maritime Administration. Several maritime consulting firms supported the NMRC in the effort.

The objective of the risk management program is the development of a basis for California Coastal Commission use in making federal consistency determinations relative to offshore drilling and production activities and construction.

The basic approach to risk management relative to offshore development and vessel traffic is the identification of placement recommendations for temporary or permanent offshore structures relative to the vessel traffic separation scheme (VTSS, the "traffic lanes") and safety fairways or shipping routes. Other risk mitigation measures are recommended as appropriate. This program has been fully coordinated with the Coast Guard's Port Access Route study required by the Port and Tanker Safety Act of 1978 (PL 95-474).

The program methodology and summary of data, results, and conclusions are given the the following paragraphs.

A. Assemble Data Base and Identify Applicable Risk Areas

Worldwide, nationwide (particularly the Gulf of Mexico), and Santa Barbara Channel vessel and offshore oil development casualty data were assembled. The data indicates that vessel-to-vessel collisions, ramming of off-shore structures, and vessel on-board casualties such as breakdowns are the primary risk areas. Worldwide, vessel groundings are a serious problem, but the nature of the Channel minimizes this casualty area. Of all collisions, rammings, and groundings, 78 percent have occurred either at night or under conditions of limited visibility. Human error, due to inattention or to circumstances requiring decision and action out of the ordinary, was found to be the cause of the vast majority of casualties.

The statistical data base is summarized in Chapter 5, with details in Appendix E. The risk management program structure is described in Chapter 1, with details of applicable risk areas given in Appendix A. Summary environmental data for the Channel is in Chapter 4, with detailed information in Appendix D.

B. Develop Santa Barbara Channel Vessel Traffic and Offshore Oil/Gas Development Projections

To establish the likely levels of both vessel traffic and offshore drilling or construction activities, projections were completed in both areas. Based on the West Coast port activity and commodity flow projections, as well as probable growth in ship sizes and changes in methods of shipping, vessel traffic through the Channel has been projected from the current 25 ships per day (counting both directions) to a nominal of 29 and maximum of 43 per day by the year 2000. Therefore, one of the basic assumptions under which this study was conducted is that there will be no dramatic increase in the flow of merchant ship traffic through the Santa Barbara Channel during the next 10-20 years.

Vessel traffic analysis and projections are in Chapter 3, with details in Appendix C.

Using information from the Department of Interior Lease Sales in the Channel, plus known physical characteristics of the Channel with respect to the state-of-the-art in oil drilling and production, areas and densities of likely drilling, construction, and production have been projected through the year 2000. By that time, the nominal number of new platforms in production is 29, and the maximum projection is 47. Due to the locations of potential oil reserves, there are numerous desirable locations for exploratory drilling and production platforms near or within the

VTSS. However, given the nature of the projections, extensive drilling activities at the exact edge of the traffic lanes are not anticipated.

C. Identify Potentially Applicable Risk Management Measures

There are a number of risk mitigation measures currently in effect in the Santa Barbara Channel. Primary among these is the passive Vessel Traffic Separation Scheme (VTSS). U.S. Coast Guard surveys have shown that compliance with the voluntary VTSS is virtually 100 percent for merchant ships transiting the Channel. Numerous other risk mitigation measures are possible, ranging from additional safety fairways to a positive vessel traffic position monitoring system and active Vessel Traffic Service (VTS) by the U.S. Coast Guard. However, it was one of the basic assumptions of this study that the VTSS would remain in its present location with no modifications to its existing geometry.

A detailed discussion of existing and potentially applicable risk management measures is contained in Chapter 7. It is from this spectrum of choices that the recommended Channel risk management measures have been selected. In particular, constraints are recommended on the placement of temporary or permanent structures proximate to paths of vessel traffic.

D. Generate and Prioritize Risk Exposure Scenarios

Based on the oil-related development and vessel traffic projections described above, a number of situations were developed representing conditions of vessel/structure exposure to hazard. These situations formed the basis for the analytical and simulation experimental work carried out, and are:

1. Drilling rigs (or ships) in or near the Traffic Separation Scheme (TSS).

2. Production platforms near the TSS.

3. Production platforms or drilling rigs in the separation zone.

4. Platforms/rigs near the TSS dogleg.

5. Platforms/rigs near the safety fairway/TSS intersection(s).

6. Platforms/rigs at northern end of TSS.

7. Vessel navigation accuracy while transiting the Channel.

8. Supply boat, crew boat, barge traffic in all areas.

These situations were synthesized into a number of scenarios, which were then subjected to analysis and simulation.

E. Conduct Computer- and Simulator-Assisted Experiments and Analysis of Risk Scenarios

High speed computer models were employed to examine the effects of various human and navigation equipment inaccuracies in the climatological and oceanographic conditions in the Channel. Potential navigation inaccuracies were examined based on existing aids to navigation and sailing procedures. The Computer Assisted Operations Research Facility (CAORF) ship bridge simulator at NMRC was used to examine ship and master performance in the scenarios. Man-in-the-loop bridge simulations were conducted of thirteen different potentially hazardous scenarios. The phrase "man-in-the-loop" refers to the use of human operators to control the ship in various problem situations. For a discussion of the concept of man-in-the-loop simulation, the reader is referred to Appendix G. A total of twenty ship masters, ten from tankers and ten from containerships, were employed as test subjects.

The ship simulator experimental results led to the generation of "development-dependent" placement constraints for drill ships/rigs and production platforms relative to the vessel traffic lanes.

F. Analyze Results and Recommend Appropriate Mitigation Measures

Results/Conclusions

The man-in-the-loop simulation conducted involved two generic problems to be encountered in the Santa Barbara Channel. They were:

- The effects on merchant ship traffic of stationary drill rigs and platforms near the edge of the traffic lane.
- The effects on merchant ship traffic of other crossing traffic in the vicinity of a safety fairway intersecting the traffic lane.

The group of test subjects was comprised of practicing tanker and containership masters.

Stationary Drill Ships/Rigs Near the Traffic Lane

The experiments conducted with a single stationary drill ship near the edge of the traffic lane indicated that ship masters definitely reacted to the presence of the drill ship. The evasive maneuvers of test subjects ranged from small maneuvers to maneuvers out of the traffic lane on the side opposite the stationary drill ship. In general, maneuvers were smaller with the drill ship set back 500 meters from the edge of the traffic lane than with the drill ship located at the edge of the traffic lane.

Additional experiments were conducted with the drill ship and a platform located opposite one another at the edges of the traffic lane, forming a "gate." Faced with the prospect of either leaving the traffic lane to go around the gate, or navigating through the gate, most masters remained in the lane and sailed through the gate. Navigation performance as well as post-experimental debriefings indicate, however, that many did so with reluctance.

Subsequent experimental runs were made in which the opposing rig of the above gated configuration was moved down the lane a distance of 1 and 2 nautical miles to form staggered gates. The responses of the test subjects were more variable in these situations than in either of the single drill ship or gated configurations, especially on the part of the tanker masters. Several test subjects left the lane completely to avoid the situation and there was a significant difference between the containership and tanker master performance. Containership masters tended to sail down the center of the lane with little or no deviation. Tanker masters were more likely to perform a slalom type of maneuver, moving right away from the drill ship and then to the left away from the subsequent rig. This slalom maneuver was more pronounced in the tanker master group with the 2 mile staggered configuration.

Cross Traffic Encounters at Fairway Intersections

This part of the simulation experiment presented the test subjects with vessel traffic of a crossing nature, encountered while ownship was navigated within the lanes of a Traffic Separation Scheme (TSS). The problem simulated for the mariners took place at an intersection of a Port Access Fairway with the traffic lanes at Port Hueneme, California.

Conditions which co-existed with the traffic encounter problem included the presence or absence of a fixed structure within the TSS (a production platform), and varying levels of small craft such as resource recovery support vessels.

The results of these simulation runs showed a variety of responses to the crossing traffic problem which are independent of the restriction/workload conditions. More tanker masters than containership masters departed the traffic lanes in executing their avoidance maneuvers and reduction of speed was a prominent characteristic of the former group. Although these out-of-lane deviations were made with little hesitation in order to comply with the collision regulations, the higher frequency of occurrence within the tanker group is consistent with the maneuvering characteristics inherent in large tankers versus the capabilities of the fine-lined, high speed containership. The tendency among the tanker masters to reduce speed initially indicates a more conservative reaction to the traffic problem.

The siting of a stationary object in the Separation Zone, either alone or in conjunction with additional small vessel traffic, did not appear to influence the maneuvering decisions. These conditions were apparently assigned a priority which was secondary to the maneuvering requirements with respect to the capital ships present. Likewise the subjects' individual criteria for acceptable passing distances to other vessels, and their perceived obligations under the International Regulations for Preventing Collisions at Sea (COLREGS '72) in a crossing situation, took precedence over the exhibited desire to remain within the confines of the traffic lanes.

Recommendations

1) No structures, whether of a permanent or temporary nature, should be permitted to be situated in the traffic lane of a TSS nor within a Safety Fairway. This should include stationary drill ships and drilling rigs engaged in exploratory operations. In particular, the idea of moving the traffic lanes on a temporary basis to accommodate such drilling activities is not recommended. The logistics involved in effectively communicating such a lane change to the worldwide marine community are substantial, and it is unlikely that complete dissemination of information could occur in any short period of time. The negative implications for safety are obvious.

2) Permanent structures should not be sited within 500 meters of the boundary of a Traffic Separation Scheme lane in order to maintain the integrity of the established lanewidth. (See Figure ES-1a.) The erection of two structures

on opposite sides of a traffic lane so as to form a "gated" configuration should not be permitted if either structure would be sited within 1000 meters of the closest lane boundary. If a permanent structure is positioned within 1000 meters of the nearest lane boundary (but not closer than 500 meters in any case) no structure should be permitted to be erected on the opposite side of the traffic lane within 1000 meters of the opposite boundary for a distance of at least two nautical miles in either direction along the lane from the initial structure. (See Figure ES-1b.)

3) The presence of even temporary structures (e.g., drill ships, drilling rigs, or other resource recovery-related obstacles) within 500 meters of the traffic lane poses some threat. While the mitigation measures detailed in Recommendation 6 will reduce this threat, there is not adequate information at this time to conclude that it would be reduced to an acceptable level.

4) No temporary or permanent obstructions, including platforms, drilling rigs, and drill ships should be permitted to be erected or to operate within the extension of an intersecting Safety Fairway through the TSS traffic lanes or Separation Zone, nor within 1000 meters of the traffic lane boundaries and extension boundaries at the intersection. (See Figure ES-1c.)

5) A marshalling or designated waiting area should be defined during the construction of pipelines or erection of any structure where tug/barge units or other support craft involved in the operation will impact the users of the traffic lanes. Such marshalling areas should be situated well clear of the Traffic Separation Scheme, Safety Fairways, and normal approach routes utilized by tankers enroute to coastal terminals, and will serve to consolidate slow moving small craft away from the shipping routes. It will also minimize the number of points at which the traffic lanes would be crossed by these craft enroute to the construction site.

6) In order to enhance the radar echoes of fixed structures, both permanent and temporary, consideration should be given to the installation of large radar reflectors, particularly where a structure presents a minimal profile because of its small size and relatively light construction. The use of large radar reflectors on all structures within six nautical miles of the TSS or a Port Access Fairway will enhance the radar return and provide unique and early identification of stationary targets as fixed objects.

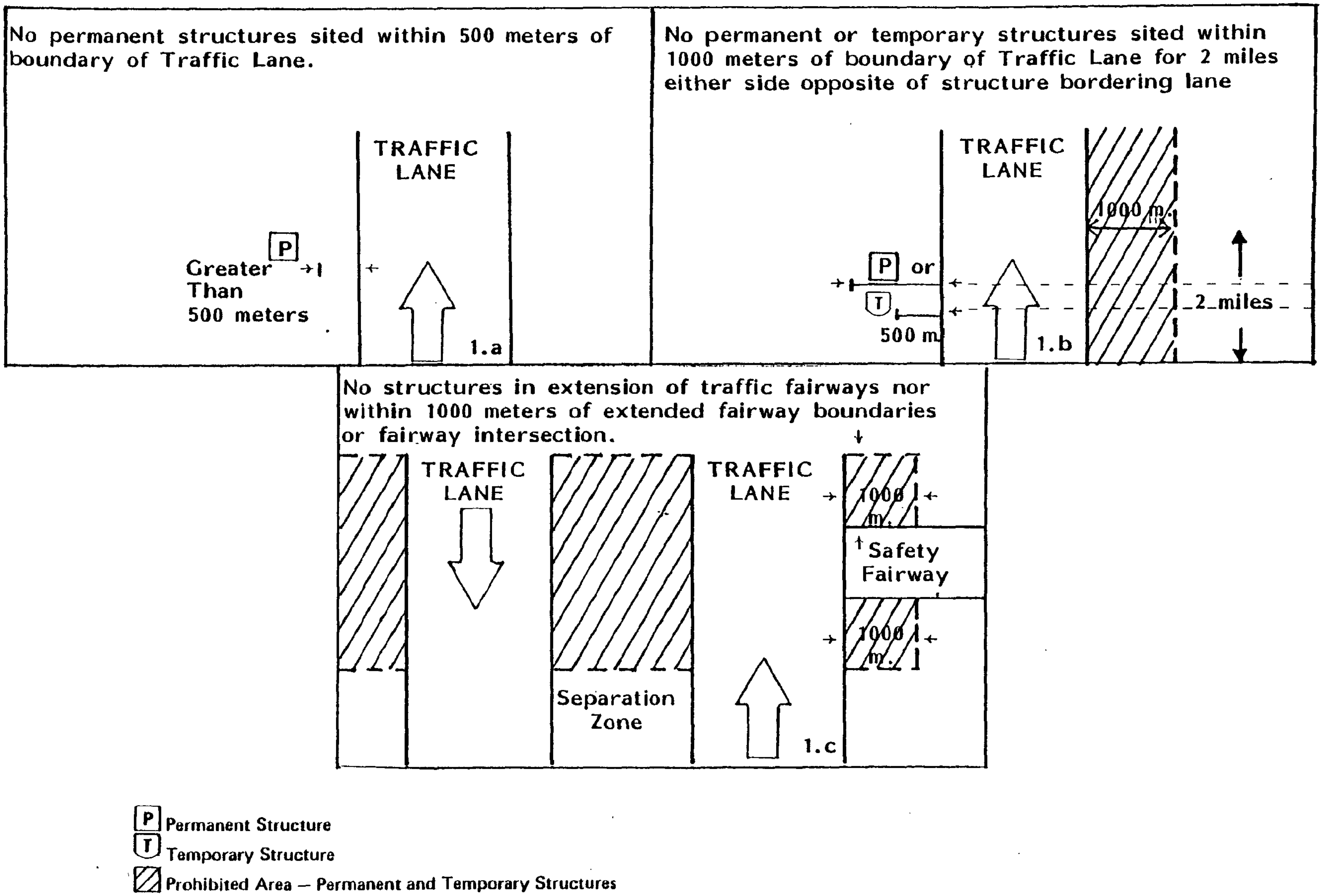


Figure ES-1. Structure Placement Recommendations

CHAPTER 1

RISK MANAGEMENT PROGRAM STRUCTURE

1.1 INTRODUCTION

The Port and Tanker Safety Act of 1978, which is an update and major amendment to the Ports and Waterways Safety Act of 1972, directly addresses the need for a comprehensive management and mitigation program for marine hazards and risks. The findings and declarations of this Act constitute substantive requirement for a complete framework for maritime risk management.

The Statement of Policy (Section 1) of the "Port Safety and Tank Vessel Safety Act of 1978" is reproduced below.

"The Congress finds and declares –

"(a) that navigation and vessel safety and protection of the marine environment are matters of major national importance;

"(b) that increased vessel traffic in the Nation's ports and waterways creates substantial hazard to life, property, and the marine environment;

"(c) that increased supervision of vessel and port operations is necessary in order to –

"(1) reduce the possibility of vessel or cargo loss, or damage to life, property, or the marine environment;

"(2) prevent damage to structures in, on, or immediately adjacent to the navigable waters of the United States or the resources within such waters;

"(3) ensure that vessels operating in the navigable waters of the United States shall comply with all applicable standards and requirements for vessel construction, equipment, manning, and operational procedures; and

"(4) ensure that the handling of dangerous articles and substances on structures in, on, or immediately adjacent to the navigable waters of the United States is conducted in accordance with established standards and requirements; and

"(d) that advance planning is critical in determining proper and adequate protective measures for the Nation's ports and waterways and the marine environment (emphasis added), with continuing consultation with other Federal agencies, State representatives, affected users, and the general public, in the development and implementation of such measures."

In response to the Port and Tanker Safety Act of 1978, the National Maritime Research Center (NMRC) developed in early 1979 a comprehensive maritime risk management program for general application to maritime areas or projects. This overall program structure is described in Reference (1).* The development of a risk management program for the Santa Barbara Channel represents a specific application of the overall, more generally-defined program. Certain areas of the total risk management program are either not applicable to the situation engendered by offshore oil/gas exploration and recovery and vessel traffic in the Santa Barbara Channel or are specifically outside the scope of this program. The Santa Barbara Channel Risk Management Program (SBCRMP) does, however, represent the application of a significant subset of the total NMRC-developed program.

Two of three major risk areas are included in this program, risks to equipment and risks to the environment (or, as expressed in the Port and Tanker Safety Act of 1978, risks to "property" and the "marine environment"). Although included by implication, risks to project associated personnel and to the general public are not directly addressed within the SBCRMP.

The following subsections describe the elements of the program.

1.2 RISK TO EQUIPMENT

The areas of identifying, analyzing, and mitigating risks to equipment (or "property") is the larger of the two major

*Numbers in parenthesis refer to references on page 10-1.

areas included in the scope of the Santa Barbara Channel Risk Management Program. This risk area addresses not only the actual risk and potential damage to vessels transiting the Channel and to oil/gas-associated structures in the Channel, but also by implication the risks and potential damage to the Channel environment which could result from a casualty to either a vessel or a structure, or both. The risks to equipment covered in the SBCRMP include risks to own ship, other vessels, and offshore structures (denoted "terminal" on the more general chart). The two specific risk categories included are ramming (of an offshore structure by a ship) and collision (between two vessels).

The particular risk of a ramming arises if offshore structures, either permanent or temporary, are erected close to the vessel traffic separation scheme, in the separation zone between the northbound and southbound lanes, or close to a safety fairway or route leading to a port or anchorage. A traffic separation scheme (TSS) has existed in the Santa Barbara Channel since 1969. Several studies of the vessel traffic in the Channel have been conducted, with the most recent and comprehensive being the Vessel Traffic Analysis of the Channel performed in conjunction with the Environmental Impact Report for the proposed LNG import terminal at Point Conception, California (2). This proposed terminal, located at the western end of the Channel, may generate LNG Carrier (LNGC) traffic in and across the far western end of the TSS.

Numerous coastal sea berths are located along the Santa Barbara Channel, at which oil is transferred from a tank ship to a shore tank (such as fuel for a coastal power plant), or from shore tanks to tankers (such as oil accumulated from either coastal wells or offshore production). The tankers serving these sea berths move through the TSS and then approach the Coast, through areas in which offshore oil/gas-related structures exist or may be erected.

The overall level of merchant vessel traffic through the Channel is relatively low, but is projected to increase somewhat over the next 20 years. Chapter 3 of this report contains vessel traffic projections updated from those contained in Reference (2). The basic problem to be examined is the mitigation of risk of a ramming casualty by control of placement of offshore structure and other means. The analysis of this problem area is handled by simulation of potential casualty situations under differing conditions of TSS-to-structure proximity, environmental and vessel conditions, vessel traffic, and master/pilot performance. This simulation and analysis is described in Chapter 7 of this report.

Risk of vessel collision exists in the Santa Barbara Channel due merely to the presence of transiting vessels. The level of risk, however, increases with a number of factors, namely; increasing numbers of vessels, vessels entering, leaving, or crossing traffic lanes, and presence of other vessels such as oil platform construction or support vessels or tug-barge combinations. It is also possible that the presence of offshore structures near the traffic lanes or safety fairways could restrict the ability of vessels to perform collision-avoidance maneuvers. The collision avoidance analysis is also described in Chapter 7 of this report.

The various available risk management measures include: recommendations as to the proximity of placement of structures to the vessel traffic lanes, safety fairways, and other normally-used routes; necessary aids to navigation or marking and identification of structures; aspects of any additional features to the existing Vessel Traffic Service; recommended shipboard equipment; particular routing or piloting measures such as designated constructing marshalling areas; suggestions for the availability of tugboat fireboat, or oil cleanup craft; special communication procedures; and restricted environmental operational envelopes. The applicability and potential effectiveness of these measures are discussed in Chapter 10 of this report.

1.3 RISK TO ENVIRONMENT

The risk to the marine environment which is the principal focus of the Santa Barbara Channel Risk Management Program is that of oil spills into the water. An oil spill could result from either of three basic causes: a casualty involving a tank vessel; a casualty involving the collision/ramming of any type vessel and an offshore structure (either permanent or temporary); a casualty associated with drilling, production, or storage operations at an offshore structure or facility.

In this program, the potential areas of oil spills will be identified, based on the traffic and OCS development scenario analysis. These identified areas will serve as inputs to the evaluation of support vessel capability, including tugboats, fireboats, and salvage vessels.

The evaluation of oil spill containment and cleanup capability available/required along the Santa Barbara Channel is the subject of a separate study the California Coastal Commission, but may be based on the vessel traffic and OSC development projections, and on the response vessel analysis contained in this program.

No quantitative analysis will be performed on the possible adverse impacts of oil spills, as this work has been previously considered elsewhere, such as in Reference (3).

Appendix A contains detailed discussions of the definition of applicable risk areas and the identification of appropriate risk analysis procedures or techniques employed in this program.

CHAPTER 2

OCS ENERGY RECOVERY DEVELOPMENT SCENARIOS FOR THE SANTA BARBARA CHANNEL

2.1 OVERVIEW

The purpose of the OCS Development Scenarios is to determine what kinds of obstacles oil and gas development may create for ship traffic in the Santa Barbara Channel. They are not intended to be a forecast of the future because the actual future number and locations of offshore oil and gas facilities will depend upon the results of further exploration and analysis by the oil companies. Each scenario is designed to serve as the realistic but hypothetical basis for experiment sets involving computer simulations of ship movements in the Channel. Information obtained from the simulations will be used to analyze the risk of ships colliding with drill ships, platforms, and other oil and gas related obstructions in the Channel.

2.2 SCOPE OF THE SCENARIOS

The scenarios include all expected OCS petroleum related activity in the Santa Barbara Channel between 1980 and 2000. However, not all twenty years are portrayed individually. Instead, three separate years are shown on the charts. 1984, 1989 and 2000 were chosen because they represent the peaks in projected oil exploration, platform construction and oil production, respectively. These overlays are, essentially, "snapshots" of activity on a typical day of the year portrayed. Each chart shows hypothetical locations of platforms and current construction or exploration activities. For example, platforms under construction on the 1984 chart appear in the production phase of the 1989 chart. Also, any platforms that may have been built between 1984 and 1989 are on the 1989 chart. Drill ships have been shown at locations likely to be explored during that year. However, these locations have no special significance other than to help set the stage for the simulations. The methods used for estimating the number and locations of platforms and drill ships shown in each "snapshot" are discussed in the appendix. Oil and gas development in the state tidelands are not examined in this study.

2.3 CRITERIA FOR PRIORITY OF DEVELOPMENT

Although the EIS for lease sale 48 gave possible numbers of platforms, it did not indicate where they would be built. Consequently, a set of criteria was devised for estimating the priorities according to which tracts in the Channel were the most likely to be explored and developed. This was done by considering water depth, bottom conditions and price paid for the tract as indicators of both where the resources might be and where platforms could be built, as described in the appendix. These considerations are summarized in Figure 2-1. It should be noted that two of the sixteen tracts drawing the highest bids overlap the traffic lanes or their extensions.

2.4 EXPLORATORY DRILLING

An exploration scenario was created for the Channel. It was used as additional information in developing the "snapshots." Included were both tracts leased in 1968 and 1979 as well as tracts that may be leased in the future. There are three more lease sales scheduled which will affect the Channel. The first is lease sale 68 and it is slated for June of 1982. After it are lease sale 73 in 1983 and lease sale 80 in 1984. Essentially, both the leased tracts and those that are likely to be leased were divided into three periods of time for exploration, based upon when leased and the criteria discussed in the appendix. The results are summarized in Table 2-1 and Figure 2-2. Figure 2-2 is not designed to show any drill ship locations, but merely to indicate a sequence in which the tracts are likely to be explored. However, an estimate was made of how many drill ships would be operating during each time period. Note that 32% of 62 tracts overlapping the traffic lanes are likely to warrant exploration in the period 1980-1990.

2.5 NUMBER OF PLATFORMS

There are three scenarios. Two are concerned with the most probable number of platforms that are likely to be built.

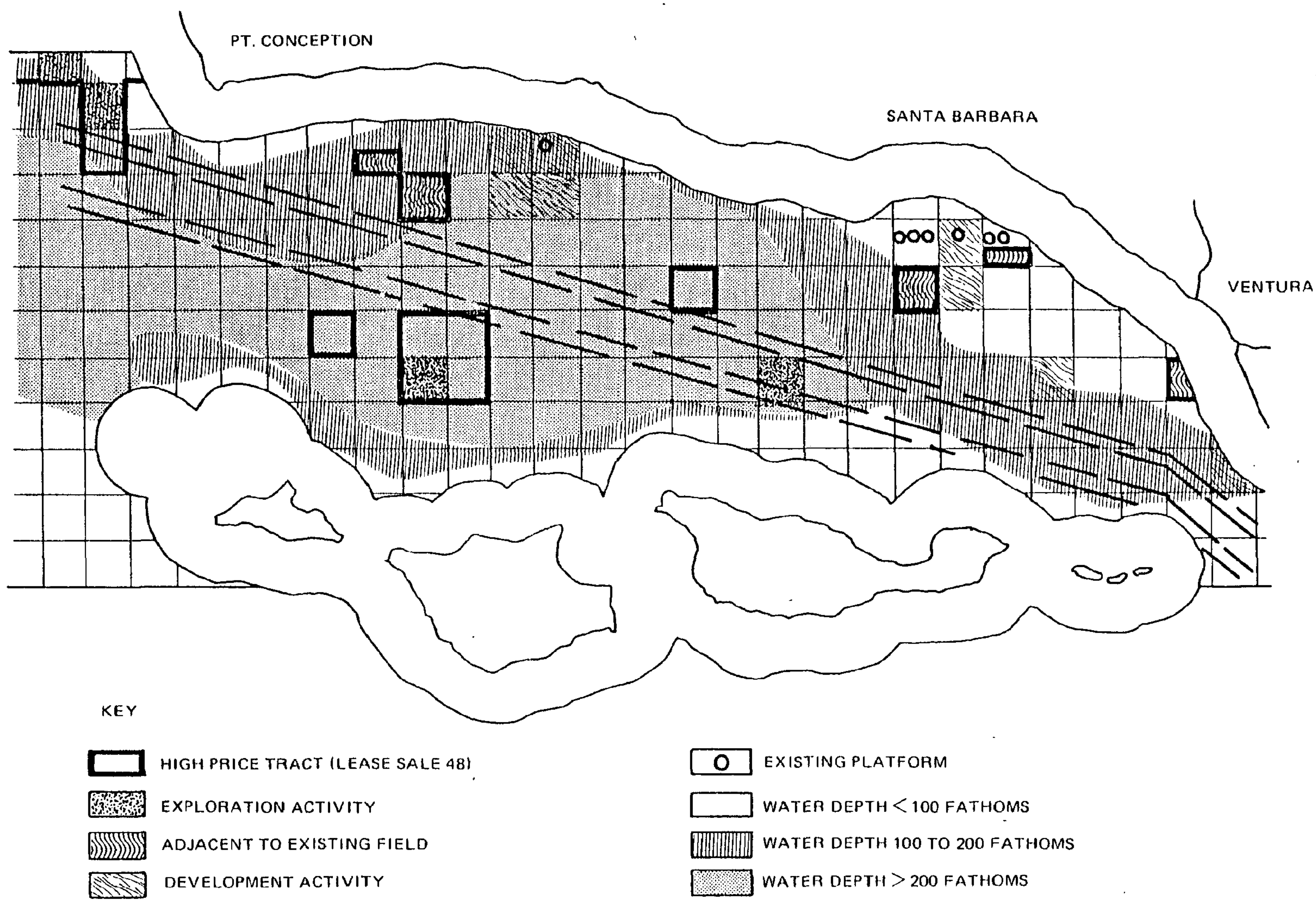


Figure 2-1. Criteria for Distribution of OSC Development Projection

TABLE 2-1. EXPLORATION IN THE SANTA BARBARA CHANNEL FROM 1980 TO 1990

Year	Number of Ships	Number of Tracts Being Explored
1980-82	3	18
1983-85	4	41
1986-90	2	13

NOTE: This table assumes that drill ships will spend about 60 days per tract.

These are both considered nominal schemes. The third scenario deals with the maximum number of platforms that might be constructed. Estimates for both the most probable and the maximum numbers for the Santa Barbara Channel OCS were taken from the Final Environmental Impact Statement written prior to lease sale 48,[1] which addressed prior and subsequent lease sales as well as the development of the parcels offered for lease at that time. These estimates are summarized in Tables 2-2 and 2-3.

2.6 LOCATION OF OFFSHORE PLATFORMS AND PIPELINES

Hypothetical locations for the projected numbers of offshore platforms and pipelines at various future times are given in hree series of map overlays in the appendix. Taken together, the alternative scenarios demonstrate that regardless of the specific geometry of development, the following general features are likely to occur:

- There will be considerable pressure for exploration and possibly for platform development in the area off Point Conception west of the present end of the traffic lanes
- There will probably be clusters of exploration and development activity east and west of the known producing fields in the northwest and northeast portions of the Channel
- It is quite possible that some activity will occur south of the traffic lanes, requiring supply traffic and conceivably pipeline construction across the lanes
- It is almost certain that major OCS petroleum activity will occur within the area now traversed by the traffic lanes unless specifically excluded by governmental action.

2.7 CHARACTERISTICS OF DRILLING, CONSTRUCTION AND SUPPORT VESSELS

2.7.1 Exploration

Exploratory drilling in the Santa Barbara Channel will be done from dynamically-positioned drill ships.* When these ships move to location, it will generally take between two and four days for them to get positioned correctly. At this time, supply boats* shuttle back and forth 24-hours a day. After everything is in place and the drilling begins, a supply boat will only be needed once every day or day-and-a-half. In addition, at least one smaller boat will stand-by at all times. Sometimes, particularly in the case of bad weather, there could be as many as three of these smaller boats on hand.

2.7.2 Platform Installation

Platform installation will take six weeks or more. First, the structural part of the platform will be brought to the site by barge.* Cranes and pile drivers will also be brought out on barges. Each barge will require at least three tug boats. The top part of the platform, including drilling equipment, will arrive on from two to four more barges. During installation, supply boats are operating on a 24-hour basis.

2.7.3 Development Drilling

Once the platform is up and development drilling has started, supply boat activity will drop to about one a day. This could last anywhere from one to two years.

2.7.4 Platform Production

When a platform is ready to go into production, about one month is needed to remove the drilling hardware and install production equipment. Two barges will go out to the site. One will have a crane and the other will take out pipeline risers, etc. and bring back the drilling equipment. When the platform gets set up and running it will only need one supply boat every two or three days.

[1] Final Environmental Impact Statement for Lease Sale 48; January 1979, Bureau of Land Management.

*See Table 2-3 for typical vessel dimensions.

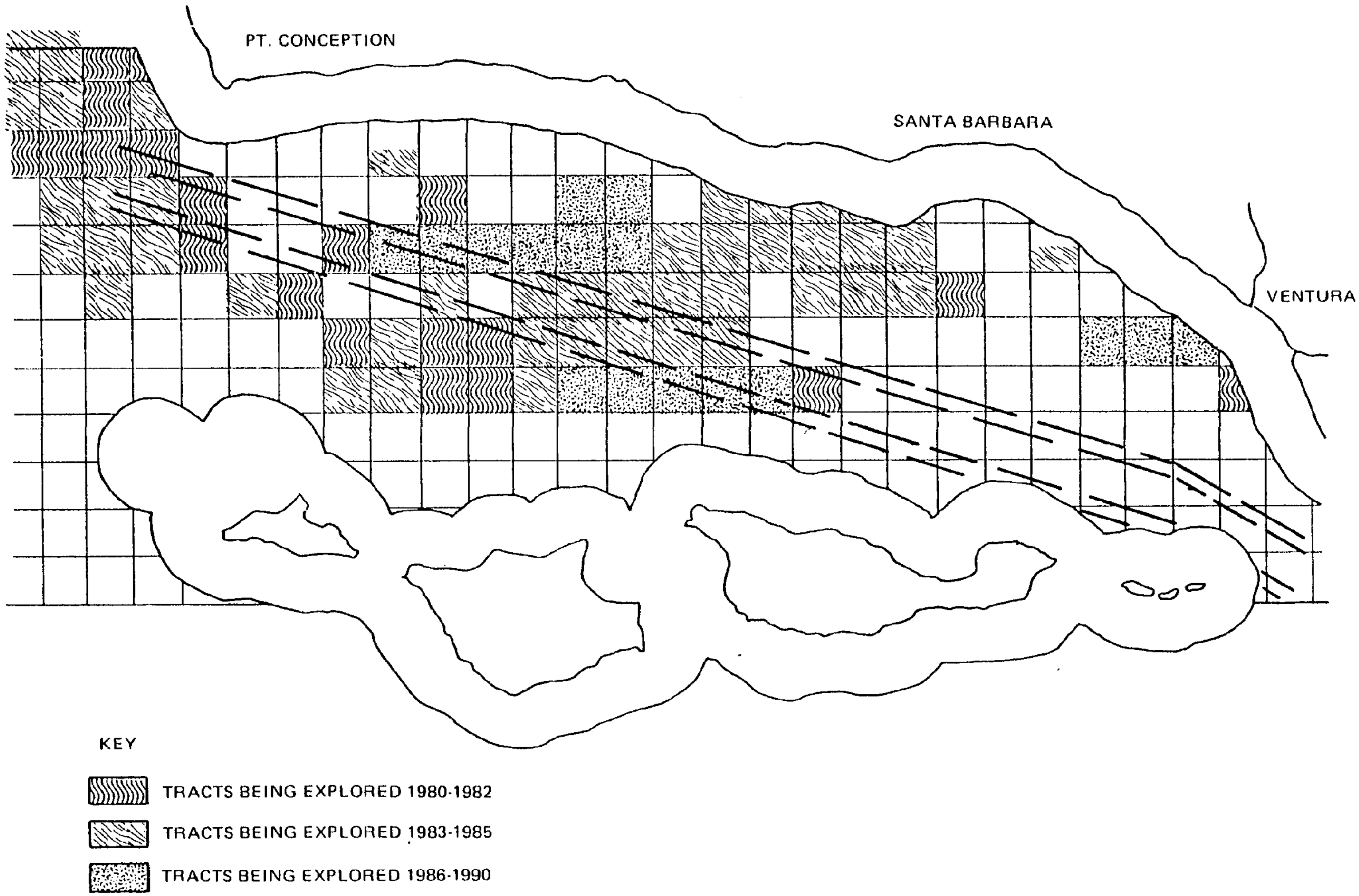


Figure 2-2. Phases of Exploration for Santa Barbara Channel

2.7.5 Supply Boat Operations

After arriving at a supply base, supply boats have a turn-around time of 12 to 24 hours. Some of the time depends on how well-equipped the supply base is. All vessels are loaded differently according to company policy and supply base operations. Deck cargo is the easiest to load if a good crane is available. Fuel is the most critical item, then bulk, and then water. When the supply boats get out to the platform, it only takes about six hours to unload.

2.7.6 Pipeline Laying Barges

There are two different types of pipe laying barges. Economic favtors are generally the main consideration in choosing which type of barge will be used for a particular job. The first type is set up to store and weld pipe on board. It requires two tugs* to move it. Anchor positions are changed after approximately 120 feet of pipe has been laid. One or possibly two vessels will be used to carry pipe and supplies to the barge. They will make about one trip every two days. If things are going very well, this pace may be accelerated slightly. The second type of barge is about the same size as the first and is also moved by two boats. The difference is that it carries pre-welded pipe on a giant reel. However, it can only handle pipe up to 8" in diameter. Since the pipe is already welded, this cuts down on the amount of time the barge is in operation. A smaller boat can accommodate the supply needs of the barge with one trip every two days. Only a small vessel is required because the barge already has all the pipe it will need. A third construction method for subsea pipelines is the "bottom-pull" approach, in which pipe lengths are welded together in a yard on shore and towed out to sea by heavy tugs.

*See Table 2-3 for typical vessel dimensions.

2.7.7 Crew Boats

Offshore crews live aboard for several days at a time. A shift change requires a large crew boat. Smaller crew boats make frequent calls at all sites to deliver technicians, subcontractors and small tools.

TABLE 2-2. ACTIVITY LEVELS IN THE SANTA BARBARA CHANNEL 1984 TO 2000

	Nominal Activity Levels			Maximum Activity Levels		
	1984	1989	2000	1984	1989	2000
Platforms in production phase	12	18	28	8	25	45
Platforms with development drilling	8	2	–	11	7	–
Platforms under construction	2	5	–	5	8	–
Number of drill ships	4	2	–	4	–	–
Offshore storage and treatment facility/marine terminal	1	1	–	1	–	–
LNG terminal	0	1	1			

TABLE 2-3. TYPICAL OFFSHORE SUPPORT VESSEL
TABLE OF CHARACTERISTICS FOR SANTA BARBARA CHANNEL

Type of Vessel	Length	Beam	Draft	Displacement	Crew Size	Speed
Drill ship	400 ft.	65 ft.	21 ft.	11,220 tons	up to 78	12 knots
Supply vessel	180-190 ft.	36-40 ft.	10-16 ft.	1,500-2,000 tons	8-11	12 knots
Crew boats	140 ft.	28-30 ft.	10. ft.	–	5-6	14-18 knots
Barges	250 ft.	50-60 ft.	11-12 ft.	4,000-4,500 tons	–	–
Pipeline laying barges	–	–	–	–	20-40	–
Tug	140 ft.	28 ft.	15 ft.	1,000-1,500 tons	6-9	5 knots

CHAPTER 3

VESSEL TRAFFIC PROJECTIONS

Projections of commercial vessel traffic through the Santa Barbara Channel through the year 2000 have been made as a part of this risk management program. These projections have been made to establish the level of vessel traffic and hence the density of ships that might be present in any particular situation. The number of ships that can be expected in any instance is an important factor in the definition of a maritime risk management program for the Channel.

The vessel traffic projections are limited to commercial vessels over 100 tons. Fishing and recreational boating are not included. The projections are based on the extensive vessel traffic analysis contained in Reference 4, updated as necessary for factors since the time of the earlier study. The vessel traffic analysis in Reference 4 began with the projected commodity flows through the Santa Barbara Channel. These are Los Angeles, Long Beach, and the Port of Hueneme. In the case of all three ports, the commodity volumes are projected by the Ports, in their port master plans, to increase significantly. Next, the earlier study examined the projections of vessel sizes, types, and methods of shipping. As ships are getting larger, and new types of ships and shipping permit more efficient cargo movement, the number of ships required to move a commodity volume tends to be reduced. Based on these two prime factors, vessel traffic in the Santa Barbara Channel was projected.

Since the vessel traffic analysis of Reference 4, two major factors contribute to an update of the projections. First, a recent and extensive U.S. Coast Guard vessel route survey (Appendix C) determined that an increasing percentage of ships traveling through the area are using the Santa Barbara Channel Traffic Separation Scheme (TSS) as opposed to alternate routes outside the Channel Islands. Second, significant additional dry bulk cargo movements are now projected between the Ports of Los Angeles and Long Beach and the Far East.

Total Santa Barbara Channel Projected Traffic

Adjusting the number of vessels through the Channel (Reference 4) by the change in percentage of route selection described above, and adding the projected dry bulk traffic results in the following table of vessel traffic:

Max./Nom. No. of Ships Annually through Santa Barbara Channel arriving at Ports of LA/LB (departures equals arrivals)

	1980(1)	1990(2)	2000(2)
Liquid bulk carriers	1558/1244	1812/1341	2078/1474
Containerships	1111/846	1293/906	1474/966
Breakbulk carriers	1413/1123	1220/870	1075/725
Dry bulk carriers	701/556	1376/1037	1269/829
Other ships(3)	676/519	664/471	1413/834

NOTES:

1. Same as Reference 4, adjusted only route changes.
2. From Reference 4, adjusted for route changes and additional dry bulk carriers.
3. Includes auto carriers, neo-bulk carriers, passenger ships, etc.

The volume of vessel traffic generated by the Port of Hueneme through the Santa Barbara Channel is projected to remain the same as shown in Reference 4, which is summarized below.

Max./Nom. No. of Ships Annually through Santa Barbara Channel arriving at Port of Hueneme (departures equals arrivals)

	1980	1990	2000
All type ships	255/220	690/440	625/420

Adding together the vessel traffic generated by the major ports of Los Angeles and Long Beach and that to/from the Port of Hueneme, the following daily figures are derived:

Max./Nom. No. of Ships through Santa Barbara Channel on a Daily Basis in each direction

	1980	1990	2000
All type ships	15.7/12.4	19.3/13.9	21.7/14.4

CHAPTER 4

ENVIRONMENTAL DATA SUMMARY

In order to carry out a realistic simulation of weather conditions in the Santa Barbara channel, an extensive review of environmental conditions was performed and is contained in Appendix D. The following is a brief summary of the major results of this review together with a specification of the wind, visibility and water current values utilized in the various simulation exercises.

4.1 GENERAL WIND REGIME

The moderating influence of the ocean is the basis for the stable, persistent weather regime along the coastal region of Southern California. The ocean provides a nearly constant, continuous supply of cool, moist, marine air to the coast. Although the coastal waters experience a very small seasonal and diurnal variation in temperature, the coastal strip forms a boundary separating the marine air from the land air. The California Ocean Current, flowing southward, is relatively cold and induces a band of cool surface air from 200 to 300 miles wide between the coast and the warmer water out to sea. The onshore flow of this cool, moist air, which is further trapped in the coastal basin, results in a relatively cool shoreline climate with frequent periods of fog, particularly during the summer months. The basic air flow along the Southern California coastal area is northwesterly, resulting from the semi-permanent Pacific high pressure cell. The northwest winds are strongest and most constant during the warm months when the Pacific High is most intense. During the colder part of the year, the basic air flow is still northwesterly, but weaker. The wind flow north of Point Arguello and Point Conception is relatively strong and has a northerly component. The transition zone of climatic and meteorological regions occurs at Point Conception primarily because the north-south orientation of the coastline changes to an east-west alignment. The prevailing northwest wind at Point Conception changes to a westerly wind along the Santa Barbara Channel to the east. Consequently, wind and sea conditions become progressively moderate to the east within the Santa Barbara Channel region.

Primarily during the winter season, frontal systems moving southeastward along the California coast move across the offshore areas to modify prevailing wind speeds and directions. When these storms approach, winds are from the east and southeast, and at times these winds are strong with sustained speeds of 25 to 35 knots, accompanied by local gusts of 40 to 45 knots. As the front approaches, the area experiences southeasterly to southerly winds of up to 30 knots, with locally higher gusts caused by convergence along the shoreline bluffs and mountains of the islands. Winter storm winds with velocities over 25 knots seldom persist more than 12 hours.

During the fall and winter, the pressure gradient after the passage of a cold front, discussed above, is further increased because the ocean off Southern California is warmer than the land and high plateaus. A flow of winds between these high and low pressure areas results. Forced and drawn through mountain passes, these warm downslope (Santa Ana) winds can reach velocities of over 50 knots at the Santa Barbara Channel coastline but moderate quickly as they spread out into the channel.

4.2 VISIBILITY

Restriction of visibility in the Santa Barbara Channel is due almost entirely to the California coastal fog and stratus clouds, which are caused by complex effects of the atmospheric and oceanic circulations. Atmospheric pollution from the cities has occasional contributory effects. The season of greatest intensity of the coastal fog is from spring through summer and into late fall. The location and intensity of the fog fluctuates. Generally the fog tends to become lower and more intense at night and to move in close to shore and over the land during late night and early morning. Late in the morning the fog tends to dissipate over land, move out to sea, and to become less intense. These diurnal variations dominate fluctuations in the visibility, but other larger scale effects disrupt the diurnal pattern. Occasionally the fog persists over the shore for several days, and at other times it remains well out to sea for long periods.

4.3 CURRENTS

The direction of the current along the southern California coast is generally toward the southeast, parallel to the coastline. It is strongly influenced by the prevailing northwesterly winds, and the current averages about 0.2 knots. Currents in the Santa Barbara Channel are variable and depend largely upon the wind. In the prevailing northwesterly winds, the current makes into the south side of west entrance to the channel and along the north shore of the Channel Islands.

4.4 DATA USED FOR SIMULATION

Following an extensive collection effort, the data were reviewed by a meteorologist familiar with the Santa Barbara Channel area and specific values of wind, visibility, and water current were selected. These values are shown on Table 4-1. The headings "western," "central," and "eastern" are used to describe the weather conditions associated with these three separate areas of the channel. The periods for which the values apply are intended to represent a winter (Feb.-Mar.) and late summer (Aug.-Sept.) weather regime. Finally, the specific values chosen were selected to represent maximum credible adverse environmental conditions which can be expected to occur on a yearly basis. We were not, for example, interested in "extreme" conditions which could be expected to occur once every 20-30 years.

TABLE 4-1. MAXIMUM CREDIBLE ADVERSE ENVIRONMENTAL CONDITIONS

	Western Channel		Central Channel		Eastern Channel	
	Feb.-Mar.	Aug.-Sept.	Feb.-Mar.	Aug.-Sept.	Feb.-Mar.	Aug.-Sept.
Wind Direction	250°	290°	270°	270°	045°*	270°
Wind Speed	30 Kts	18 Kts	25 Kts	15 Kts	35 Kts	15 Kts
Current Direction	090°	110°	135°	110°	225°	090°
Current Speed	0.7 Kts	0.4 Kts	1.0 Kts	0.5 Kts	0.2 Kts	0.4 Kts
Visibility	2 n.m.	0.12 n.m.	3 n.m.	0.5 n.m.	10 n.m.	0.12 n.m.

NOTE: By convention, wind direction is that **from** which the wind blows. Current direction is that **toward** which the current flows.

*Represents Santa Barbara condition.

CHAPTER 5

STATISTICAL DATA BASE FOR RISK ANALYSIS

5.1 INTRODUCTION

Pertinent factors and aspects of the statistical data base underlying the Santa Barbara Channel Risk Management Program development are summarized in this chapter. In summary, the worldwide and United States historical experience of vessel casualties provides support for concern in numerous areas, including vessel collisions, ramming of offshore structures, groundings, the influence of limited visibility and bad weather, plus other individual ship difficulties. Appendix E of this report contains a detailed casualty data base description.

Casualty data for the Santa Barbara Channel are relatively sparse and does not provide an adequate statistical data base for risk analysis. Not only have there been few reported casualties but also the dynamic state of the Channel in terms of oil and gas development with attendant structures renders extrapolations from current data of little value. Although from 30 to 40 vessels will pass through the channel per day during the next 20-year time period, the number of drill ships and production platforms is a source of uncertainty until drilling is carried out under lease sales No. 48 and No. 53. The likely presence of an LNG import terminal at Point Conception and its future growth also adds to the uncertainties for future ship-to-ship and ship-to-platform encounters.

The lack of a valid statistical base had led recently (5) to a probabilistic approach to marine traffic hazard analysis for the Santa Barbara Channel. It is to be noted, however, that the Port and Tanker Safety Act of 1978, which generated the current vessel access route study, is deterministic in regard to vessel accidents. Therefore, a probabilistic risk assessment which leads to a low value of risk will still be unacceptable if the possible accident leads to a high consequence oil spill.

The year 1979 was the worst year in history for oil tankers in terms of worldwide accidents. In 1979, more than 776,000 tons of oil were spilled—about 100,000 tons more than in the last three accident-plagued years combined. The year 1980 shows no signs of the lessening in the rate of accidents. The recent Tampa Bay and Galveston channel accidents are good examples. Besides ship-ship and ship-fixed object collisions, there is a significant rise in tankers breaking up under storm induced stresses. In great measure this is a function of ship design and age. As tankers grow older, the incidence of stress crack failures goes up. Besides the standard casualty data, there is incipient casualty data. This is a more sophisticated approach to the determination of future casualties. After the SEA WITCH - ESSO BRUSSELS accident in New York Harbor, the Coast Guard began to consider changing the casualty reporting requirements. In 1978 the Coast Guard (6) proposed changing the casualty reporting requirements from a minimum dollar value of damage to a more realistic set of criteria. In addition to dollar value of damage, loss of steering, or any occurrence affecting the seaworthiness or efficiency of the vessel, failures of transfer equipment, etc., are now reportable.

5.2 WORLDWIDE CASUALTY DATA

Casualty data for commercial vessels are compiled on an annual basis by a number of organizations. Primary sources are the U.S. Coast Guard and Lloyds Register in London. Within the past few years, a computerized data base for all commercial ships of the world over 1,000 gross tons (MARDATA, Reference 7) has been developed by Lloyds Register of Shipping, containing, among other data, tanker casualty information. By means of an international time-sharing computer network system, data can be retrieved concerning any ship traversing the Santa Barbara Channel almost instantaneously through the use of desk-top computer teletype. Currently, the U.S. Coast Guard Inspection Division is using this system in conjunction with their own Maritime Safety Information System. The user of this library is able to determine within seconds whether a particular vessel has a higher than normal accident risk and is a potential pollution source.

The U.S. Coast Guard compiles statistics about marine accidents that primarily involve the U.S. commercial fleet or have occurred in U.S. waters. For other data, the U.S.

Coast Guard relies on Lloyds list. In 1978, the Inter-Governmental Marine Consultative Organization (IMCO) in London published a report (8) on serious casualties to ocean-going tankers for the ten-year period 1968 to 1978. This latest published report covers the longest time period and provides the most thorough treatment of serious casualties on a worldwide basis. Table 5-1 shows these data for all tankers above 10,000 DWT. Note that a high percentage of tanker accidents occur at sea while in a loaded condition. Figure 5-1 shows the distribution of tanker ship involvement in various failure modes for the years 1968 to 1977. It can be seen that ship breakdown is just as important a factor as collisions and groundings. Table 5-2 displays major tanker casualty oil spills due to collision or grounding over an 11-year period.

TABLE 5-1. EXPLOSION/FIRE TANKER INCIDENTS
WORLDWIDE DATA 1968-1977 – IMCO

Location	Number	Number Per Year	Percent of Total
Worldwide	201	20.1	100
Harbor	(26)	(2.6)	13
Dock	(64)	(6.4)	32
At Sea	(111)	(11.1)	55
Cargo Tank	99	9.9	49
Other	102	10.2	51
CARGO TANK CONDITION			
Loaded	[9]	[0.9]	9
Discharging	[8]	[0.8]	8
Ballast	[26]	[2.6]	26
Other (washing, etc.)	[56]	[5.6]	57

NOTE: Above data does not include fire/explosion resulting from collision.

TANKER COLLISIONS
WORLDWIDE DATA 1968-1977 – IMCO

Location	Number	Number Per Year	Percent of Total
Worldwide	134	13.4	100
Harbor	(50)	(5.0)	37
At Sea	(84)	(8.4)	63
CARGO TANK CONDITION			
Loaded	[98]	[9.8]	73
Ballast	[36]	[3.6]	27
Result in Fire	34	3.4	25

( ) Estimated numbers—applies relative frequency of occurrence from Card, Ponce and Snider, 1969-1973 data to 1968-1977 IMCO data (21).

[ ] Estimated numbers—applies relative frequency of occurrence from Keith and Porricelli, 1969-1970 to 1968-1977 IMCO data (22).

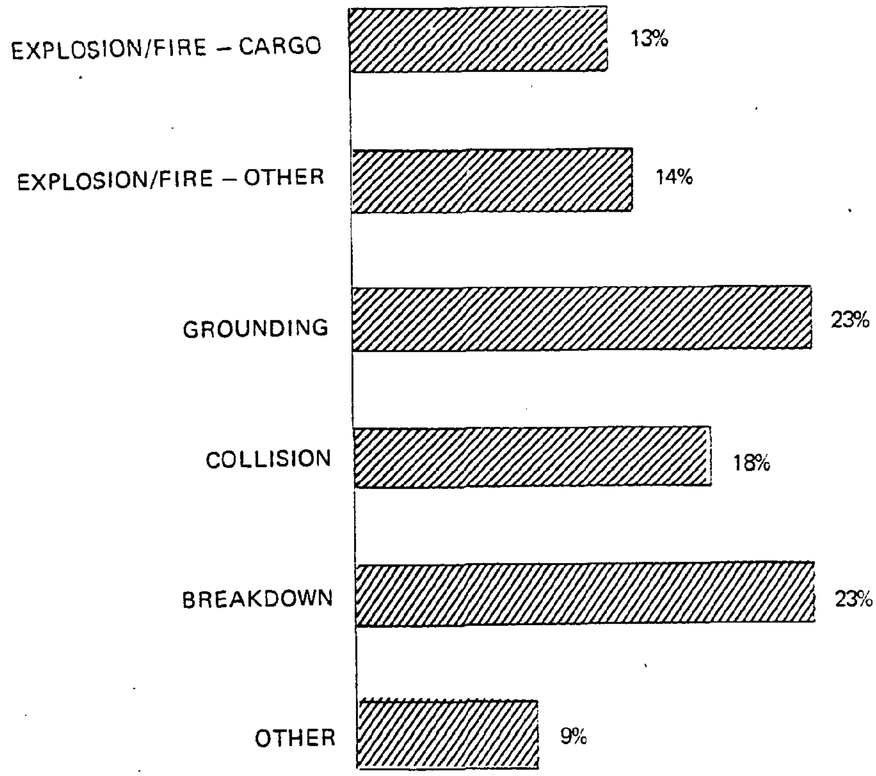


Figure 5-1. Distribution of Tank Ship Involvement, 1968-1977, Tank Ships over 10,000 Deadweight Tons

TABLE 5-2. MAJOR TANKER CASUALTY OIL SPILLS IN THE WORLD (1967-1978)

Year	Name of Vessel	Location	Type of Accident	Amount of Oil Spilled (in Long Tons)
1978	Amoco Cadiz	NW Coast	Grounding	220,000
1976	Argo Merchant	SE Nantucket	Grounding	23,200
1974	Metula	Straits of Magellan	Grounding	47,600
1974	Transhuron	SW Coast of India	Grounding	26,600
1972	Sea Star	West Indian Ocean	Grounding	120,300
1967	Torrey Canyon	SW Coast of England	Grounding	109,500

5.3 U.S. WATERS CASUALTY DATA

A series of tank vessel casualties in U.S. waters during the winter of 1976 to 1977 highlighted the need for improvements in marine safety. As a result of these casualties, the Coast Guard initiated a risk management program. Another result was the passage of the Port and Tanker Safety Act of 1978 which mandated the installation of a number of safety systems on all tankers, U.S. or foreign, that call at U.S. ports. These systems are to be installed over a period of years. In addition to mandating a number of satety systems, the Act directed the Coast Guard to carry out two studies relevant to marine safety. These are:

1. A Port access route study for each Coast Guard district and

2. A study of positive vessel traffic monitoring systems.

The port access route study is underway in the 11th Coast Guard District (Long Beach, California) and should be completed by December 1980. The vessel traffic monitoring system study is being carried out by the Transportation Systems Center, Department of Transportation, Cambridge, Massachusetts and should be completed by October 1980.

Transportation Systems Center Casualty Data

In order to develop effective positive vessel traffic monitoring systems, it is essential to understand the factors contributing to tank vessel pollution incidents. A detailed casualty analysis (vessels over 1,000 gross tons) was carried out by the Center using the following casualty data sources:

1. Coast Guard merchant vessel casualty reports,

2. Lloyds weekly casualty reports, and

3. MARDATA computerized casualty files.

The output of the causative analysis was used to derive preliminary requirements for a vessel traffic management system. Estimates of future casualty trends were based on future traffic projections and past traffic and casualty patterns. Of the 20,047 incidents in the total casualty file for 1972 through 1977, approximately 11 percent involved tank vessels greater than 1,000 tons in U.S. waters. These data are shown in Table 5-3.

When the casualties involving groundings, collisions, and rammings are cross-examined for time-of-day and visibility, it is found that 78 percent occurred at night or during periods of poor visibility (less than one mile). When subjected to causal analysis, it is found that 73 percent of the groundings involve a navigation error, and 18 percent involve a conning error; for rammings, failure to maintain proper lookout accounted for 50 percent of the casualties; for collisions, 59 percent of the cases involved improper execution of passing maneuvers, but in almost all collision cases the vessels were aware of each others presence.

It is important to emphasize that the number of casualties upon which the causal analysis is based is too small to allow highly reliable statistical analysis. As has been done by the Transportation Systems Center (TSC), it is possible to perform an extensive analysis of the casualty data and derive percentages of casualties with certain combinations of characteristics and causal factors. However, there are problems with this approach because grouping casualties into causal categories ignores secondary factors that may be important in later analysis. This concern is clearly justified if some of the most recent casualties in 1978 and 1979 are considered. The casualties discussed are a matter of historical record. In order to estimate the effectiveness of various vessel traffic monitoring systems, TSC projected casualty scenarios for the 1980s. The objective was to estimate the number of potentially preventable casualties involving tank vessels and offshore platforms if no new vessel traffic or risk management (VTRM) techniques were adopted and compare this number with the casualty projection if new VTRM methods were adopted.

The basis for the projections was:

1. The number of collisions is assumed to increase as the square of the vessel traffic in U.S. waters.

2. The number of rammings of offshore rigs/platforms is assumed to increase at the product of the number of vessels and the number of offshore platforms in U.S. waters.

Table 5-4 shows the casualty projections for U.S. waters if no new VTRM techniques are adopted. These data are based on the assumption that the same pattern of causative factors which prevailed during the base data period (1972-1977) will continue to occur with the same percentage of tank vessel trips resulting in a casualty. However, as pointed out previously, the Port and Tanker Safety Act of 1978 mandated certain safety equipment plus a study of VTRM systems. If these are implemented, TSC estimates that groundings will be reduced by 25 percent, collisions by 7 percent, and rammings by 45 percent with an equipment availability of 95 percent. Based on these estimates, the casualty projections are significantly reduced as shown in Table 5-5.

TABLE 5-3. TANK VESSEL CASUALTIES IN U.S. WATERS BY NATURE OF CASUALTY (FY 1972 – FY 1977)

	Number of Incidents[2]		
Nature of Casualty	Inland	International	Total
Groundings			
With damage	248	13	261
Without damage	431	30	461
Total Groundings	679	43	722
Collisions			
Meeting/crossing/overtaking	97	22	119
Anchored	107	12	119
Docking/undocking[1]	41	1	42
Fog	18	4	22
Minor bumps, tug and vessel[1]	74	19	93
Total Collisions	337	58	395
Rammings			
Offshore rigs	0	1	1
Floating or submerged objects	54	10	64
Ice	16	2	18
Aids to navigation	60	5	65
Fixed objects	371	6	377
Total Rammings	501	24	525
Explosions/Fires[1]	69	14	83
Founderings/Capsizings/Floodings[1]	22	10	32
Heavy Weather Damage[1]	6	42	48
Cargo Damage Only[1]	1	0	1
Material Failure			
Vessel structure[1]	41	18	59
Machinery/equipment[1]	152	112	264
Other[1]	47	4	51
Total	338	200	538
Grand Total	1,855	325	2,180
	-453[1]	-220[1]	-673[1]
	1,402	105	1,507

NOTES:

1. Not controllable by vessel traffic or risk management techniques.
2. Tank vessels >1,000 gross tons.

TABLE 5-4. CASUALTY PROJECTIONS – CURRENT SYSTEM

	Base Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	10-Year Total
Number of Groundings	17.0	19.0	20.0	21.0	23.0	24.0	26.0	28.0	29.0	31.0	32.0	253.0
Number of Collisions	2.2	2.8	2.9	3.8	4.8	5.9	7.1	8.4	9.8	11.4	13.0	69.0
Number of Rammings	1.0	1.0	1.0	1.2	1.3	1.3	1.7	1.8	2.0	2.2	2.4	16.1

TABLE 5-5. CASUALTY PROJECTIONS – BASELINE VESSEL TRAFFIC AND RISK MANAGEMENT SYSTEM

	Base Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	10-Year Total
Number of Groundings	17.0	16.0	16.0	17.0	18.0	18.0	20.0	21.0	22.0	24.0	24.0	196.0
Number of Collisions	2.2	2.7	2.7	3.6	45.	5.5	6.6	7.8	9.1	10.6	12.0	65.1
Number of Rammings	1.0	0.7	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.3	1.4	9.5

5.4 SANTA BARBARA CHANNEL – SOUTHERN CALIFORNIA BIGHT AREA

It was previously pointed out that the statistical data base for the Southern California bight region was very sparse. In a presentation given at hearings at Santa Barbara, California in June 1978 (9), the claim was made that 116 ships have sunk in the Santa Barbara area since the early 1700s. Heavy weather was considered to be a major contributing factor. Recent verified losses have included the freighter CHICASAU lost when it went aground on Santa Rosa Island in the fog in 1962. In 1968, the freighter COPPER STATE collided head-on with the Navy tanker COSATOT. In 1969, a cruise ship was blown ashore from its anchorage off Port Hueneme and wrecked. In July 1976, a near miss (10) was observed in the northbound traffic lane between a Maersk line containership and the cargo ship KYRIALOUD D. LEMOS. More recently, the sport fishing boat CHELAN collided with the tanker SANSENINA II in the shipping lanes two miles north of Santa Cruz Island in clear weather. Since drilling started in the Santa Barbara Channel, there have been no collisions reported between platforms and ships in Federal waters. The most recent report on casualties from the Mexican border to Point Arguello California has been prepared by the Marine Casualties branch of the Coast Guard in April 1980. These data covering the time period from fiscal 1970 through 1978 are shown in Table 5-6.

TABLE 5-6. SHIP COLLISIONS IN SOUTHERN CALIFORNIA BIGHT AREA

Dates	Collision Description	Location
Between(1) 1967-76	2 Collisions between ships	One in Santa Barbara Channel; one off Point Conception
Between(1) 1967-76	1 Grounding	Outside of LA/LB breakwater
Between(1) 1967-76	4 Collisions with pleasure craft (no damage to ship)	San Pedro Bay Channel
Between(1) 1967-76	1 Collision with buoy	San Pedro Bay Channel
Dec. 1976(1)	1 Collision between ships	Port Hueneme
Feb. 1978(1)	1 Collision between fishing craft and ship	Santa Barbara Channel
1967 to 1979(2)	No collision between seven platforms in Federal waters and ships	Santa Barbara Channel

NOTES:
1. U.S. Coast Guard, Marine Safety Office, Long Beach, California.
2. U.S. Geological Survey.

5.4.1 PROBABILISTIC ASSESSMENTS

In the absence of adequate statistical data, probabilistic methods are often used to assess the risk of ship operations. Relative to the nuclear ship program, the Maritime Administration has sponsored a ship accident study program with George G. Sharp, Inc., of New York (11). Part of the program involved development of a method of calculating the probability of any accident along a specific route. This methodology has been developed jointly with the Babcock and Wilcox Company. Heller and Pegram (12) recently reported on the development of this model based on regions of potential encounter. Spaans and van der Tak of the Netherlands Maritime Institute (13) have developed a model for calculating a maritime risk criterion number using a "ship domain" concept in which ship traffic is partitioned into ship flows in lanes while in each lane the ships are divided into different danger classes. Ship traffic in the Netherlands, of course, is much greater than in the Santa Barbara Channel. In the Southern California bight area, Science Applications, Inc. (14, 15) has carried out a probabilistic risk assessment for LNG carriers operating into the Little Cojo Bay terminal near Point Conception. This model was based upon a random ship movement stochastic flux mathematical treatment. SAI obtained a value of 7.3×10^{-6} LNG ship collisions per year. Reese et al. (16) estimated the probability of an LNG tanker collision transiting across the Santa Barbara Channel as 5×10^{-6} per year. Wright et al. (17) in late 1979 carried out a marine traffic hazard analysis for the Santa Barbara Channel in reference to Union Oil drilling activities about three miles from Point Conception. The analysis was based upon Mac Duff's study of traffic in the Dover Straits. Probability of a collision with another vessel or drill ship was considered to be the product of a causation probability and a geometric probability. For the Santa Barbara Channel, Wright estimated that the probability of a collision given an encounter between vessels was approximately 1×10^{-5} collisions per encounter. The probability of damage to a transiting vessel operating in the Santa Barbara Channel in the vicinity of the drill ship was estimated as 5×10^{-6} per transit for northbound ships and 2.5×10^{-6} for southbound ships.

In considering the merits of probabilistic safety analysis, it is important to note that the Coast Guard is on public record that such an approach is not employed to set maritime safety procedures. This is made clear by the deterministic requirements of the Port and Tanker Safety Act of 1978.

5.4.2 BUREAU OF LAND MANAGEMENT ASSESSMENT

As part of the environmental impact statement for lease sale no. 48 (offshore Southern California), the Bureau of Land Management, U.S. Department of Interior, carried out an analysis of potential collisions with offshore structures (18). Since there are insufficient ship/platform collision records in the Southern California bight region, BLM used the collision record in the Gulf of Mexico to estimate the number of collisions for Lease Sale No. 48 and No. 48 combined with existing Federal leases. Table 5-6 displays the record of ship collisions in the bight area. Note the scarcity of data. Table 5-7 gives data on ship/platform collisions in the Gulf of Mexico. This table is considerably out of date in light of ramming accidents in the Gulf of Mexico in recent years. Table 5-8 gives the estimated collisions between ships and platforms for Lease Sale No. 48 and combined with other Federal leases.

Steinberg (19), president of the Pacific Merchant Shipping Association, recently commented on the BLM derivation of estimates of Santa Barbara Channel platform collisions from Gulf of Mexico data. He noted that such extrapolations are tenuous at best.

5.5 OFFSHORE OIL PLATFORM CASUALTIES

In addition to the viewpoint of vessel casualties discussed above, there have been a number of offshore rig mishaps over the twenty-four year period 1955-1979. Table 5-9 summarizes rig casualties over that period, worldwide. These should be considered as indicators of the type and relative frequency of occurrence of rig mishaps.

Although this table indicates a collision (between ship and platform) frequency of only about one per year, there have been a number of recent incidents in the Gulf of Mexico. On November 28, 1979, the Greek ship SKYMNOS rammed an oil platform on the edge of the vessel safety fairway ten miles off the Galveston entrance, with moderate damage to both platform and ship. On February 26, 1980, the USNS tank vessel SEALIFT INDIAN OCEAN collided with an oil platform also on the edge of a vessel fairway 100 miles from the Galveston entrance with over $2 million damage to platform and vessel. On April 16, 1980, the Chilean motor vessel LAGO HUALAIHUE rammed platform DXY B1 outside the fairways, ten miles offshore Galveston near Bolivar Peninsula with very extensive damage to both rig and vessel. On August 21, 1980, the 565-foot Texaco tanker NORTH DAKOTA rammed a Chevron oil platform under construction, 25 miles south of Morgan City inbound to Port Arthur. All of these collisions occurred in darkness during the early morning hours.

TABLE 5-7. COLLISION BETWEEN SHIPS AND PLATFORMS IN GULF OF MEXICO

Date	Number of Collisions Between Ships and Platforms	Ship Size Gross Tons	Location of Collisions	Accidents Deaths	Damage in Dollars	
					Platform	Ships
Between July 1962 and June 1973	8	>1,000	Three less than five miles from shipping fairways and anchor areas	0	3.2×10^6	87,000
Between July 1962 and June 1973	7 15	100-650 <100	(1)	0	102,000	426,000
August 1975	1	(1)	Between British Oil Tanker and an unmanned platform under construction caused large oil spill	6	(1)	(1)

Source: FES Sale No. 43
(1) Not indicated in the source.

TABLE 5-8. ESTIMATED COLLISION BETWEEN SHIPS AND PLATFORMS FOR SALE NO. 48 AND COMBINED

Items	No. of Platforms	No. of Years	Total No. of Collisions
Gulf of Mexico	1,180	11	30
Sale No. 48	31	14	2.0(1)
Combined Sale No. 48 and existing Federal leases	86	14	2.8(1)

Source: FES Sale No. 48.
(1) Estimates in source.

TABLE 5-9. OFFSHORE RIG CASUALTIES 1955–MID-1979 NUMBER OF CASUALTIES (REFERENCE 20)

Type of Casualty	Catastrophic; Loss of Rig	Major Accident – Damage over $1M	Minor Accident – Damage under $1M
Blowout/fire	11	7	3
Storm induced	10	8	18
Moving/preparing to move	11	15	3
Drilling	3	3	0
Collision	0	2	21
Other/not designated	4	3	6
Total Cost*	$249M	$110M	$ 9M

*Dollars as of year of occurrence.

CHAPTER 6

EXISTING AND POTENTIALLY APPLICABLE RISK MANAGEMENT MITIGATION MEASURES

6.1 INTRODUCTION

In the course of the analysis and development of a risk management program for the Santa Barbara Channel relative to potential offshore energy resource recovery development and vessel traffic, the existing risk management program was assessed and potential upgrades or additions to the existing program were reviewed.

This chapter presents a summary of the existing and potential risk management programs, with considerably more detail provided in Appendix G.

6.2 EXISTING RISK MANAGEMENT PROGRAM

Although there is no "risk management program" for the Santa Barbara Channel under that title, numerous elements of such a program are, in fact, in place and in effect. These factors contribute to the low ambient hazard level evidenced by the history of no significant casualty involving a merchant vessel and an offshore structure, drill ship, or support vessel in the approximately 15 years of Channel offshore exploration and development. The risk management program has four significant elements:

1. The existing Vessel Traffic Service;

2. The available oil spill response capability and contingency planning;

3. The standards to which most vessels, particularly tankers, must be constructed and operate;

4. The available aids to navigation and safety of life and property on offshore structures.

Vessel Traffic Service (VTS)

As is described in Appendix H, there are numerous levels of VTS, ranging from simple designations of shipping lanes to complex full-time monitoring of ship positions and movements by electronic means, coupled with advice or direction to ships regarding their movements. The simpler types of VTS involve only passive measures, with more complex active measures involved in the higher-level VTSs. In the United States, any VTS is administered and/or operated by the Coast Guard.

In the Santa Barbara Channel, the VTS consists principally of the defined Vessel Traffic Separation Scheme (VTSS). The VTSS was originally established in the Channel in 1969 by the 11th Distrct of the Coast Guard. The VTSS consists of two designated one-mile-wide vessel traffic lanes, separated by a two-mile-wide separation zone. These lanes serve the purposes of defining a path through the Channel for vessels, and separating the northbound and southbound traffic flows. Use of the VTSS is voluntary, but the lanes are internationally sanctioned and recognized, and their use by commercial vessels transiting the Santa Barbara Channel is virtually 100 percent (see Appendix C). The Coast Guard has further established a buffer zone 500 meters wide along each side of the north and southbound lanes of the VTSS. In general, no structures are permitted in these buffer zones or in the traffic lanes themselves.

Available Oil Spill Response Capability and Contingency Planning

In the Santa Barbara Channel, the existing organization and planning for response to an actual or threatened oil spill lies in two major areas, governmental and industry. The governmental response planning is further divided into Federal and State.

The Federal spill contingency plans begin with the National Response Team, and includes the Regional Response Team at a regional level and the local planning of the local On-Scene Coordinator (OSC). The primary physical response capability by the Federal government is the U.S. Coast Guard's three Strike Teams. For the Santa Barbara Channel, the Coast Guard Pacific Strike Team, headquartered at Hamilton Air Force Base (near San Francisco) would provide the first on-scene Federal oil containment and recovery hardware and personnel.

The State plans provide for organizational response by a number of State Agencies such as the Department of Fish and Game, Regional Water Quality Control Boards, Office of Emergency Services, and others.

At the industry level, a very large amount of planning and equipment for oil spill response is available within the oil industry and also by virtue of spill response cooperatives established to protect the coastal areas.

Industry response, hardware, and capabilities may be divided into three categories. These are:

- on-scene equipment;
- spill response cooperative equipment and resources, and existing contingency plans;
- contractor equipment and resources.

a. On-Scene Equipment. For exploratory drilling activities in the Santa Barbara Channel, the California Coastal Commission in conjunction with the USGS require a certain minimum of equipment and preparation at the drill site. This includes at least 1,500 feet of spill containment boom and a boat capable of deploying it. Further, some type of skimming or pickup device must be on site, as well as certain dispersants and sorbent material. These on-site requirements have been developed by the Coastal Commission and USGS over a period of time, and are exercised via surprise drills called from time to time.

The on-scene equipment may be viewed as the "first-level" response to a spill incident at the operation.

b. Spill Response Cooperative and Contingency Plans. The oil spill cooperative specifically organized to respond to spills in the area which includes the Santa Barbara Channel is Clean Seas, headquartered in Goleta. Clean Seas is a cooperative organization of fifteen oil companies, and maintains a large inventory of spill containment and cleanup equipment, both prestaged at points along the coast and stored at its main yard at Carpinteria. The prestaged inventory is located at eight points from Estero Bay to Ventura, and is mostly stored in large semi-trailers for rapid movement to a spill scene.

The Clean Seas equipment includes at least four miles of containment boom, skimmers of various capabilities and capacities, and storage systems of various sizes including a large barge based in Ventura Harbor. Some of the containment boom is prepacked in boats for fast deployment. A complete inventory, including locations, capability and capacities, and deployment plans are contained in the Clean Seas Oil Spill Cleanup Manual (27).

In addition to the equipment and planning to contain and pick up oil spilled at the site of a casualty, Clean Seas has equipment and detailed plans for defense of sensitive or otherwise important shoreline areas such as harbors and marinas. Plans and prepositioned attachment points, pilings, etc., have been established by Clean Seas for the placement of primary, secondary, and diversionary booms as necessary. Detailed maps of the area potentially impacted by a spill from any proposed drilling operations are included in the Clean Seas manual. These maps and their associated text describe sensitive areas, general shoreline descriptive data, access routes, biological data, property ownership and control with points of contact, seasonal influences, potential disposal sites, and many other factors necessary and/or useful in planning pollution defense and cleanup.

Finally, the local planning by the cooperative includes use of outside contractors and services for provision of manpower and equipment. Areas are covered such as beach cleanup, helicopter surveillance, crane services, trucking, welding, boat usage, diving, towing, earth moving and hauling, vacuum truck operation, and other special services. Contractors in most of these support areas are under contract to Clean Seas as a matter of policy.

c. Contractors. There are three primary oil spill response contractors in Southern California, possessing a vast amount of equipment of many types, i.e., Crowley Environmental Services, IT Services, and Crosby and Overton. While they are equipped primarily to handle oil spills in sheltered waters, each has some capability to respond in the offshore area of the proposed drilling operations. This capability can be augmented by hiring of equipment from others and/or by making use of offshore equipment held by the cooperatives. Crowley's parent company has a fleet of tugs, barges, and salvage craft at its disposal. These contractors can be set into action by direction of the Federal On-Scene Coordinator, by the Cooperatives, or by the spiller itself.

Tank Ship Risk Mitigation

During the winter of 1976/1977, several tanker casualties occurred in or near U.S. waters which demonstrated the need for a global effort to improve both the level of safety and degree of pollution prevention from oil tankers. This series of casualties resulted in great public concern within the United States regarding the risks associated with the marine transportation of oil. Public demand for the Federal Government to take additional steps to improve tanker safety and pollution prevention was evident.

As a result, on October 17, 1978, the Port and Tanker Safety Act of 1978 (PTSA, PL 95-474) became law and mandated a number of tanker construction and equipment standards. These standards included:

- Segregated and/or dedicated clean ballast tanks;
- Crude oil washing systems;
- Inert gas systems;
- Improved steering gear systems;
- Navigation equipment, including dual radars, electronic relative motion analyzer, electronic position fixing devices, communications equipment, depth finders, gyrocompasses, and charts;
- Personnel, manning, and training standards.

As of this date, regulations addressing all of these subjects have not been issued. Regulations for some of these standards have been issued as final rules, others have been issued as proposed rules, and still others have yet to be issued.

The U.S. Coast Guard goal is to implement these standards and their interpretations in a policy that is consistent with those agreed to internationally at IMCO. Work regarding interpretations has been conducted, and is continuing at IMCO with U.S. Coast Guard participation. To assist the industry with the interpretations of the U.S. Coast Guard regulations that were issued on November 19, 1979, a draft regulatory guide has been prepared.

Aids to Navigation and Safety of Life and Property on Offshore Structures

The primary authorities on the Outer Continental Shelf (OCS) reside with the U.S. Coast Guard and stem from the following Federal laws that make the Coast Guard responsible for promoting maritime safety and environmental protection in offshore areas:

- Ports and Waterways Safety Act as amended by the Port and Tanker Safety Act of 1978.
- Outer Continental Shelf Lands Act as amended by the Outer Continental Shelf Act Amendments of 1978.
- Federal Water Pollution Control Act as amended by the Clean Water Act of 1977.

These laws provide for the safety of navigation, the safety of life and property on both structures and support vessels, and marine environmental protection. In carrying out these responsibilities, the Coast Guard works in close cooperation with other Federal agencies (U.S. Geological Survey, U.S. Army Corps of Engineers, etc.) that also have responsibilities in offshore areas. Through various interagency agreements, the respective responsibilities of each agency are established and duplications of effort are avoided.

1. Safety of Navigation

The growing activity on and under the waters of the OCS increases the possible navigational hazards to vessels approaching and departing U.S. ports and transiting coastal waters. The Coast Guard is responsible for establishing port access routes, where necessary, to provide safe access to U.S. ports and through coastal waters. Vessel traffic routing measures, such as fairways and traffic separation schemes, are used to provide access, depending on the specific hazard. A study of the potential traffic density and the need for safe access routes must be made in consultation with all users and other interested parties prior to the establishment of any of these measures. Because foreign vessels are involved, vessel traffic routing measures must be submitted to the Intergovernmental Maritime Consultative Organization (IMCO, the body which establishes the international rules of the sea) for international adoption. The current 11th District Coast Guard Port Access Route Study has revealed low level traffic densities in the Santa Barbara Channel and will not recommend the establishment of any additional Safety Fairways into offshore moorings nor any changes to the existing Santa Barbara Channel Traffic Separation Scheme in the Channel itself. An extension of the traffic lanes westward will be recommended to route ships around an area of high potential offshore development offshore Point Arguello and Point Conception.

Safety zones may be established in the vicinity of a structure on the OCS whenever the Coast Guard believes it is necessary to exclude all vessels except those engaged in the construction and operation of such a structure. It has been common practice to establish a 500-meter radius safety zone during the construction of structures in the Santa Barbara Channel. The Coast Guard has also proposed the establishment of permanent 500-meter safety zones around a large number of selected structures on the OCS. It is probable that the Coast Guard will establish a permanent 500-meter safety zone around platforms in the vicinity of the VTSS.

The Coast Guard requires markings and navigational aids on all structures in offshore areas. Every structure must have unique identification markings (name, number, etc.) clearly visible from both vessels and aircraft. More importantly, each corner of a structure must be marked with a quick-flashing white light, and one approved sound (fog) signal must be in operation during periods of low visibility. The Coast Guard must approve navigational aids for platforms before their installation.

Through both broadcast and published Notices to Mariners, the Coast Guard keeps all mariners advised of the location and construction of a structure and associated pipelines and cables, as well as the existence of safety zones and the condition of navigational aids. This information is used to update charts and nautical publications by the National Ocean Survey. All information provided the Coast Guard concerning the construction and operation of platforms will be distributed to mariners in a timely manner.

Although other Federal and State agencies issue permits for the routing and depth of associated pipelines and cables, the Coast Guard regularly offers advice as to possible impact to vessel traffic, anchoring, etc. Such advice has a strong impact on the permitting process.

2. Safety of Life and Property on Structures

The Coast Guard regulates offshore structures on the OCS to promote the safety of life and property of all parties. Regulations govern the construction and arrangement of the structure including emergency alarms and means of escape, specify lifesaving and firefighting equipment, and regulate the operation of the structure including the designation of a person in charge, casualty and accident reporting, duties of personnel, and emergency drills. The Coast Guard conducts regular inspections of these structures and their equipment to ensure compliance with the above requirements. The Coast Guard is also charged with providing for the occupational safety and health of personnel working on OCS. As such, they investigate accidents and review allegations of the violation of safety rules.

In carrying out the above responsibilities, the Coast Guard coordinates closely with the U.S. Geological Survey, which is responsible for the safety of drilling and production operations, to avoid duplication of effort in the regulation and inspection program. Coast Guard personnel will inspect platforms for compliance with these standards after completion but before manned operations begin.

3. Safety of Life and Property on Support Vessels

The Coast Guard regularly inspects and certificates most U.S. vessels involved in offshore operations. This includes crew boats, supply vessels, construction vessels such as derrick and pipelaying barges, and mobile drilling rigs. They also examine and license the personnel that crew the majority of these vessels. The Coast Guard investigates and reviews casualties involving these vessels and personnel to identify the causes of accidents, and recommends corrective measures to prevent recurrences. Action against licensed personnel may be taken if an investigation has found them to be negligent.

Although few foreign-flag vessels are permitted to engage in OCS operations, they too are regularly inspected by the Coast Guard to ensure their compliance with applicable U.S. regulations and the international standards of IMCO.

4. Marine Environmental Protection

The Coast Guard has been given the responsibility for enforcing the requirements for prevention, control, and cleanup of discharges of oil and other hazardous substances from facilities engaged in OCS activities. Through OCS Orders, the Geological Survey has established pollution prevention and control measures for offshore structures. These are aimed at spills originating from the structure and provide for prevention measures as well as oil spill response equipment, training and exercising personnel, and contingency planning. Coast Guard regulations cover the prevention of spills during the transfer of oil between vessels and offshore structures.

In the event of an oil spill on the OCS, the Coast Guard provides an On-Scene Coordinator (OSC) with the authorities and responsibilities provided for by the National Oil and Hazardous Substances Contingency Plan. As provided for by a Memorandum of Understanding, the Geological Survey is responsible for the coordination of efforts to abate the source of pollution when the source is an oil, gas, or sulfur well. The Coast Guard has the coordination responsibility for containing and removing pollutants. In the event the spiller is not taking proper action, Coast Guard personnel and contractors with specialized pollution control and removal equipment are available to take over the containment and removal operations (see Section 3.14.6). The Coast Guard OSC for the Santa Barbara Channel is headquartered in Santa Barbara.

The Coast Guard also administers the Offshore Oil Pollution Compensation Fund. The Fund levies a 3-cent-per-barrel fee on OCS oil producers to provide compensation to persons damaged by OCS oil spills. Procedures and standards for the settlement of claims for economic loss, removal costs, and damage to natural resources are provided for in the reguations.

6.3 POTENTIALLY APPLICABLE RISK MANAGEMENT MEASURES

During the development of the risk management program for the Santa Barbara Channel, numerous concepts were reviewed for potential inclusion in the program. This subsection presents a brief summary of the scope of projects analyzed. Detailed descriptions of these concepts are included in Appendix H.

The following paragraphs enumerate various risk mitigation measures, and are listed in no particular order, and no arguments for or priority of implementation is intended.

1. **Casualty Data Base.** As discussed in Chapter 5, a computerized data base for all commercial ships over 1,000 tons has been developed. This data bank contains ship characteristics, accident and casualty records, berthing practices, ownership, crew training information, etc. It is used by the Coast Guard to identify vessels deserving special attention during port calls. Such a data base could be expanded and used to examine records of ships passing through the Channel, and to maintain safety/casualty records for drill ships, support vessels, and production platforms in the area.

2. **Vessel Speed Control.** Speed limits for ships transiting the Channel could be instituted possibly as a function of ship type or size, or of weather conditions.

3. **Simulator Research.** A ship simulator could be employed to assist in determination of appropriate separation distances between shipping lanes and drill ships/platforms. The performance of vessel masters in potentially hazardous situations could be evaluated in detail and standards developed.

4. **Emergency Response Systems.** Additional emergency response resources could be made available in the Channel. This could include tugboat, firefighting, or salvage vessels positioned locally.

5. **Advanced Aids to Navigation.** Equipment potentially available for shipboard use includes various satellite-aided position-determining systems.

6. **Transponders.** Devices which respond to radar signals could be positioned on offshore platforms to enhance their detectability and identification by radar on ships.

7. **Precision LORAN Navigation.** Equipment is available for shipboard use to take advantage of the complete LORAN-C navigation chain available on the U.S. West Coast. This equipment allows position determination to accuracies as small as 10 meters.

8. **Pilots.** Use of pilots while transiting the Channel could be required.

9. **Vessel Traffic Services (VTS).** Increasing the level of the VTS in the Santa Barbara Channel is possible. Increases could include active surveillance of ships, satellite-aided position monitoring, and/or active direction of vessel movements. Numerous VTSs are operational at ports and waterways of the United States. Each is and must be specifically tailored and configured to its individual geography, conditions, and vessel traffic. Appendix H describes several existing VTSs.

CHAPTER 7

RESULTS OF THE SIMULATION EXPERIMENT

7.1 INTRODUCTION

The Computer Aided Operations Research Facility (CAORF) of the Maritime Administration is a sophisticated simulator used in marine related human performance research. It was applied in support of this risk management project to elicit realistic human reactions to various probable offshore development situations expected to occur in the Santa Barbara Channel during the next 10-20 years. Such human performance data will be used to evaluate the relative risk involved in different offshore development scenarios and may be useful in guiding appropriate legislation and rule making.

Two fundamental types of problems were chosen for investigation. They were:

- Effects of drill ship/rig configurations near the edge of a traffic lane upon passing merchant ship traffic.
- Effects crossing traffic at the entrance to a busy harbor upon passing merchant traffic.

Furthermore, two distinctly different groups of test subjects were utilized in the investigation. They were containership and tanker masters, intended to correspond to the two principal classes of ships projected to be transiting the channel area.

The experimental procedure was to simply recreate the Santa Barbara Channel area on the CAORF simulator, design hypothetical problem situations with a high probability of occurrence, expose the test subjects to these problems and record their performance.

7.2 METHODOLOGY

This study investigated the performance of two distinct subject populations: tanker masters and containership masters. The ship's bridge simulator at CAORF was used to simulate both an 80,000 DWT tank vessel and a container vessel of 12,000 GRT to elicit subject responses to a number of production platform and drilling rig configurations, including vessel traffic, in close proximity to the Santa Barbara Channel Traffic Separation Scheme (TSS).

7.2.1 TEST SUBJECTS

Twenty masters comprising 10 masters with experience on tankers of 80,000 DWT or greater and 10 masters currently commanding container vessels, were selected as test subjects. This selection was further predicated on all subjects having had some experience sailing on the U.S. West Coast.

7.2.2 DATA BASE

CAORF's Santa Barbara Channel data base, which covers the coastline and outlying islands from several miles south of Pt. Mugu northward to Pt. Conception, was used in this simulation. This includes a complete radar data base to display landmass echoes on the two bridge radars, and a visual data base showing islands, mainland coastal characteristics, lights, buoys and offshore oil production platforms. Since the study investigated the effects of anticipated development of petroleum resources in the next decade, additional platforms were added to the data base where projections of future resource development indicated potential siting would take place. However, for the purposes of this study, extraneous platforms so placed to provide additional radar targets were not sited closer than two miles to the northbound traffic lane of the TSS.

7.2.3 SCENARIO DESIGN

A total of thirteen (13) conditions was developed to examine the responses of the mariner (through his navigation of the vessel) to a variety of platform and drill ship siting configurations, and with regard to potential traffic encounters in the Santa Barbara Channel, all of which are of concern to the California Coastal Commission. The scenarios occurred in a part of the Santa Barbara Channel approximately 15 miles in length, between the mainland and the channel islands, and centered about Port Hueneme, California.

The data base was divided into two segments, one starting 4.5 miles south of the Port Hueneme Access Fairway, extending to the turn axis of the TSS on a course of 300°T along the northbound traffic lane (Segment A). The second segment (Segment B) started at the turn axis and extended along the 285°T leg of the northbound traffic lane to a point 5 miles beyond the turn axis (Figure 7-1).

A total of four conditions were presented in Segment A and nine in Segment B. One condition in each segment served as a baseline run to assess individual trackkeeping performance in the absence of the interactive traffic vessels or obstructions near the northbound traffic lane.

Mariner responses to various small vessel traffic in and about the traffic lanes and interactive ship traffic at the lane's intersection with the access fairway at Port Hueneme were the subject of Segment A runs under three conditions (Figure 7-2). In addition to the traffic, two scenarios included the presence of fixed platform in the separation Zone near the fairway intersection, the position of which was known by the subject and plotted on the chart. (See Appendix F.) Segment A scenarios were run in daylight with a three mile visibility range.

The nine conditions in Segment B were all run in daylight with restricted visibility (0.5 mile). The visibility conditions imposed are not uncommon for the area. Eight of the nine conditions in the B Segment investigated the response of ship masters to different siting configurations for stationary drill vessels alone and in conjunction with fixed platforms, near to or straddling the traffic lanes (Figure 7-3). A worst case condition was investigated where visibility was poor and subjects had no foreknowledge of drilling vessel and platform positions. Because of the imposed visibility condition, the vessel's radar was heavily relied upon. In order to prevent subjects from taking a complacent attitude after a few runs to the stationary targets representing platforms and drilling rigs, a number of additional vessels were included in each scenario so that no immediately discernable pattern would be displayed on the radar PPI. A variety of vessels including other ship traffic, fishing boats, and support craft such as crew boats, supply boats, tugs and barges, etc., performed different maneuvers so that plotting of all echoes became necessary in order to distinguish slowly maneuvering vessels from stationary targets. Appendix F presents a graphic description, using actual test runs, of each of these conditions.

Wind, current and visibility conditions were comparable to actual local conditions during late Summer/early Fall. Wind was input as westerly at 15 knots and the current was about 0.5 knot setting 090°T. The reduced visibility conditions differed by scenario segment and were described previously.

The same conditions were presented to both groups of masters in a random order. To compensate for differences in speed between the tanker and the container vessel, (15.5 knots for the tanker and 19.3 knots for the containership) start positions and timing of the programmed interactive traffic vessels (no more than two vessels in any condition) were adjusted.

7.2.4 OWNSHIP SIMULATION

The two vessel types simulated for ownship were an 80,000 DWT tanker and a 12,000 GRT containership, to be operated by the masters in each category respectively. The particulars for each ship are indicated in Table 7-1.

The CAORF bridge contained the same equipment regardless of the ship type simulated. A full array of control and monitoring equipment as well as navigation aids was made available to the test subjects (see Appendix F/CAORF Description). In particular, two functioning radars were available for navigation and collision avoidance problem solving. These equipments were strongly relied upon in the reduced visibility conditions which were imposed.

7.2.5 BRIDGE WATCH

All conditions which were presented required the master to be conning the vessel due to the reduced visibility and the presence of traffic, particularly the increased density of vessel traffic in the approaches to Port Hueneme. The master in each case was assisted on the bridge by the Watch Officer, a qualified and licensed second or third mate. A helmsman was provided and steering was in the manual mode. While the Watch Officer performed duties assigned by the master, he was instructed not to volunteer any information unless it pertained to the assigned duty (such as the master requiring him to call out range and bearing to all radar contacts). The master was required to make all decisions based on the information available and without consultation with the Watch Officer.

7.2.6 FAMILIARIZATION AND RUN SEQUENCE

Upon arriving at the CAORF facility, all subjects were provided with a handout which explained what they were participating in. This briefing form provided such information as:

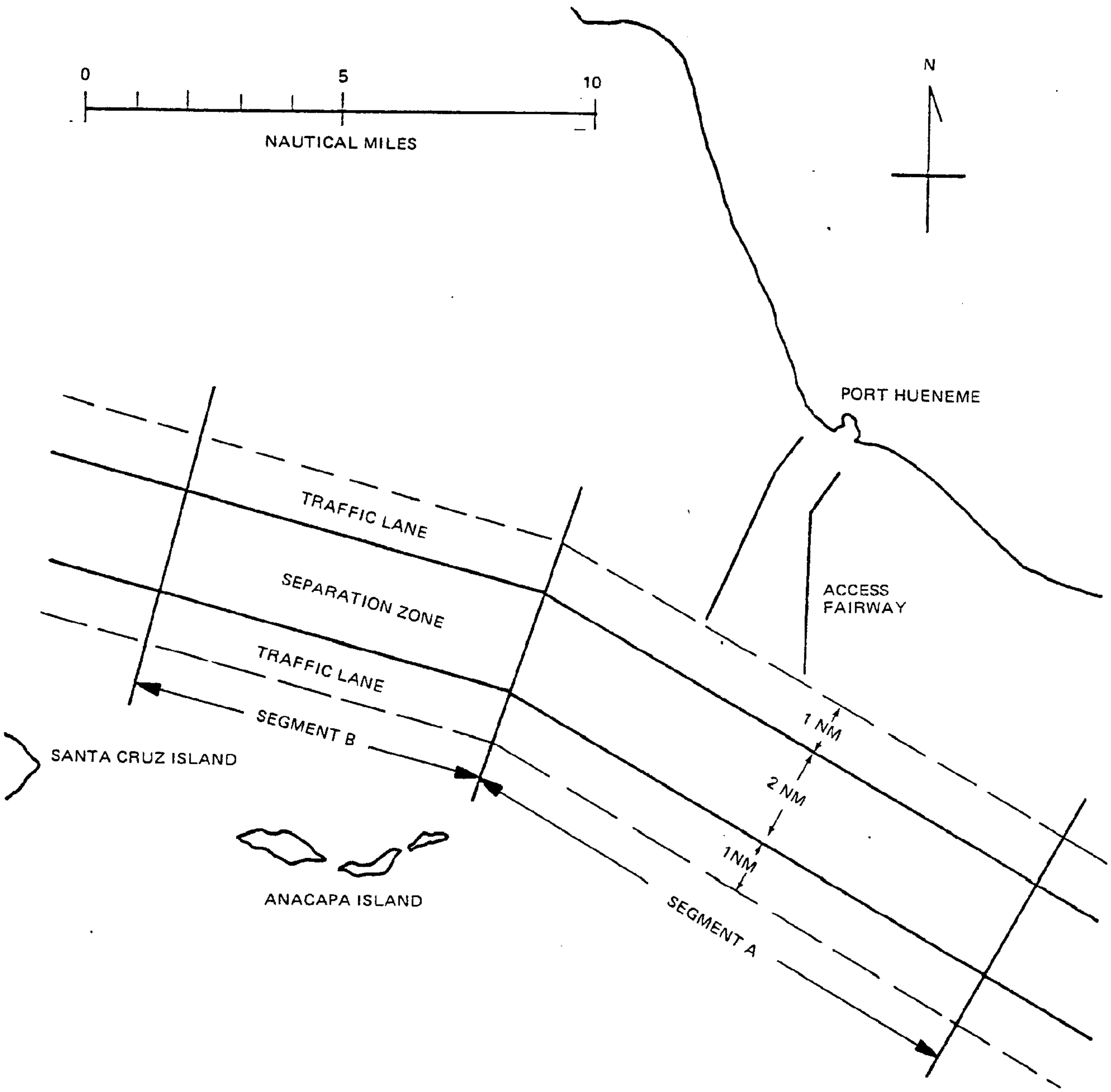


Figure 7-1. The Santa Barbara Channel Traffic Separation Scheme Showing Segments A and B Used to Develop Various Simulation Scenarios

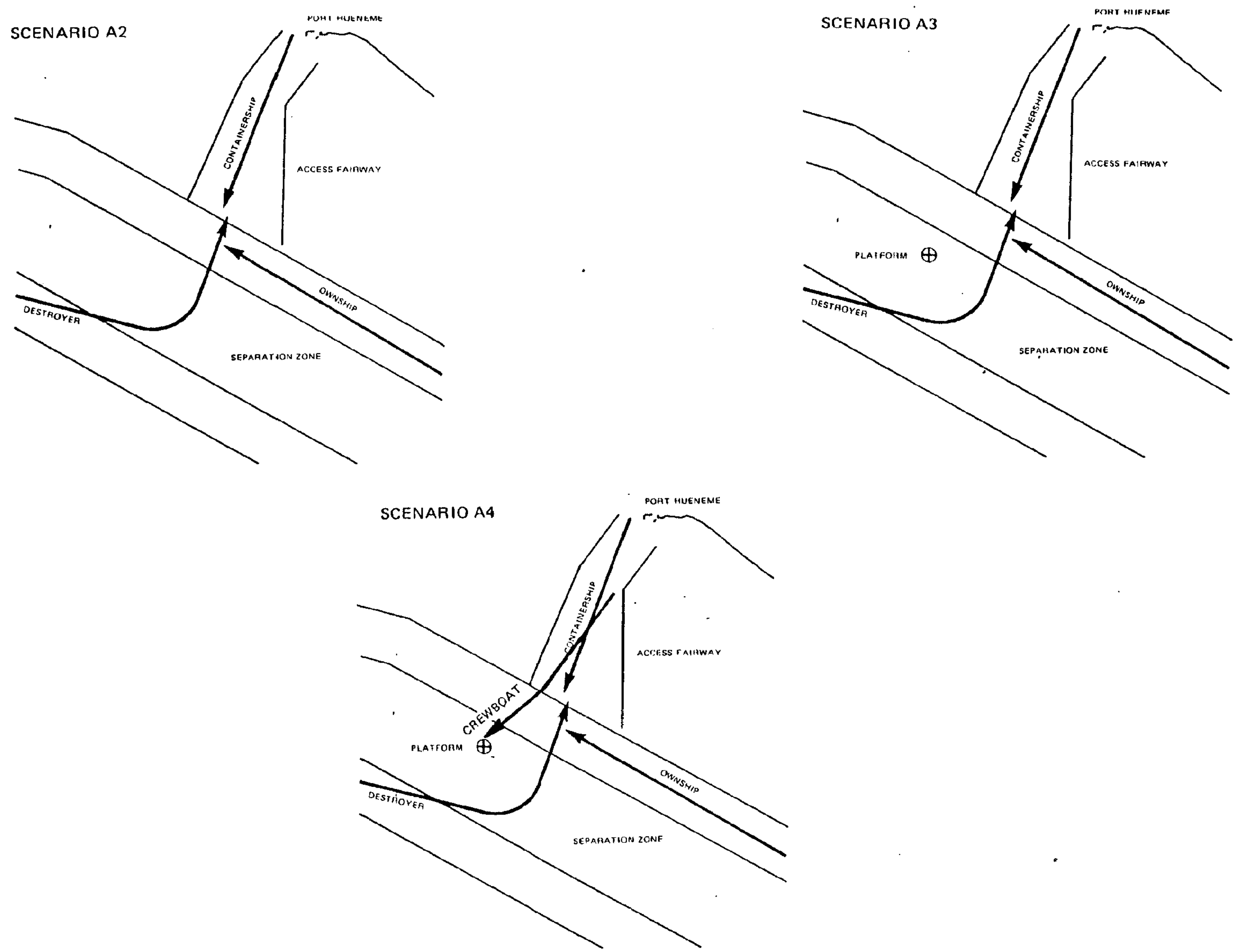


Figure 7-2. Segment A Scenarios Showing Three Traffic/Platform Configurations About the Traffic Lanes and Access Fairway. "Chaff" Traffic is Not Depicted

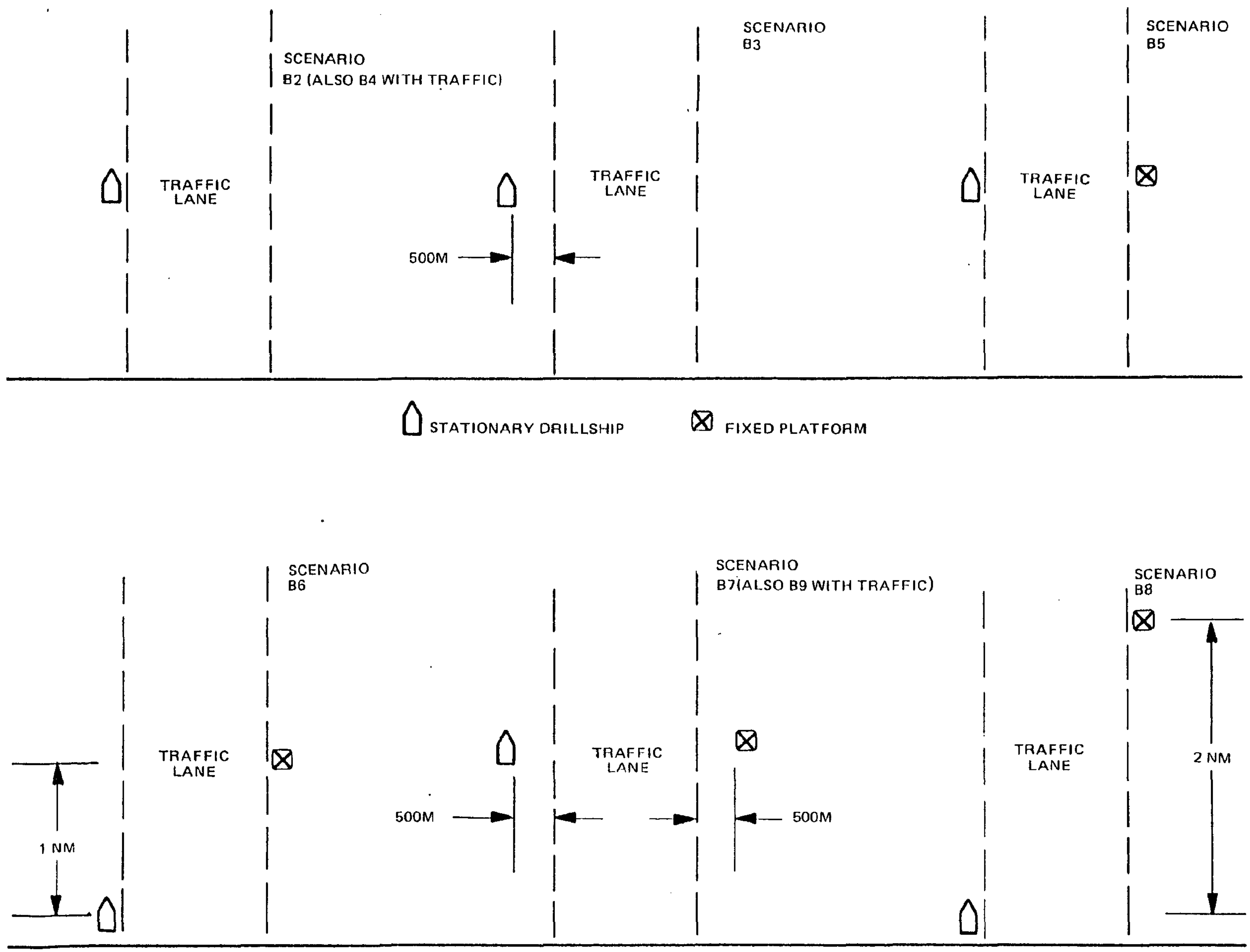


Figure 7-3. Segment B Scenarios Showing Various Drill Ship/Platform Configurations About the Traffic Lane (Dashed Lines)

TABLE 7-1. OWNSHIP PARTICULARS FOR THE TWO SHIP TYPES SIMULATED
This information was provided to each subject prior to commencing experimental runs

Type and Configuration	Containership/House Amidships	Tanker/House Aft
Deadweight/displacement	22,635 displ.	79,683 DWT
LOA	504.0′	800.3′
LBP	468.7′	762.9′
Beam	78.7′	125.0′
Draft (even keel)	30.5′	39.9′
Propulsion	Geared stm. turbine 17,500 SHP	Geared stm. turbine 23,000 SHP
Single screw	4 blade propeller Dia. 19.0′/Pitch 18.5′	5 blade propeller Dia. 23.0′/Pitch 19.0′
Wheelhouse location	250′ forward of stern	Aft bulkhead/Bow 675′ Fwd bulkhead/Stn 139′
Bridge ht. of eye	77′ above waterline	60′ above main deck
Maximum rudder	35° port or stbd	35° port or stbd

- Ship type and particulars
- Bridge equipment
- Bridge watch complement and duties
- Operating area
- Environmental data; wind, current, time of day, visibility

In discussing the program, the handout was purposely vague as to the objective in order that subjects would be less likely to influence their performance because of opinions held regarding oil exploration or recovery in proximity to navigation lanes.

Following this short briefing, each master was provided with a familiarization run which entailed observing from the bridge as the vessel was conned by a CAORF staff member in the scenario area but outside of the traffic lanes. Familiarization was presented in clear visibility with the staff member identifying objects in the visual scene and pointing out the location and operation of all of the bridge equipment. Finally, the test subject was permitted to conn the vessel for a short time to get the "feel" of the ship. It should be pointed out that, as this study did not involve any difficulty in navigation or piloting and all subjects were somewhat familiar with the West Coast, there was no intention of familiarizing the masters with the scenario's geographic area. Such information as was necessary for the simple navigation task was available from the chart provided. Familiarization with the CAORF bridge and its equipment, and with the visual imagery was the primary intent of this preliminary run to allow the subjects to become acclimated to CAORF.

Following the familiarization run, and having received answers to any questions regarding bridge equipment, etc., each subject performed the experimental runs. Conditions 1 through 4 in Segments A and B (designated scenario A1, B2, etc.) were always run in pairs. For example, scenario A1 was always followed by B1, however, the order in which the pairs were presented was randomized. The objective of

Segment A in all cases is completely different from the B segments and each scenario was run only once per subject so that, to the subject, the running of the A-B segment pairs appeared as eight distinct scenarios which alternated in the two parts of the channel.

The statistical analysis recognized two overlapping experiments, with all subjects receiving A1-B1 through A4-B4 initially. Those subjects (12 only) who participated in the second part of the study performed the remaining Segment B scenarios (B5-B9) following the completion of the A-B scenario pairs.

7.2.7 SUBJECT DEBRIEFING

A comprehensive questionnaire was answered by all of the masters following completion of their experimental runs. It covered aspects of their compliance with traffic fairways and separation schemes, acceptable CPA ranges, safe passing distances from obstructions and fixed objects, and opinions regarding the placement of platforms and drill rigs operating near or in established navigation lanes. An analysis of subject responses to the questionnaire will be found in Section 7.3.5 of this report.

7.3 RESULTS OF CAORF SIMULATION

7.3.1 BASELINE RUNS (A1 AND B1)

In scenario A1 (Segment A, condition 1), test subjects were required to navigate up the northbound traffic lane, utilizing the appropriate CAORF ship model (e.g. tanker masters on the 80,000 DWT tanker, etc.), to record their baseline navigational performance. The visibility was 3 nm and there was no ship traffic requiring avoidance maneuvering. The subjects were merely required to navigate the northbound lane to a location just past the dog leg turn north of Port Hueneme at which point the run was ended.

The typical performance of test subjects for this situation is graphically depicted in Figures 7-4 through 7-6. In Figure 7-4, the test subject was able to maintain a fairly constant position in the center of the channel. His maximum deviation (measured with respect to the centerline of the lane) is essentially zero. Nearly one half of the 20 test subjects navigated at this high level of performance with only small deviations to the right or left. Figure 7-5 represents a lower level of performance. Here the test subjects was somewhat premature in accomplishing the turn and consequently placed his ship very near the southern edge of the lane, far from the centerline. Figure 7-5 depicts that run with the largest deviation from centerline which occurred among the 20 test subjects. The subject performing on this run, and in several others, characteristically changed course by several degrees early in the run to position himself closer to the right side of the lane. In this particular case, he neglected to come back on course and thus continued to move steadily east out of the lane. The maximum deviation, measured from the centerline of the lane was 0.8 nm.

The data which summarize all test subject performance in these scenarios are shown in Table 7-2. It contains the average maximum deviation and standard deviation for each group of test subjects. The average maximum deviation was obtained by averaging the single, maximum deviation value obtained by each subject for these particular scenarios over all relevant subjects.

The reader should note that the average maximum deviation for tanker masters (0.28 nm) is larger than that for the containership masters (0.22 nm) although the difference is not statistically significant. If the value associated with the one tanker master who deviated out of lane (Figure 7-6) is deleted, the average maximum deviation and standard deviation values for tanker masters become 0.22 nm and 0.13 nm respectively (essentially identical to the containership master values). When viewing all 20 subjects as a group, the average maximum deviation is 0.25 nm with a standard deviation of 0.17 nm. Suppose one were to make the assumption that test subject performance is normally distributed (in the statistical sense) with a mean of 0.25 nm and a standard deviation of 0.17 nm. Then 68% (mean ± one standard deviation) of all transits of the northbound lane under these experimental conditions (wind, current, visibility, etc.) could be expected to deviate from the centerline by less than 0.42 (0.25 + 0.17) nm to the right or left side. However, 32% could be expected to deviate by more than 0.42 nm which would place them near the edge or out of the lane (which is 1.0 nm wide). The implications, for those mariners who are inattentive or unaware of the existence of stationary objects at the edge of the traffic lanes, are obvious.

In scenario B1 (Segment B, condition 1) test subjects were required to navigate along the northbound traffic lane from a point beginning at the apex of the dog leg turn. The visibility in this scenario was 0.5 nm with wind and current conditions as previously defined. There were no traffic ships requiring collision avoidance maneuvering. A review

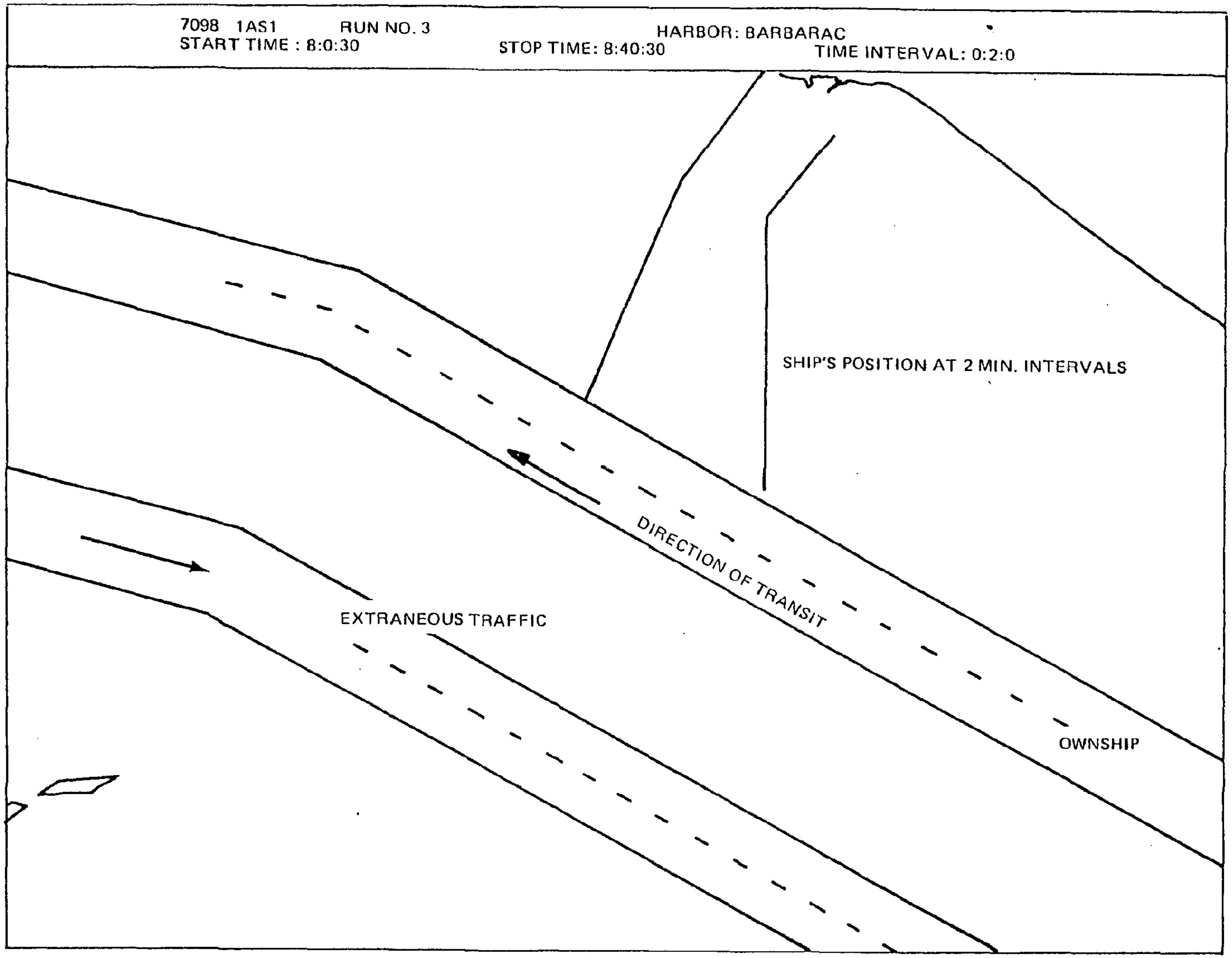


Figure 7-4. Typical Performance in the Baseline Run by a Tanker Master

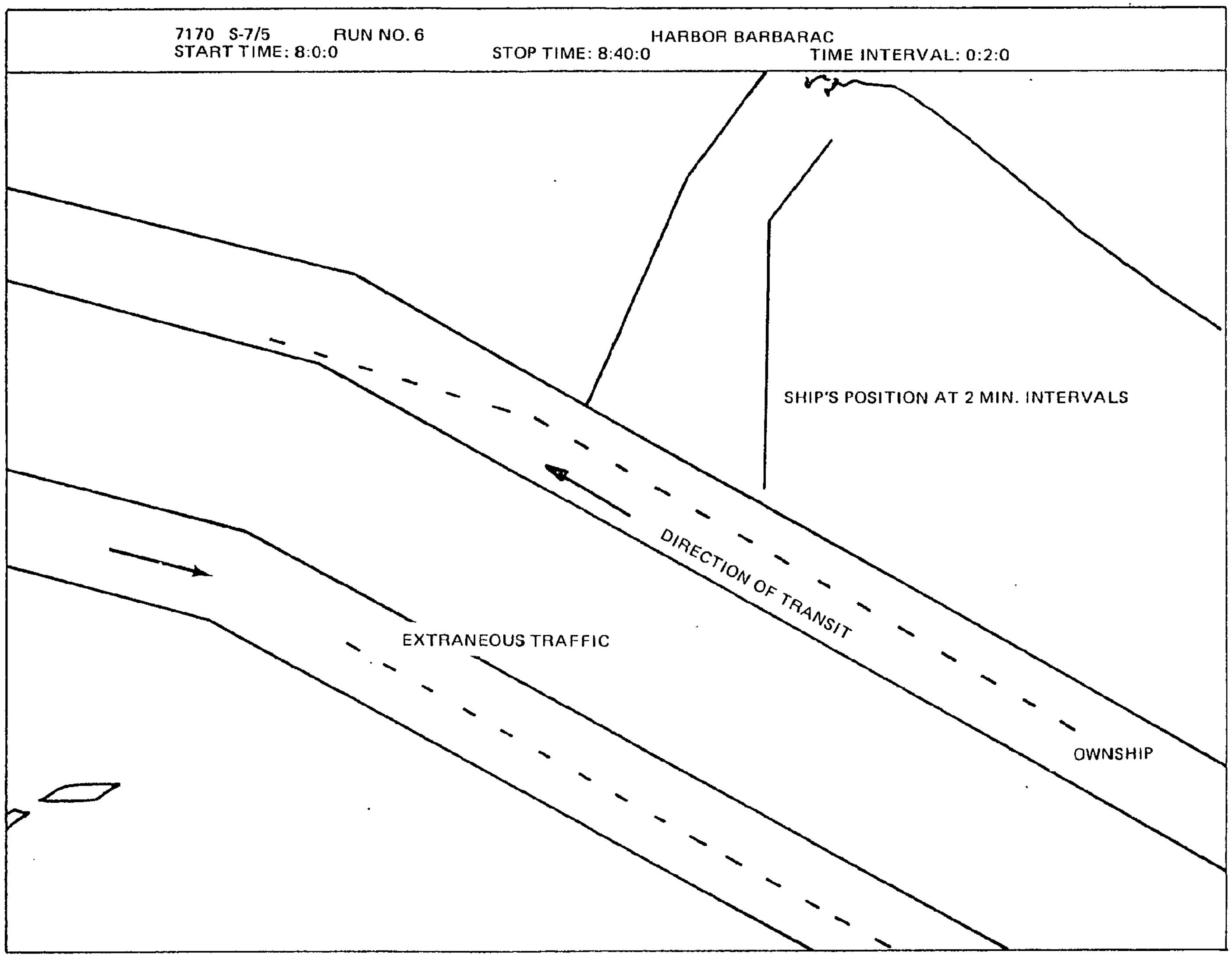


Figure 7-5. Example of a Premature Turn Executed by a Tanker Master in the Baseline Run Condition

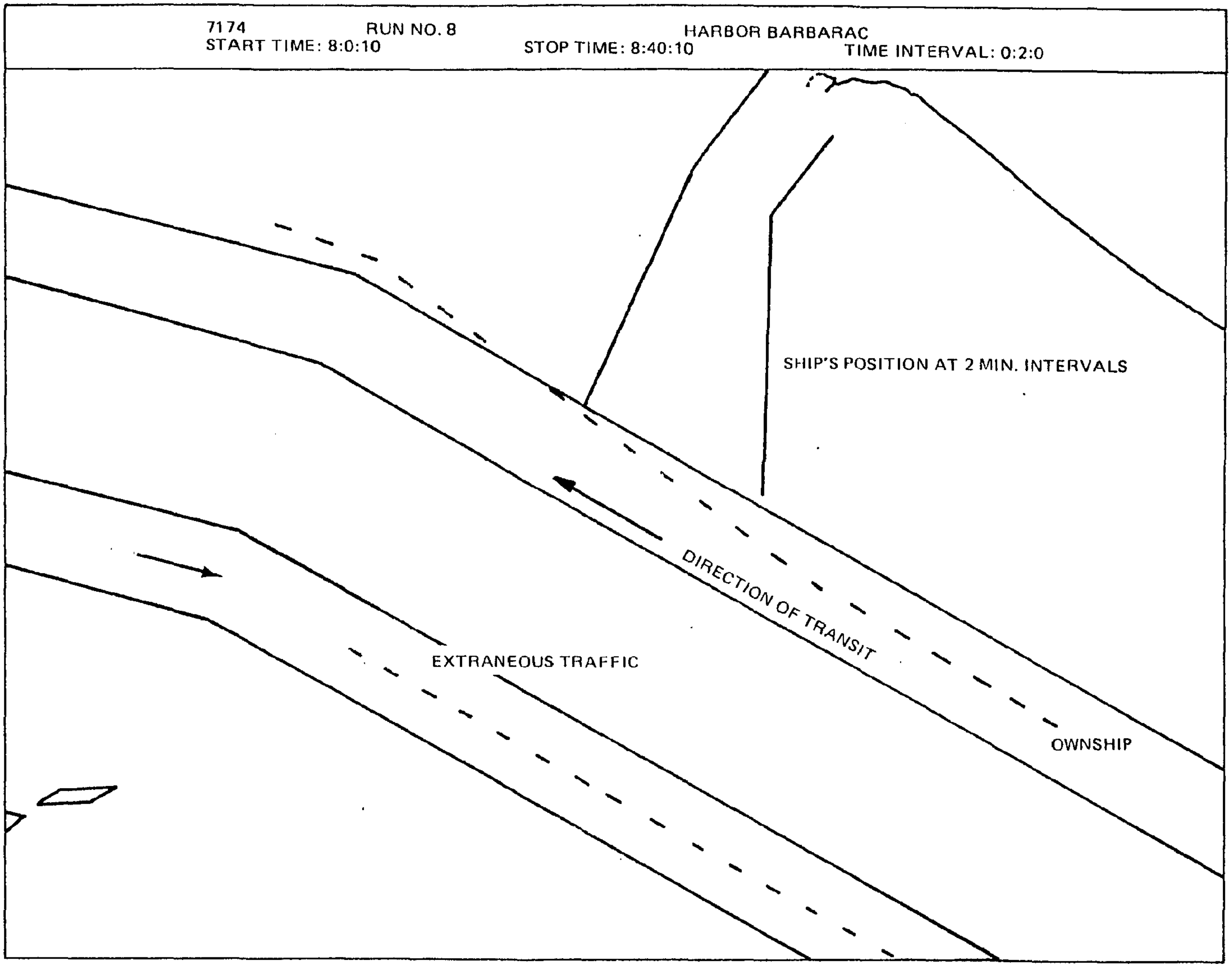


Figure 7-6. Example of a Delayed Turn Executed by a Tanker Master in the Baseline Run Condition

TABLE 7-2. AVERAGE MAXIMUM DEVIATION FOR SCENARIOS A1 AND B1 (BASELINE CONDITIONS)

	Tanker Masters		Containership Masters		All Masters	
	A1	B1	A1	B1	A1	B1
Average maximum deviation (n.m.)	0.28	0.04	0.22	0.04	0.25	0.04
Standard deviation (n.m.)	0.22	0.04	0.09	0.05	0.17	0.04

of the data in Table 7-2 reveals that all test subjects were able to maintain an essentially centerline position with maximum deviation values averaging 0.04 nm. An example of one such run is provided in Figure 7-6.

7.3.2 SCENARIOS A2, A3, AND A4

Four conditions were investigated in Segment A, three of which examined mariner response to collision avoidance problems and the location of fixed structures in areas of relatively high traffic density. The first of the four conditions served to provide baseline data for each subject and was described above. The remaining scenarios were similar to one another in content with the principal traffic encounter comprised of two vessels crossing the traffic lane at its intersection with the Port Hueneme Access Fairway, one outbound and one inbound to the port (Figure 7-8). Minor differences between scearios included various "chaff" traffic configurations: small craft which presented numerous radar targets and maneuvered differently in each condition to disguise the fact that the two interactive ships (container vessel and destroyer) maneuvered in the same manner each time. Scenarios A3 and A4 differed from A2 by the presence of an oil production platform near the intersection, and positioned within the Separation Zone. Scenario A4 presented the highest level of "chaff" traffic including resource recovery support vessels, although the basic two-vessel collision avoidance problem remained the same. Figures 7-9a, b, c, and d display representative test subject responses to these situations. Chaff traffic and other details have been removed to simplify the plots.

The nature of the encounter with the two interactive vessels was such that if the test subject took no evasive action (i.e. maintained course and speed) no collision would result. However, the resulting CPA (closest point of approach) and passing distances were programmed to be smaller than what might be considered prudent. If ownship maintained its course and speed, the naval vessel would cross ahead with a range at CPA of approximately 0.6 mile while ownship would cross the bow of the outbound container vessel at a distance from her of about 0.8 mile (refer to Appendix F for a graphic description of these scenarios). Figure 7-10 presents a comparison between subject groups of the first maneuver made in this traffic encounter situation collapsed across scenarios A2, A3 and A4. Occasionally, test subjects reversed this initial maneuver and, for example, ended up going left after initially turning right.

Mariner response to the traffic problems show a marked difference in some respects between tanker masters and masters of container vessels. It is apparent that when maneuvers are made to avoid traffic, differences arise between the two groups which are directly related to the inherent maneuvering characteristics of ownship in each case. The percentage of runs in which no action was taken is approximately the same for both the tanker and the containership groups with 20% and 17% respectively, maintaining course and speed. The masters conning the 80,000 DWT tanker however, showed a tendency to reduce speed (63% of the runs) and were less likely to make alterations of course than the containership master on the handier vessel. Figure 7-10 also indicates that the complexity of the problem induced a substantial number of initial maneuvers to the left in the direction of the Separation Zone.

It is necessary to point out that this comparison is for the initial choice of maneuver and that subsequent maneuvers may have been, and quite often were, made in the opposite direction. Figure 7-11 shows a comparison between the groups of the resulting collision avoidance maneuvers (e.g., did he ultimately go right or left?). Performance which indicates that the vessel did not alter course to the left or right also includes speed reductions. At least five of the maneuvers resulted in the vessel entering the Separation

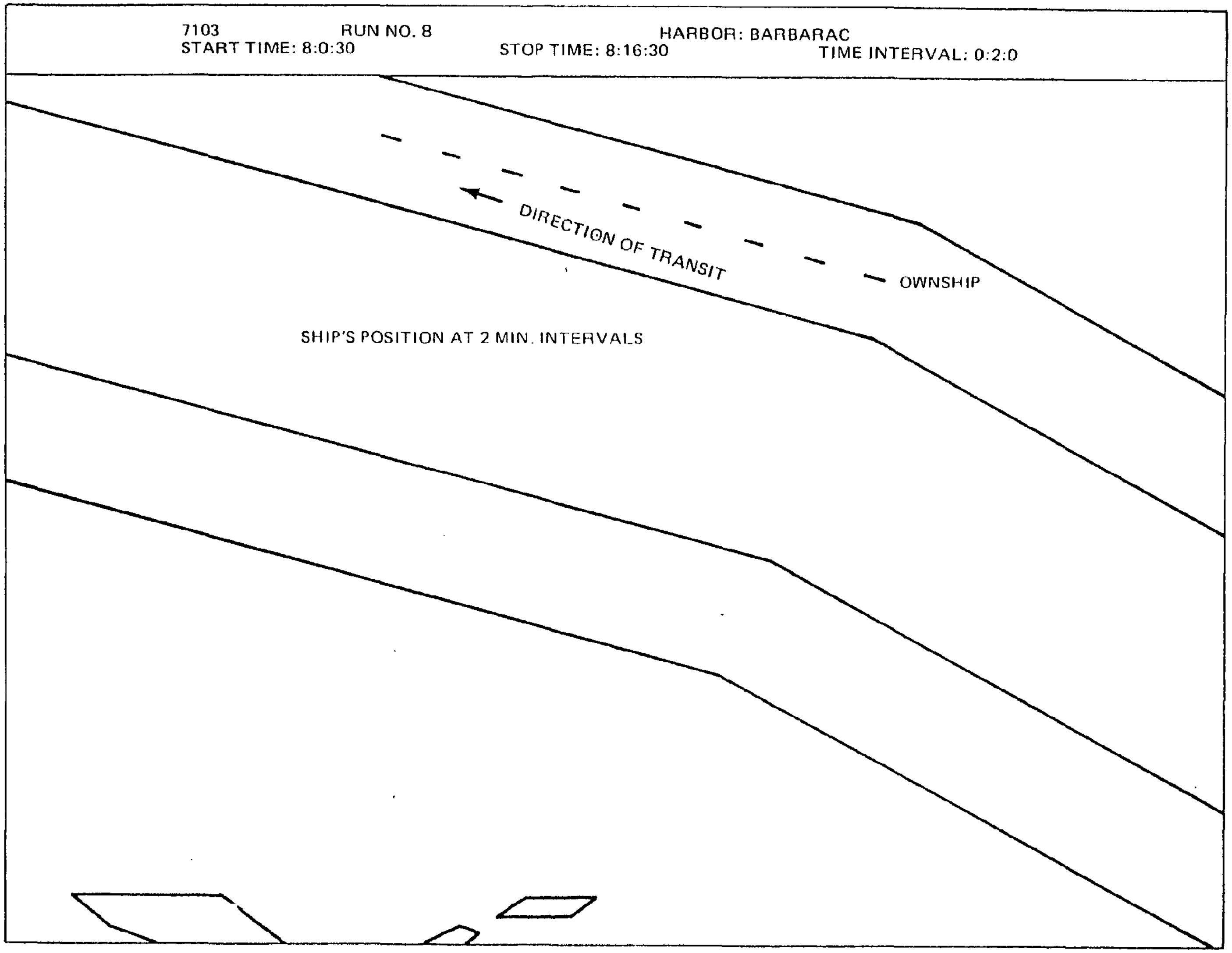


Figure 7-7. Typical Subject Performance in Baseline Run (Scenario B1)

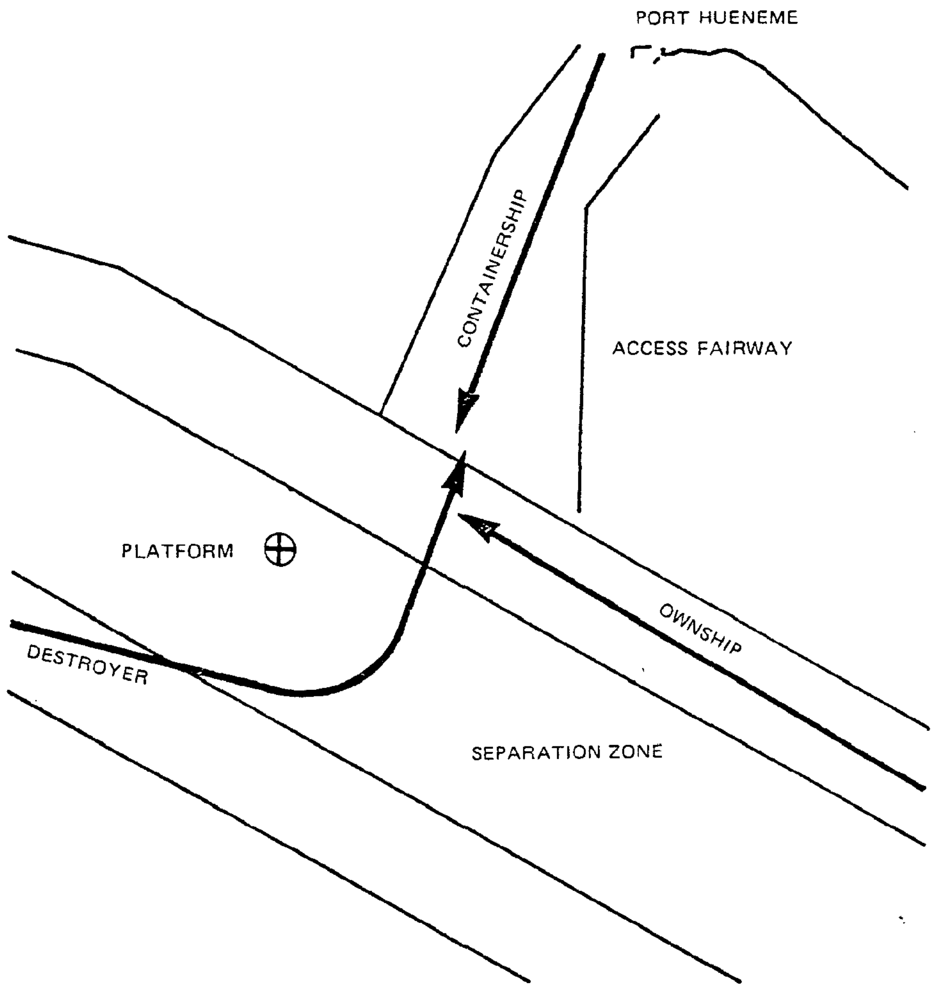
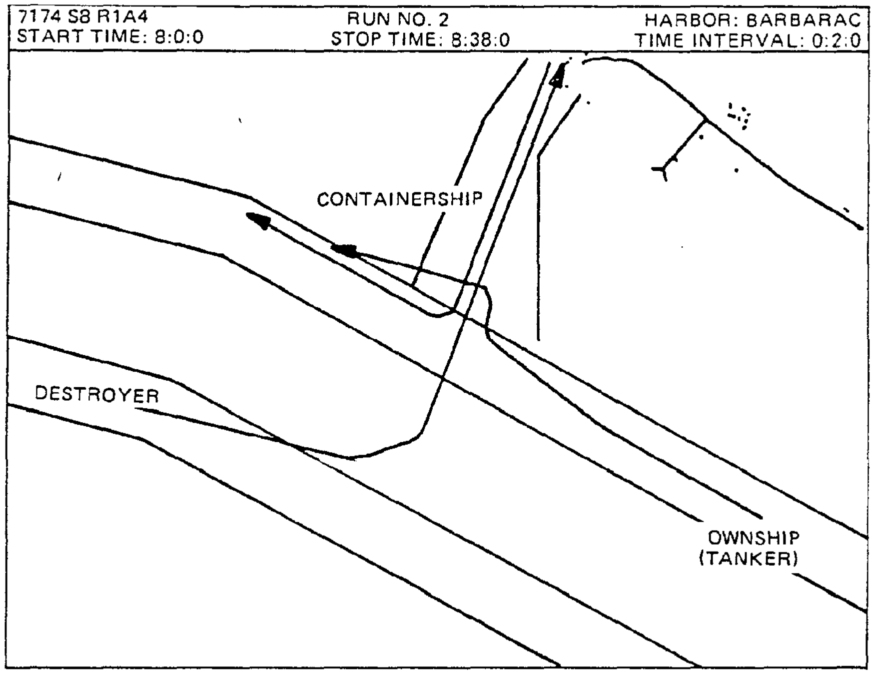


Figure 7-8. Segment A – The Traffic Encounter Presented at the Intersection of the Traffic Separation Scheme and the Port Hueneme Access Fairway. "Chaff" Traffic is Not Depicted Here.

Zone and, while this is not necessarily an unsafe or improper maneuver, subjects indicated during post-run questioning almost unanimously that they would prefer to depart the traffic lane to starboard if a departure was necessary.

The CPA measure used to examine the subjects' performance in response to the traffic encounters within scenarios A2, A3, and A4, revealed no significant differences overall between tanker and containership masters. While the preprogrammed maneuvers of the two interactive vessels remained exactly the same in each scenario, the maneuvers performed by ownship and the resulting ranges at CPA to these ships often varied widely within a subject's consecutive runs. There was no consistent pattern either within or between the two groups of masters. The mean range at CPA for each group, by condition is presented in Tables 7-3 and 7-4, and shows that there was no difference in performance measurable by variation in CPA range. The group means lie within a range of about 0.5 to 0.8 nm, however, the variability range spanned 0.1 to 2.0 nm. It is safe to say that, statements regarding preferred CPA distance notwithstanding (see results of post-run debriefing), a high complexity of traffic encounter situations will promote a highly variable response when the situation occurs within the confines of a mandatory traffic lane.



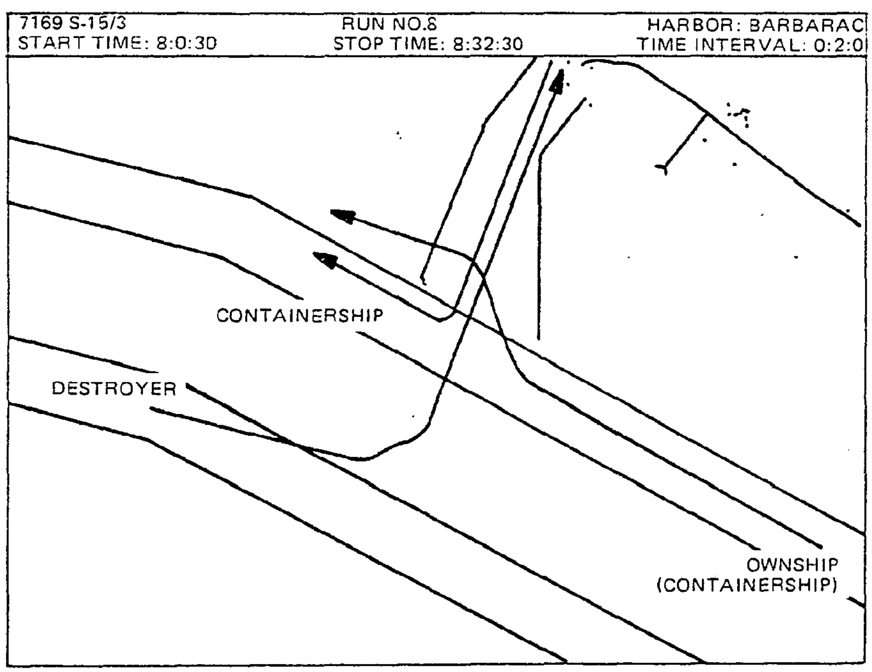
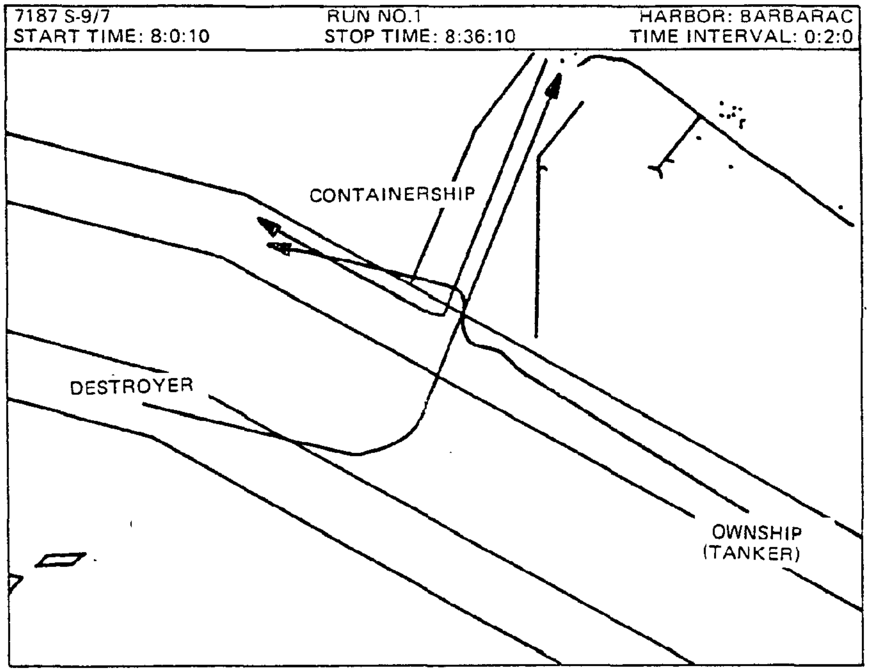


Figure 7-9a. Sample Plots of Vessel Ground Tracks Depicting Typical Responses to the Primary Traffic Encounter in Scenarios A2, A3, A4



ERRATIC MANEUVERING IS EXHIBITED BY BOTH SUBJECTS

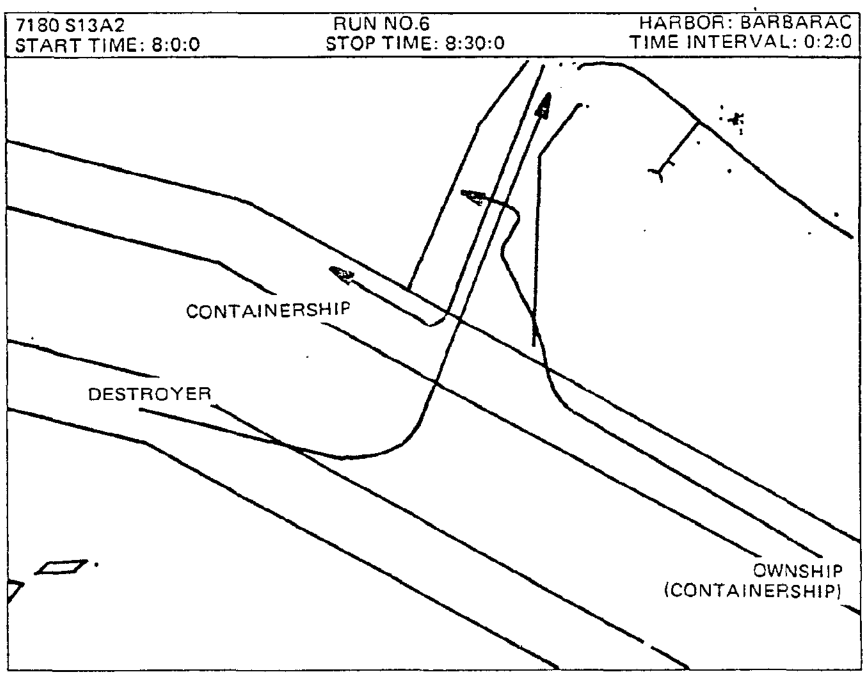
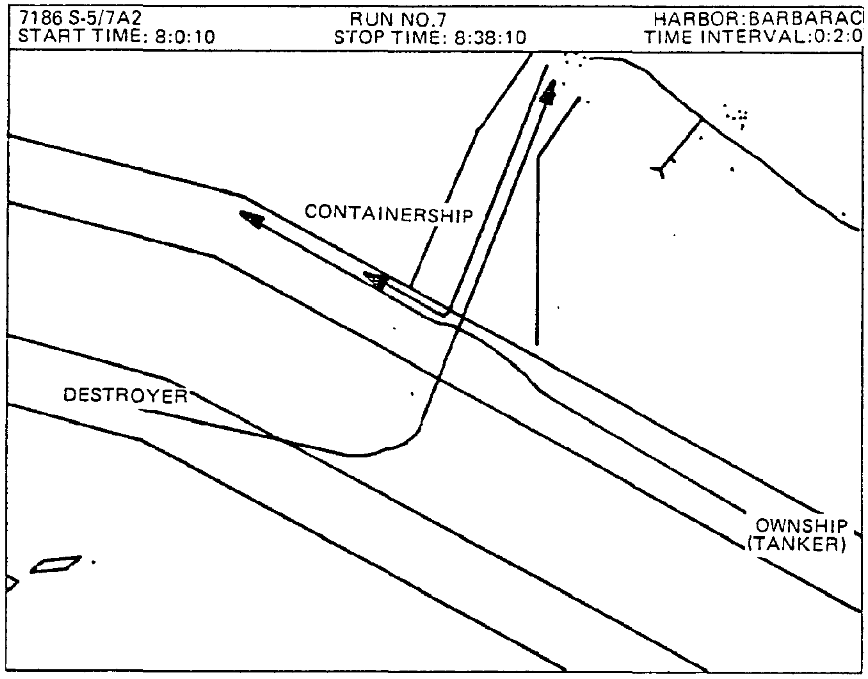


Figure 7-9b. Sample Plots of Vessel Ground Tracks Depicting Typical Responses to the Primary Traffic Encounter in Scenarios A2, A3, A4

OWNSHIP ACTION: REDUCE SPEED



OWNSHIP ACTION–MAINTAIN COURSE AND SPEED

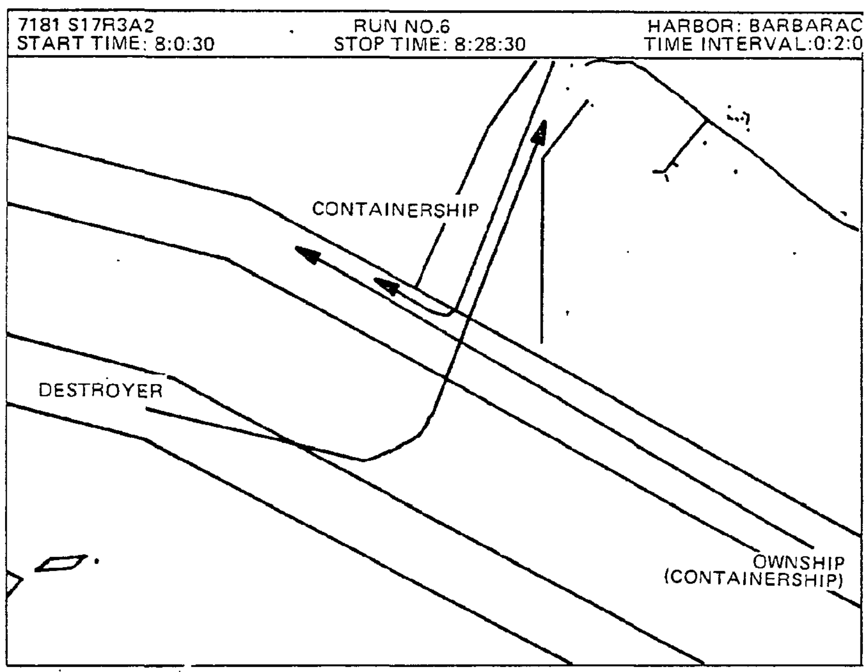
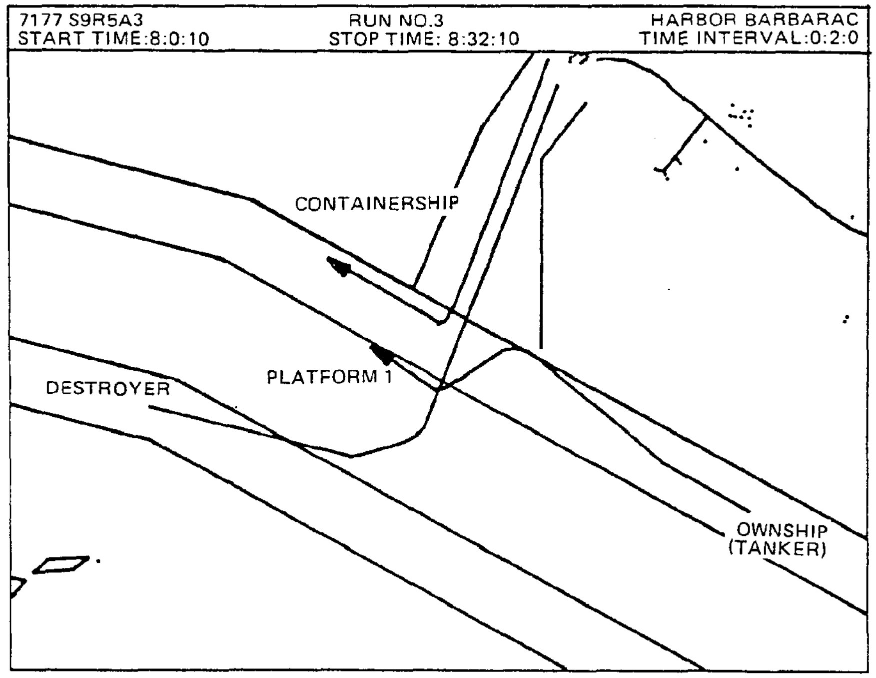


Figure 7-9c. Sample Plots of Vessel Ground Tracks Depicting Typical Responses to the Primary Traffic Encounter in Scenarios A2, A3, A4

OWNSHIP ACTION: ERRATIC MANEUVER–ENTERS SEPARATION ZONE



OWNSHIP ACTION: MANEUVER LEFT–REMAINS IN TRAFFIC LANE

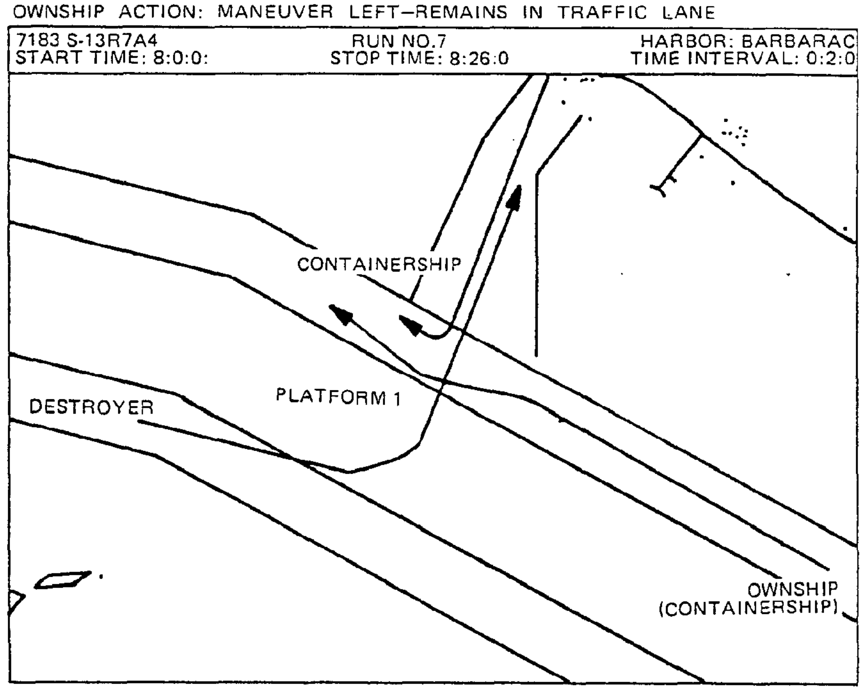


Figure 7-9d. Sample Plots of Vessel Ground Tracks Depicting Typical Responses to the Primary Traffic Encounter in Scenarios A2, A3, A4

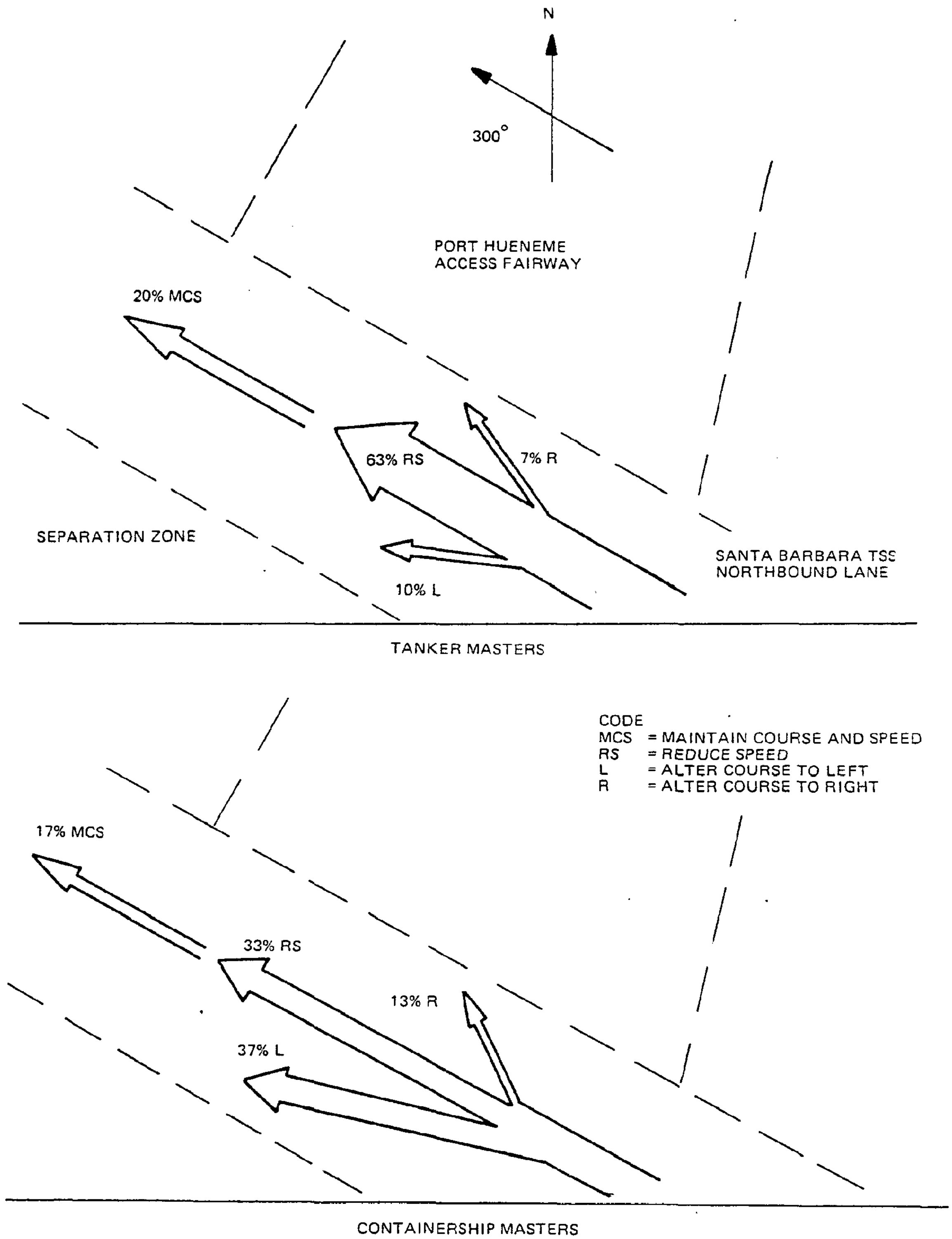


Figure 7-10. Graphic Presentation of the Distribution of Initial Commands in Response to the Collision Avoidance Problem in Scenarios A2 - A4

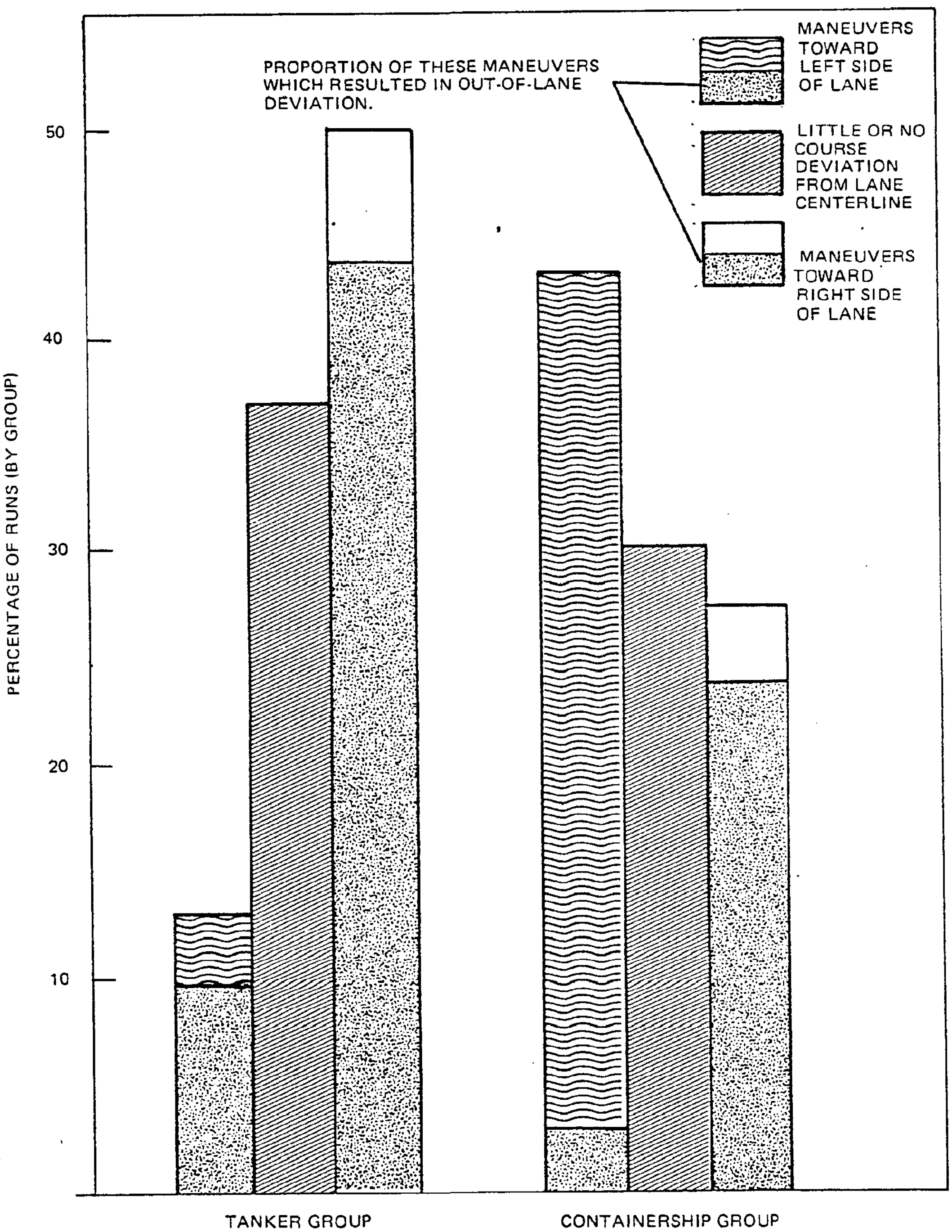


Figure 7-11. Segment A – Comparison Between Subject Groups of the Resultant Maneuvers in the Collision Avoidance Problem

TABLE 7-3. TRAFFIC SHIP: NAVAL DESTROYER

Condition (Scenario)	Measure	Tanker Masters	Container-ship Masters
A2	Mean Range @ CPA (n.m.)	0.9	0.6
	Standard Deviation	0.6	0.5
A3	Mean Range @ CPA (n.m.)	0.5	0.6
	Standard Deviation	0.2	0.1
A4	Mean Range @ CPA (n.m.)	0.7	0.6
	Standard Deviation	0.4	0.2
All	Mean Range @ CPA (n.m.)	0.7	0.6
	Standard Deviation	0.4	0.3

TABLE 7-4. TRAFFIC SHIP: CONTAINERSHIP

Condition (Scenario)	Measure	Tanker Masters	Container-ship Masters
A2	Mean Range @ CPA (n.m.)	0.8	0.7
	Standard Deviation	0.5	0.2
A3	Mean Range @ CPA (n.m.)	0.5	0.6
	Standard Deviation	0.2	0.2
A4	Mean Range @ CPA (n.m.)	0.6	0.5
	Standard Deviation	0.3	0.2
All	Mean Range @ CPA (n.m.)	0.6	0.6
	Standard Deviation	0.4	0.2

Comparison of CPA range data for primary traffic vessels (destroyer and containership) between tanker and container vessel subject groups in Segment A scenarios (A2 - A4)

The results of analysis of the measures for Segment A runs actually showed few differences in performance between masters of container vessels and large tank ships. One such difference noted was the tendency for tanker masters to prefer a reduction in speed to changing course as an initial response to complex collision avoidance problems. The maneuvering capabilities of the ship type appear to impact these differences. A second trend was the frequency with which the masters in the tanker group either reduced speed or altered course to starboard to avoid crossing the bow of the outbound container vessel. A conservative interpretation of the navigation rules often resulted in some exotic maneuvering with a less-than-nimble vessel while, on the other hand, container vessel masters chose more often than not to press on regardless of the apparent crossing situation with the outbound vessel from Port Hueneme. This comparison shows 50% of the runs performed by the tanker group giving way to the crossing vessel while only 26% of their runs showed such action by the containership group.

The presence of a fixed structure sited within the Separation Zone appears to have affected the performance of all subjects very little if at all. With the position of the platform noted on the chart and its radar echo identified, both the platform and its slowly moving support traffic were apparently assigned a lower priority than the ship traffic. The location of the structure within the Separation Zone did not prevent three deviations into the Zone, two of them within a half-mile of the platform. These two close approach cases are attributed to one subject within each group.

When the situation warrants it, maneuvers which take the vessel outside of the traffic lanes will be made without much hesitation, and from the performance on the experimental runs, we can postulate that such alterations will usually be made to the starboard side whenever possible. The percentages of all runs within scenarios A2, A3, and A4 which resulted in excursions outside of the lane boundaries were 43% for the tanker group and 30% for the containership group. High maneuverability of the container vessel and characteristic response to the traffic situation accounts for the lower frequency of out-of-lane excursions among the latter group of subjects. Figure 7-10 shows that alterations of course to the left were more prevalent than course changes to the right as a first maneuver. However, only in five runs did the subjects cross into the Separation Zone to port. (Three occasions are mentioned above and two other occurrences took place in scenario A2 with no platform present.)

An overall impression of a conservative approach to the channel transit was given by the masters conning the 80,000 DWT tanker. Their tendency to reduce speed rather than change course as a first response coupled with a reluctance to compromise the assumed crossing rights of the outbound container vessel are in contrast to the apparent attitude exhibited by the containership masters who, in general, took advantages of the excellent handling characteristics to outrun and outmaneuver the crossing traffic. In no case however, did any run result in collision or ramming of either vessels or stationary structures. Therefore, no judgements can be drawn as regards good and bad performance in the scenario because the nature of the multi-vessel encounter generated a variety of interpretations of the International Regulations for Preventing Collisions at Sea, 1972 (72 COLREGS). It becomes difficult to label performance as "good" or "poor" when the possible interpretations may exclude the applicability of the rules for two vessels meeting, which recommend specific action.

It can be stated however, that given the projections for future intense development of offshore resources in the Santa Barbara Channel with the expected substantial increase in support vessel activity (crew, supply and work boats, tugs, etc.) in and around the Port Hueneme area, conditions of moderate to high congestion may occur which will impact the normal transits of vessels using the Traffic Separation Scheme.

7.3.3 SCENARIOS B2, B3 AND B4

The basic situation in these three scenarios involves a stationary drilling vessel located at the southern edge of the northbound lane. In B2, the drilling vessel is directly on the edge of the lane. In B3, the vessel is located 500 m back in the Separation Zone with the 500 m constituting a "buffer zone" (see Figure 7-3). In B4, the drilling vessel is again on the edge of the lane but now with a tug/barge combination moving slowly near the drilling vessel in the Separation Zone, and a supply boat passing from north of the lane, astern of ownship, to the vicinity of the drilling vessel. Thus B3 may be regarded as a repetition of B2 with a buffer zone, and B4 may be regarded as B2 with the addition of drill ship/platform support traffic.

In all cases where test subjects changed course in response to these situations, the maneuver was to the right, away from the stationary drilling vessel. In some cases, the test subjects maneuvered to the right and/or slowed the speed of ownship.

Table 7-5 summarizes the responses of all test subjects for the scenarios in question. B1 is included to enable the reader to make comparisons to the baseline case. Several points can be made. In B1, virtually all subjects (18 out of 20) made no maneuver and simply maintained course and speed. There is also no significant operational overall difference between tanker and containership master performance. In view of this the following performance discussions will be made with regard to the entire subject population, rather than as distinct groups (tanker or containership masters). In B2, one can see that most subjects maneuvered with only 4 masters maintaining course and speed. In B3, only 10 masters maneuvered with the remaining 10 maintaining course and speed. In B4, virtually all masters maneuvered. In summary, one may claim that scenarios B2 and B4 elicited the greatest number of maneuvering responses with B3 eliciting a somewhat smaller number of maneuvers. It is therefore clear that a drilling vessel on the edge of the lane (with or without associated workboat traffic) elicits a greater number of maneuvers to the right side of the lane than does a drilling vessel set back in a 500 m buffer zone. However, a drilling vessel anywhere near the traffic lane (B2, B3 or B4) elicits a greater number of maneuvers than does no drilling vessel at all (B1).

The primary performance measure to be used in the remainder of this portion of the analysis will be maximum deviation from the centerline. This deviation measures the extent to which the mariner moved away from the centerline (the location from which he began) in an attempt to open up the passing distance (CPA) to the stationary drilling vessel (see Figure 7-12 for an example).

Table 7-6 summarizes the average maximum deviation data for the three scenarios in question. Several comments on these data can be made.

When viewing performance over all masters, there is a statistically (and operationally) significant difference in subject responses to scenarios B2 and B3. Average maximum deviation with the drilling vessel on the edge of the traffic lane (B2) is twice as large when compared to the case where the drilling vessel is set back by means of a buffer zone (B3). That is, masters react more strongly when passing close to the stationary drill ship, then when it is set back 500 m from the traffic lane. This same scenario dependent difference can be found in the separate performance of the tanker and containership masters. There is, however, no statistically significant difference between containership and tanker master performance within either scenario. For tanker masters, the deviation

TABLE 7-5. TEST SUBJECT MANEUVERING RESPONSES IN SCENARIOS B1, B2, B3, AND B4

	B1				B2				B3				B4			
Group	R	RS	R/RS	MCS	R	RS	R/RS	MCS	R	RS	R/RS	MCS	R	RS	R/RS	MCS
Tanker	0	1	0	9	5	0	3	2	3	2	1	4	6	0	3	1
Containership	0	0	1	9	8	0	0	2	3	1	0	6	7	0	3	0
Total	0	1	1	18	13	0	3	4	6	3	1	10	13	0	6	1

R = Right turn.
RS = Speed reduction.
R/RS = Right turn in conjunction with speed reduction.
MCS = Maintain course and speed.

values were 0.25 nm for B2 and 0.16 nm for B3, a statistically significant difference. For the group of containership subjects, deviations were 0.34 nm for B2 and 0.14 for B3, again a statistically significance difference. For both of these individual groups, the presence of the 500 m buffer zone produces a demonstrable and reliable difference in performance. For example, Figures 7-12 and 7-13 graphically depict the ground tracks of the same containership master when performing in scenarios B2 and B3 respectively. The deviation in B2 is clearly visible, while B3 indicates a relatively straight track line.

If one is willing to make the normality assumptions as before, then the following can be claimed. Since all deviations in this setting are deviations to the right, we use the measure "mean + one standard deviation to the right." Thus approximately 84% of all deviations can be expected to lie between the channel centerline and one standard deviation to the right of the mean deviation for the scenarios in question. But then approximately 16% of all deviations could be expected to exceed this value of deviation from the centerline. For B2 this value is 0.56 nm (0.30 + 0.26) and for B3 this value is 0.33 nm (0.15 + 0.18). Thus, if the results of this simulation research generalize to the real world, and if the normal distribution assumption has any validity, one may conclude the following. With a stationary drilling vessel set back 500 m from the lane edge (B3) under conditions of reduced visibility, 16% of all mariners navigating the centerline of the northbound lane could be expected to deviate by at least 0.33 nm to the right. With the drilling vessel on the edge of the lane (B2), 16% of these mariners could be expected to deviate at least 0.56 nm and be out of the traffic lane completely.

The performance in scenario B4 is similar in spirit to that of scenario B2. The average maximum deviation value for

TABLE 7-6. AVERAGE MAXIMUM DEVIATION FOR SCENARIOS B2, B3, AND B4

	Tanker Masters				Containership Masters				All Masters			
	B1	B2	B3	B4	B1	B2	B3	B4	B1	B2	B3	B4
Average Maximum Deviation (n.m.)	0.04	0.25	0.16	0.30	0.04	0.34	0.14	0.36	0.04	0.30	0.15	0.33
Standard Deviation (n.m.)	0.04	0.18	0.21	0.25	0.05	0.33	0.15	0.13	0.04	0.26	0.18	0.20

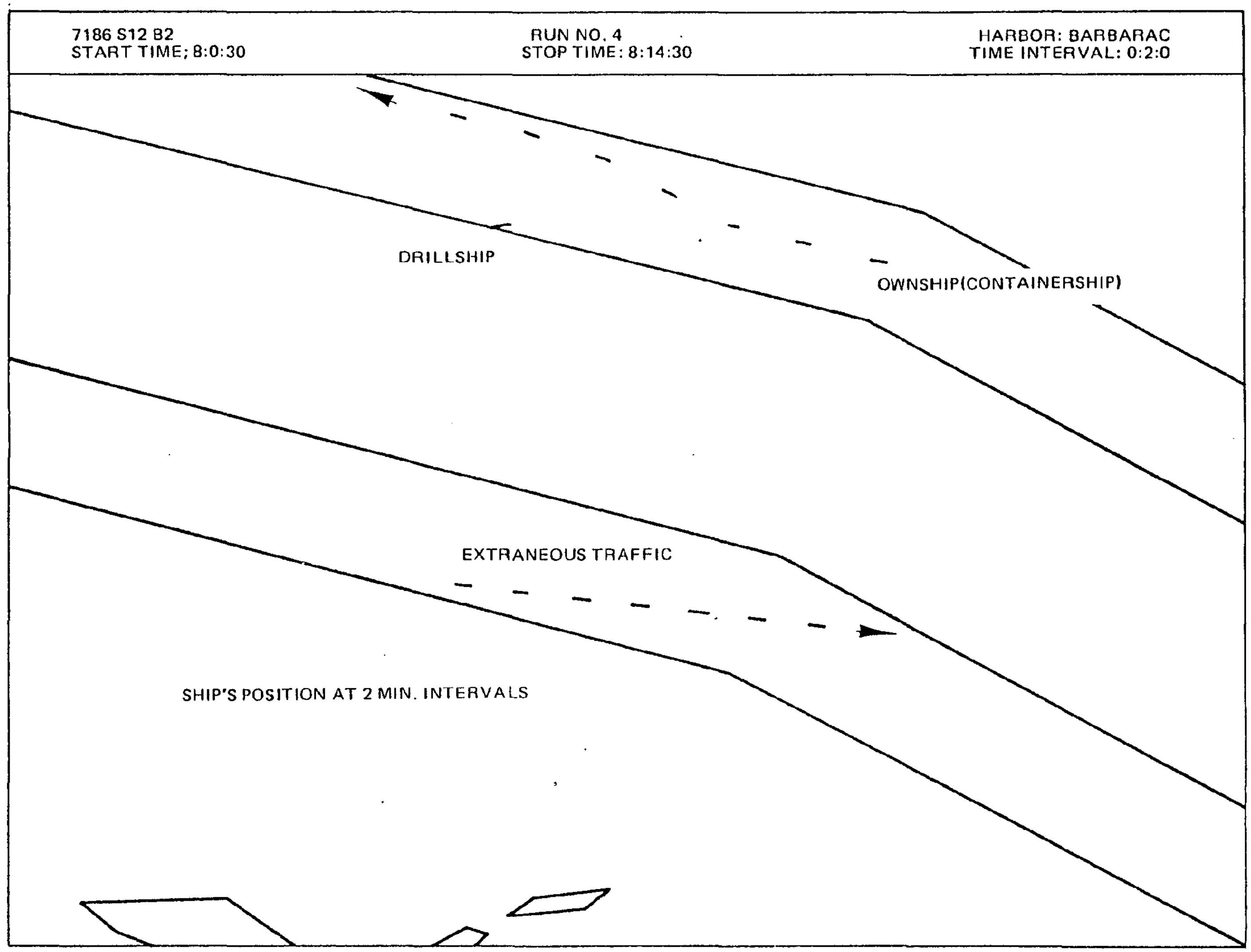


Figure 7-12. Test Subject No. 12 (Containership Master): Ground Track for Scenario B2

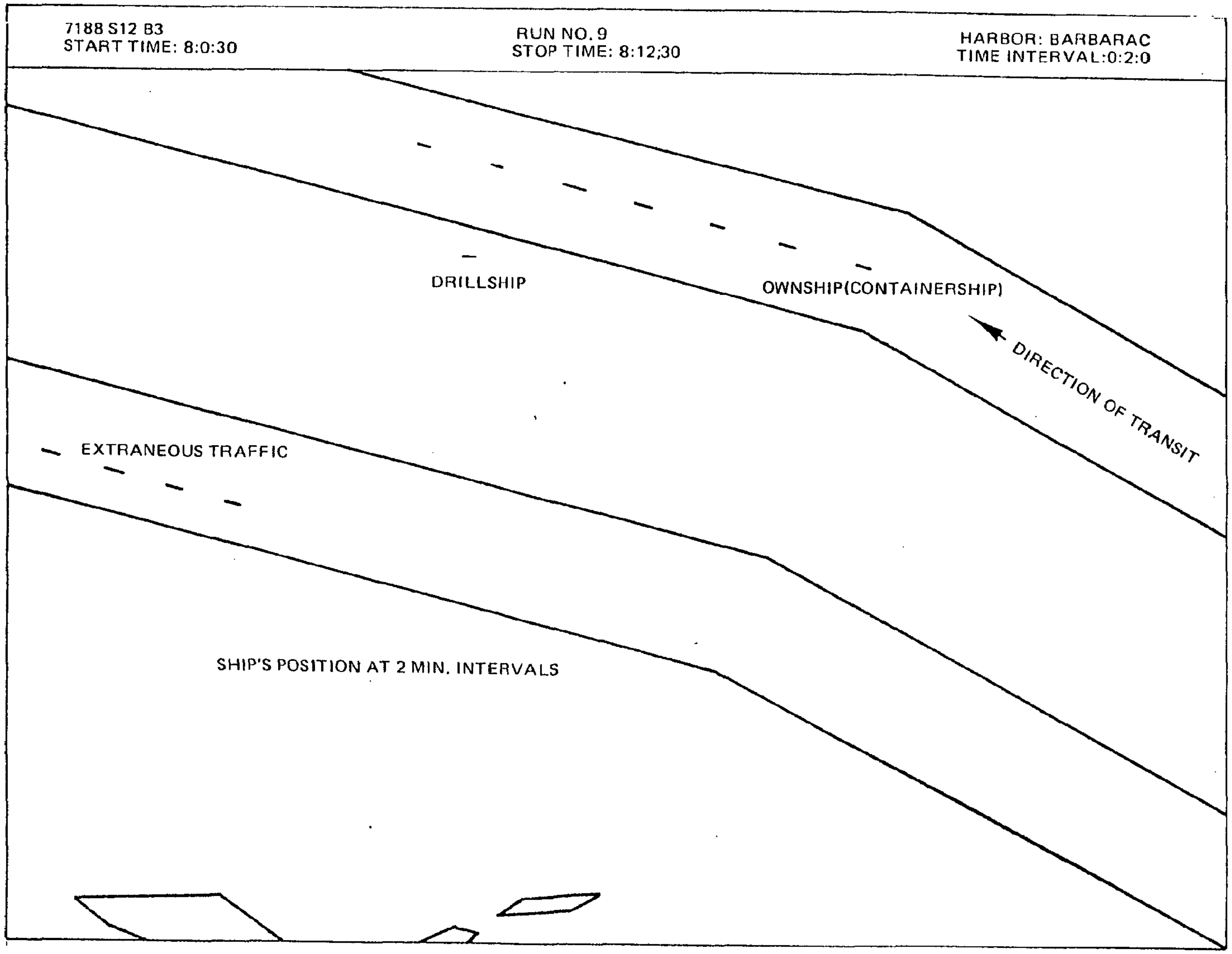


Figure 7-13. Test Subject No. 12 (Containership Master): Ground Track for Scenario B3

B4 is 0.33 nm. Invoking the normal distribution assumption used above, one sees that 16% of all mariners transiting the area under the given conditions (drilling vessel, fog and workboat traffic) could be expected to deviate at least 0.53 nm (0.33 + 0.20) and be out of the traffic lane (see Figure 7-14 for example).

On balance, it is clear that scenarios B2 and B4 are associated with the greatest deviations from centerline and that a significant proportion of mariners could be expected to actually deviate away from the drilling vessel and/or work boat traffic. In contrast, the drilling vessel set back in a buffer zone (B3) is associated with significantly smaller and less frequent deviations from centerline.

7.3.4 SCENARIOS B5 THROUGH B9 — GATED CONFIGURATIONS

Building on behavioral data from the scenarios in which obstructions were sited on only one side of the traffic lane, the "gated" arrangement scenarios (B5-B9) examined the mariner response to a reduction of the maneuvering freedom which was available and was fully utilized, in the former exercises. In order to better interpret the results, response to each scenario configuration is characterized as one of three basic courses of action which we shall refer to as performance characteristics. The data appears in table form (Table 7-7) and presents the actual number of test subjects within each group that exhibited a particular characteristic of performance in each scenario. Data from the gated drill ship/platform scenarios are presented together with the data from the single obstruction (drill ship only) scenarios, B2 and B3, in order to illustrate the effect of adding an object to the right-hand, our outside, edge of the traffic lane.

The three distinct performance characteristics which were identified as typifying the response of the ship masters in these scenarios are defined below:

1. Little or no deviation from the centerline of the traffic lane. Speed reductions, which were infrequent, are included here where a reduction was made without course alterations.

2. Course alterations away from the first object (drill ship at left lane edge) with the vessel's resulting track remaining within the traffic lane boundaries, were considered moderate alterations. All course alterations occurring at the approach to the drill ship were made to starboard.

3. This characteristic describes large course deviations to starboard on approach to the drill ship position which resulted in out-of-lane excursions on the right-hand side. In Segment B scenarios, subjects consistently avoided navigating their vessels into the Separation Zone.

In viewing the data contained in Table 7-7, it is obvious that comparisons of subject performance are made easier when the scenarios are separated into pairs according to the type of configuration. We will therefore discuss the results in terms of the vessel's maneuvering response to:

- Single obstruction—with and without buffer zone (B2, B3).
- Parallel gate configurations—again, with and without buffer zone which provides an examination of two transverse separation distances (B5, B7).
- Staggered gate configurations—two different longitudinal separation distances (B6, B8)

The single obstruction scenarios have been previously discussed. We will refer to them in this section in terms of how the gated arrangements alter the performance exhibited in scenarios B2 and B3.

Parallel Gates — Scenarios B5 and B7

Typical performance where two objects are straddling the traffic lane directly opposite one another was centerline navigation for both subject groups. The choice between a wide deviation around the gate entirely (mandating a departure well outside traffic lane) or holding the centerline and passing equidistant from both objects was presented, and the latter alternative was almost invariably selected. Although not indicated in the table (which shows only one occurrence of a subject opting to pass around the gate), masters navigated through the center of the pair with some reluctance. This is inferred by the slight increase in the number of masters who reduced speed on approaching the objects and supported by responses to the post-run questionnaire.

Two runs in particular highlighted this apparent reluctance. One subject backed ownship's engines and stopped the vessel in mid-channel before proceeding at slow speed through the gate. In another run a second subject in the same group (tanker masters) provided the only instance of deviation outside of the lane and around the gated pair. This subject exhibited an inclination in all of the Segment B

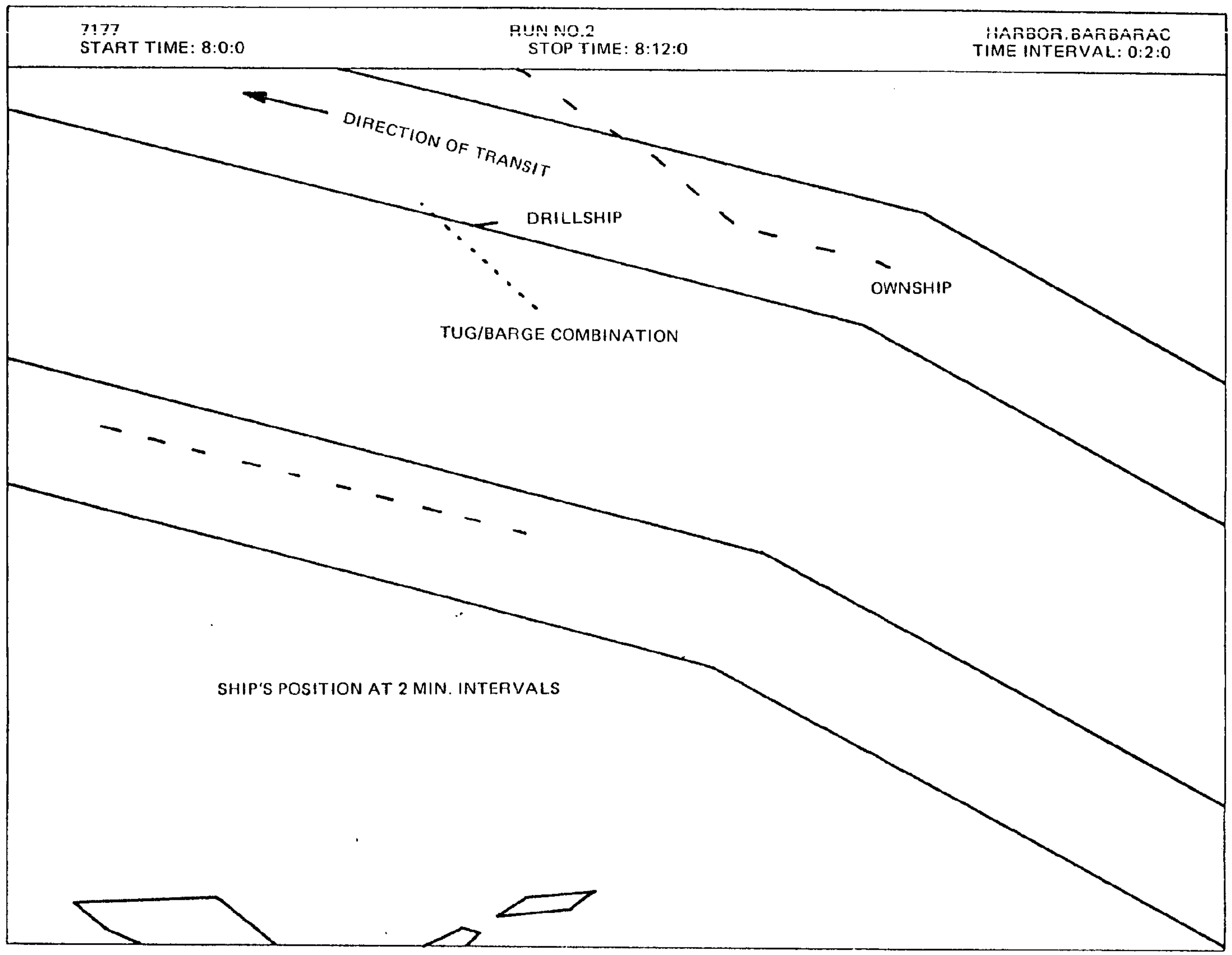
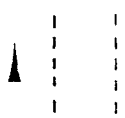


Figure 7-14. Example of Tanker Master Ground Track for Scenario B4 Which is Comprised of Scenario B2 with Support Traffic

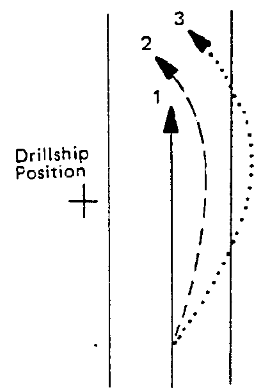
TABLE 7-7. COMPARISON OF THE PERFORMANCE CHARACTERISTICS EXHIBITED BY SUBJECTS IN RESPONSE TO EACH OF THE CONFIGURATIONS PRESENTED IN SEGMENT B SCENARIOS

Drill Ship/Platform Configurations	Scenario	Subject Group	Performance Characteristic (No. of Subjects)			Subjects per Group
	B2	T	2	7	1	10
		C	2	6	2	10
	B3	T	6	3	1	10
		C	7	3	–	10
	B5	T	5	1	–	6
		C	6	–	–	6
	B7	T	5	–	1	6
		C	6	–	–	6
	B6	T	2	2	2	6
		C	6	–	–	6
	B8	T	1	4	1	6
		C	5	–	1	6

SUBJECT GROUP CODE

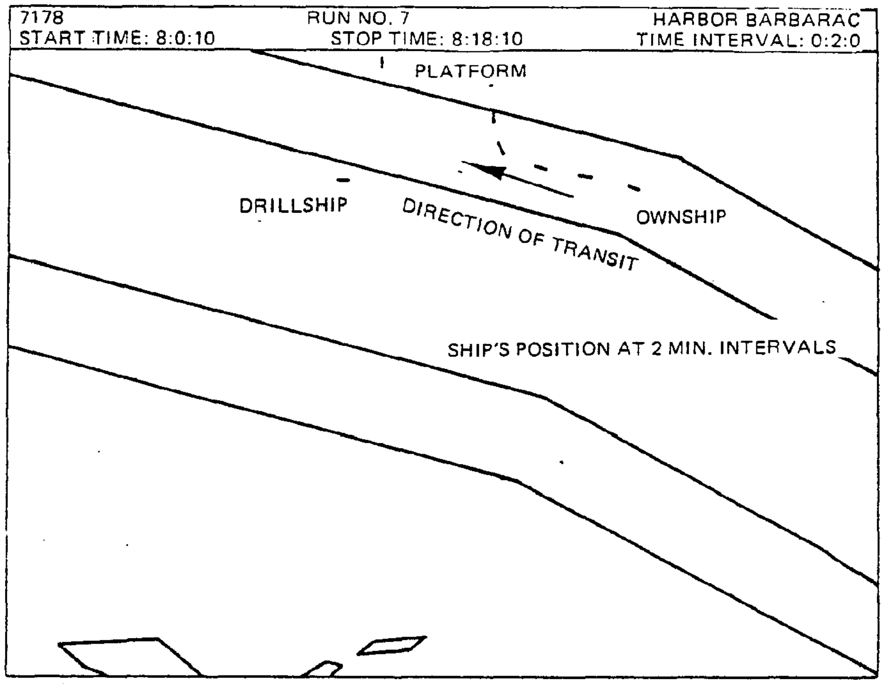
T = Tanker

C = Containership

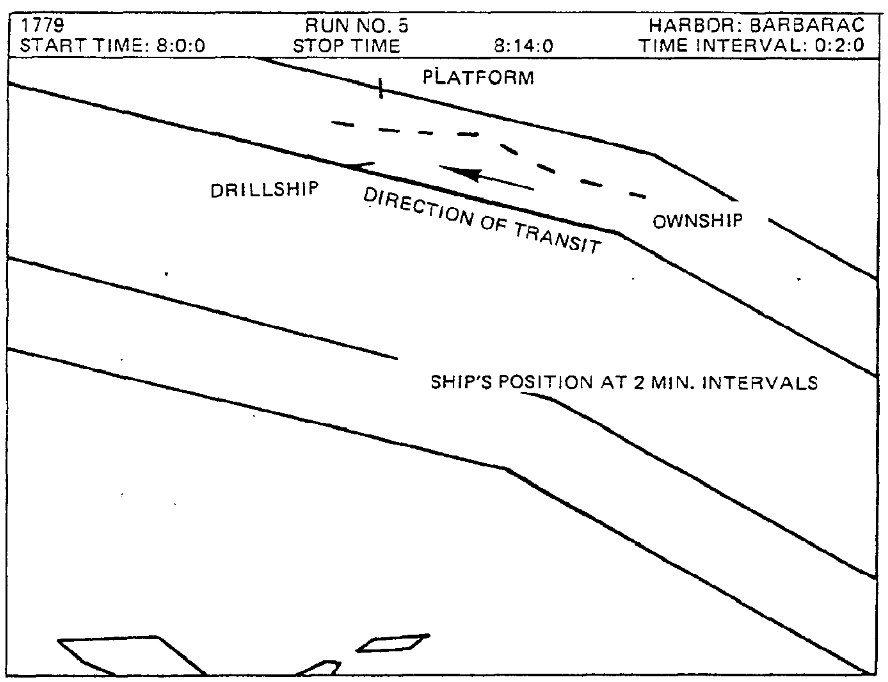


Comparison of the performance characteristics exhibited by subjects in response to each of the configurations presented in Segment B Scenarios.

runs toward large, out-of-lane maneuvers and became the only test subject to make the large deviation around the gate. While displaying consistent behavior, it is noted that this particular subject passed through the narrow gate (no buffer zones) in B5 and avoided the wider gate of B7. This is exhibited in Figure 7-15 showing that his first encounter with the parallel gate was scenario B7, in which he performed in the usual way by making the large out-of-lane course alteration. Because of the randomization of the experimental run order, his second encounter with the parallel gate was scenario B5 in which the transverse separation distance is narrower than the former by 1000 m due to the absence of two 500 m buffer zones. His ground track plot shows that the subject began to alter course to starboard as before and apparently reconsidered his action and chose to pass through holding the centerline (Figure 7-15).



SCENARIO B7



SCENARIO B5

Figure 7-15. Test Subject No. 9 (Tanker Master): Sample of Performance in Parallel Gate Scenarios

Staggered Gates—Scenarios B6 and B8

Performance in the case of staggered objects straddling the traffic lane showed slight differences between the tanker and containership subject groups. In scenarios B6 and B8, the majority of the masters in the latter group held to the centerline with no deviation away from the drill ship (Table 7-7). This response is not consistent with their performance in scenario B2 where eight out of 10 subjects in this group altered course on approaching the object and returned to mid-channel after passing abeam of it. The group of tanker masters exhibited a variety of responses. The group response to scenario B8 (two mile separation between drill ship and platform longitudinally) is similar to their performance in scenario B2. In fact the tendency was to make a slalom maneuver, that is, altering course to starboard at the first object and to port on approaching the second. In this way, the requirement for a greater-than-half mile passing distance to the objects was achieved. The tanker masters' response in B6 appears somewhat confused wherein two subjects elected to sail around the platform and left the lane entirely. The slalom type maneuver is evident (see Figure 7-16) but occurs less frequently than with the larger separation in B8.

Traffic Encounter in the Vicinity of Gated Obstructions—Scenario B9

Scenario B9 examined a dangerous traffic encounter involving a tug/barge moving across the traffic lane between the drill ship and platform. The situation is that of scenario B7 with the addition of this rig related traffic. The scenario evoked a variety of maneuvers resulting in rather close approaches to the drill ship, platform on the tug barge (see Figure 7-17).

In all but one case, when test subjects maneuvered, they turned to starboard to go under the stern of the tug/barge. The two measures of primary interest are thus CPA to tug/barge and CPA to the platform on the north side of the traffic lane. Table 7-8 contains the CPA values for both of these collision threats for each group of test subjects, and for all test subjects as a whole.

In both collision threat situations, containerships pass closer to collision threat than do the corresponding tanker subjects. In addition, the standard deviations associated with containership master performance are smaller, indicating less variability in their maneuvering responses. While overall average values of CPA are relatively large (0.4 to 0.5 nm), the range of responses of individual test subjects indicates that rig/traffic situations such as depicted here may occasionally give rise to low values of CPA caused in part by the unexpected navigation behavior of rig related traffic and/or restricted areas available for maneuvering.

7.3.5 SUMMARY OF RESPONSES TO DEBRIEFING QUESTIONNAIRE

A debriefing questionnaire was provided to each test subject following his completion of the experimental runs. The questions elicited responses regarding the subject's compliance with, and opinion of, traffic routing schemes and fairways, acceptable CPA ranges, maneuvering response to fixed permanent and temporary structures, etc. A sample of the debriefing questionnaire may be found in Appendix F of this report. Results of the Debriefing Questionnaire are as follows.

TABLE 7-8. TEST SUBJECT CPA TO CROSSING TRAFFIC AND STATIONARY PLATFORM (SCENARIO B9)

	Tanker Masters	Containership Masters	All Masters
CPA to Tug/Barge (n.m.)	0.5	0.3	0.4
Standard Deviation (n.m.)	0.2	0.1	0.2
CPA to Stationary Platform (n.m.)	0.6	0.5	0.5
Standard Deviation (n.m.)	0.2	0.1	0.2

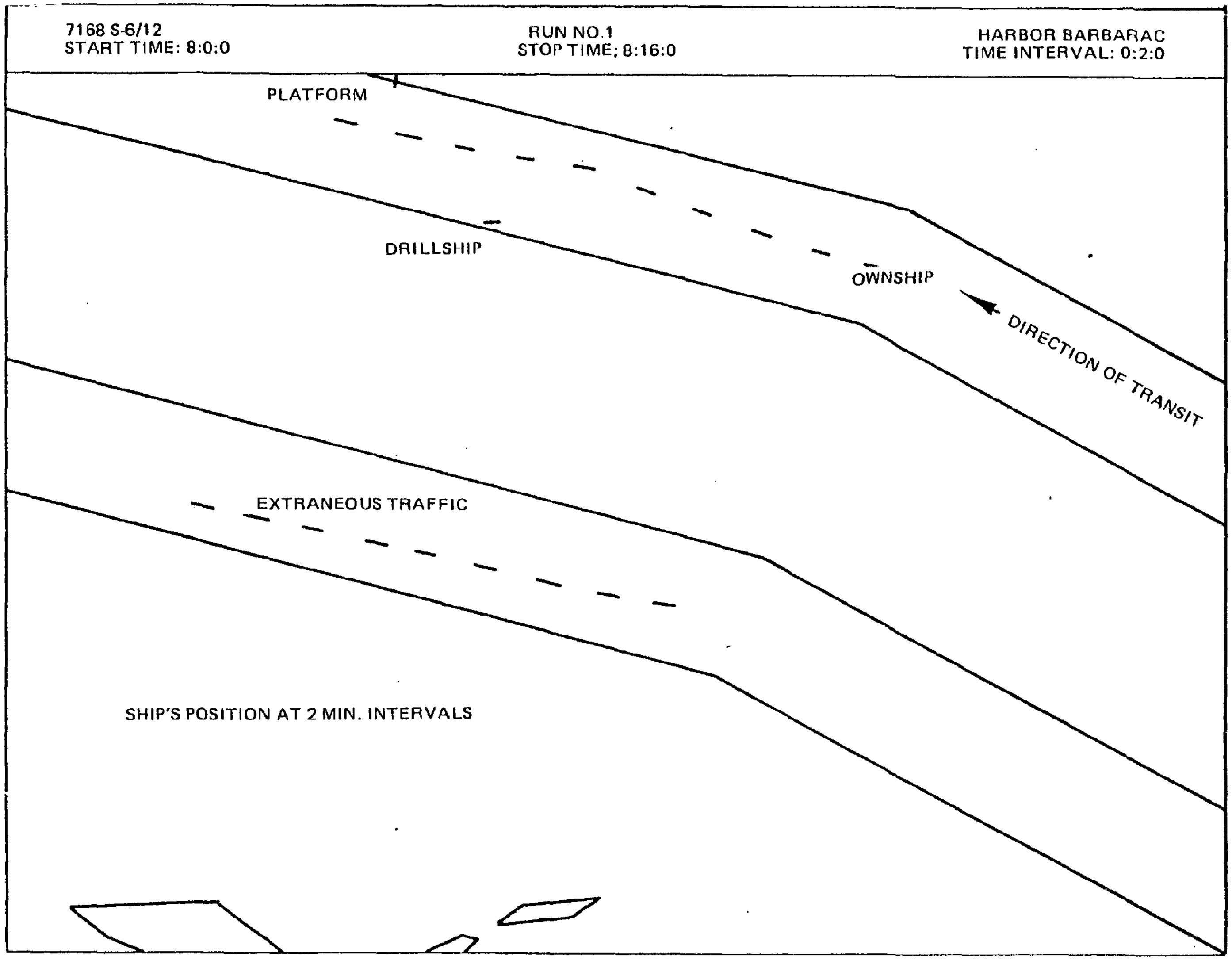


Figure 7-16. Scenario B6: Ground Track of Ownship Performing "Slalom" Type Maneuver Through the Staggered Gate

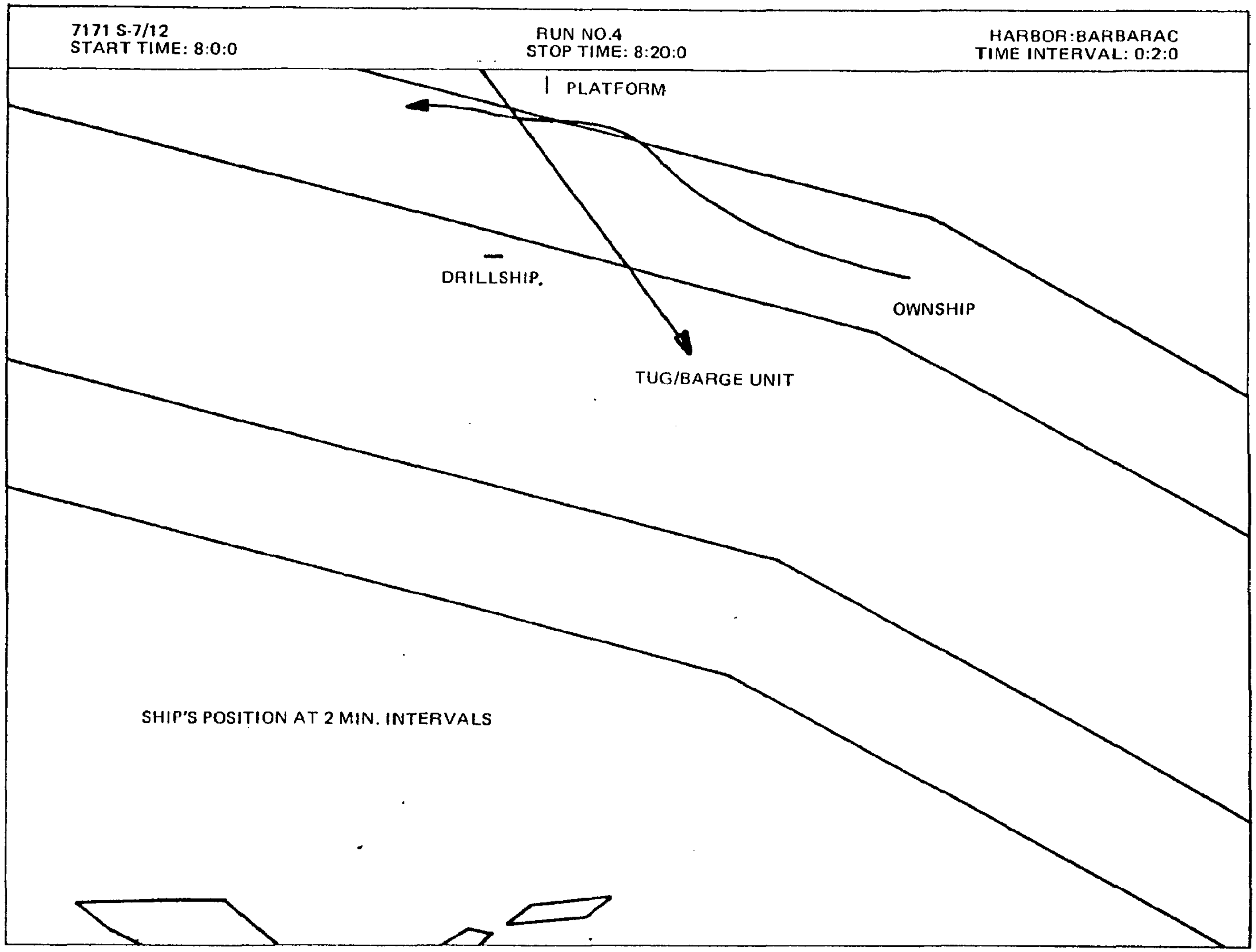


Figure 7-17. Scenario B9: Ground Track of Ownship and Threat Vessel in Close Proximity to the Gated Configuration

Question #1

Have you transitted areas of high offshore platform density previously? Where?

Masters	Tanker	Container Vessel
Yes	100%	92%
No	–	8%

Areas listed by all subjects include California Coast, Gulf of Mexico, Persian Gulf, North Sea, Borneo Coast.

Question #2

If offshore production platforms are sited in close proximity to normal traffic lanes or recommended fairways, what do you consider to be a safe passing distance for them?

Masters	Tanker	Container Vessel
¼ mi	–	17%
½ mi	50%	41.5%
1 mi or greater	50%	41.5%

Two to three subjects in each group further qualified their responses, indicating that the presence of support vessels, anchors, buoys, or reduced visibility might prescribe greater distances.

Question #3

What factors might influence your decision to alter your intended track so as to open the distance between your vessel and a platform or stationary drilling rig? (List multiple answers in order of their priority, first priority being at the top of the list.)

Both groups of subjects were consistent in their responses. The presence of other vessels in the vicinity ranked as the number one consideration. The conditions of visibility and the prevailing wind or current generally ranked second and third respectively.

Question #4

Do you recall any instances where you objected to or preferred not to follow a recommended (but not compulsory) Traffic Separation Scheme or fairway? If yes, what factors influenced your decision?

Masters	Tanker	Container Vessel
Yes	60%	58%
No	40%	42%

The responses are consistent across both groups, however, the reasons given vary greatly. Masters of container vessels most often stated that efficiency of passage (to save time) was the reason for departing from the recommended navigation lanes. Weather conditions in the vicinity of the traffic lanes was the second most stated reason by these masters. This relates to efficiency but in terms of container vessels, may also be a safety consideration. The least mentioned factor determining whether the lanes were followed (containership master responses) is the requirement to maneuver in accordance with the Rule of the Road, or simply the presence of a good deal of traffic.

Tanker masters, on the other hand, responded that the traffic situation in the navigation lanes was the foremost factor in their decision to operate outside of them. Only one master indicated efficiency as a reason. The inappropriate dimensions of the fairway or lanes through danger areas (example: Gulf of Mexico platform density) was the second most cited factor influencing such decisions.

Questions #5 and #6

Do you feel that a Separation Zone between Traffic Lanes is a "no-man's land" that should never be entered by vessels using the lanes in the normal direction of transit and under normal operating conditions (other than emergency)?

If, while proceeding in a lane of a Traffic Separation Scheme, you encountered an obstruction for which you would have to leave the Traffic Lane to pass at a safe distance, would you be more likely to enter the Separation Zone or pass out of the lane to starboard (assuming ample sea room was available to either side of the Traffic Lane)?

These questions elicited opinions of the sanctity of the Separation Zone of a TSS. Respondents in general held the same opinion regarding the purpose of, and the navigation of vessels within, a Separation Zone. The majority in both groups firmly believe that vessels, in compliance with a Traffic Separation Scheme, should make an effort to stay clear of the Zone, and that vessels should only enter with purpose. The reasons for which a vessel may enter the area between traffic lanes are in emergencies, when crossing lanes and during traffic avoidance maneuvers when safety dictates.

Only two of three subjects in either group were not quite so firm about avoiding excursions into a Separation Zone. Example of acceptable maneuvers given are a vessel moving over into the Zone to increase the passing distance between ownship and an overtaking vessel; a vessel setting into the Zone due to current or wind action was also cited.

In response to an obstruction requiring deviation from the traffic lane to meet individual safe passing distance criteria, an almost unanimous replay was received from all subjects. Altering course out of the lane to starboard rather than into the Separation Zone was advocated by all but one master. This containership master indicated that alterations to either side were acceptable as the situation dictated. He was one of those respondents who did not firmly believe that the Separation Zone should remain free of traffic in the strictest sense, in answer to Question #5.

Question #7

How do you feel, in general, about the siting of production platforms or stationary drilling vessels in the Separation Zone or a Traffic Separation Scheme? Would your opinion be altered if their positions were accurately known (either printed on local charts or available through local Notices to Mariners)?

The question of whether platforms should be located within the Separation Zone of a TSS, and whether fore-knowledge of their positioning was a determining factor evolved somewhat different reactions, both between and within the two groups of masters.

Almost all of the containership masters saw no reason why platforms could not be located within the Zone so long as the positions were known to mariners in advance of an area transit. However, half of the group did object to in-zone siting if the positions could not be accurately known beforehand.

The tanker group was evenly divided on this issue with half taking the view that platforms were acceptable within the Separation Zone whether the positions were known in advance or not, with qualification. The balance of tanker subjects firmly believed that such obstructions should not be permitted in the Zone regardless of whether positions are known.

Among both the containership and tanker masters, many of those who viewed in-Zone siting of structures as acceptable qualified their answers by recommending distances in from the traffic lanes that such structures should be allowed.

Question #8

What is your opinion of permitting stationary drilling vessels to operate within a recommended Traffic Lane? Would your opinion be altered if the vessel's position were known in advance?

Regarding the operation of stationary drill ships or rigs within a traffic lane both groups responded with a good deal of opposition whether its position is known or not.

Masters	Tanker	Container Vessel
Opposed (position known)	90%	66%
Opposed (position unknown)	100%	100%

Questions #9 and #10

When you are transitting a recommended Traffic Lane or fairway does your criteria for an acceptable CPA to vessels crossing the lanes differ from acceptable CAP's to crossing traffic in an open sea situation (no lanes)?

Approximately what range at CPA is acceptable to you in the open sea (crossing situation)? If different (question 9) what range at CPA is acceptable when trasitting a recommended Traffic Lane?

These questions gathered information as to intention rather than actual performance. They specifically asked what the subjects' criteria was for an acceptable range at CPA in traffic encounters on the open sea and when operating in a recommended traffic lane which, by its nature, tends to promote a higher traffic density than is found in the open sea. Containership masters genrally stated that the range at CPA acceptable when in a traffic lane is 0.5 mile, although the responses ranged from less than 0.25 mile to 1.0 mile. A few within the tanker group deemed 0.5 mile acceptable but most preferred 1.0 mile in traffic lanes.

In open sea encounters the containership subjects showed a preference for a range of CPA of 1.0 to 2.0 miles (42% and 50% respectively) while the tanker group responded with a 2.0 mile CPA range (70%).

A general rule of thumb to be inferred from this comparison is that CPA range acceptable in the open sea situation can be halved when transitting traffic lanes. The generally higher values for preferred CPA range given by tanker masters was not unanticipated in view of the well-known differences in the maneuvering capabilities and operating speeds of these two vessel types.

Question #11

Are there other factors which affect your criteria for acceptable range at CPA, such as weather, visibility, size or speed of other vessels? If yes, explain how these factors would change your criteria?

Responses to this question are in agreement in general across the groups. The range and nature of responses however, do not lend themselves well to comparison.

Questions #12 through #14

Are you aware of the proposal to begin drilling in or near the Santa Barbara traffic lanes?

Would you be opposed or in favor of such activity?

Have you ever voiced an opinion on this matter in the past? If so, could you briefly restate it here?

All of the masters within the containership group who responded to these questions, indicated that they were aware of the proposal to commence exploratory drilling in or near the Santa Barbara Traffic Separation Scheme, while only 70% of the tanker masters were aware of it. Three masters from each group indicated that they were definitely opposed to such activity, the balance stating that they were either in favor of it or undecided.

Less than half of the subjects in either group had never previously voiced an opinion on the subject. Of those who had and who elected to state that opinion in the questionnaire in response to question 14, respondents in both groups were evenly divided as to whether or not such exploration and production activity should take place. Of course, all those who gave opinions either favoring or opposing such operations qualified their statements by reiterating that the safety of navigation through the Santa Barbara Channel should not be impaired.

Graphic Presentations (Questionnaire)

These diagrammatical questions were developed in part to collect responses from those eight subjects who did not participate in the second part of the experiment examining gated drill ship/platform configurations. About half of these respondents in each group of masters indicated that no course alterations would be made in any of the configurations indicating an intention to navigate the middle of the traffic lane past the structure/drill ship under any conditions of visibility. In certain configurations, particularly in the staggered gate, the remaining subjects elected to make a slight "S" maneuver (containership masters predominately) which would increase their passing distance to each object. Several of the tanker masters indicated their choice would be to pass out of the traffic lane and thereby avoid passage through the gate. All of the respondents indicated that these maneuvers would be made during periods of visibility varying at 2.0 miles or less.

These graphic representations were also included in the questionnaires for those subjects who would make simulator runs in the additional conditions B5 through B9. Only four of the six presentations in the questionnaire were addressed on the simulator. Whereas problems have in the past been addressed on the basis of what people said they would in a particular situation, it was determined that the questionnaire would be a suitable means for identifying inconsistencies between stated intention and actual performance.

In comparing the responses to the graphic part of the questionnaire to the actual performance of the subject on the simulator, only those questionnaires where the intention with respect to a gated configuration was made clear, were examined, as some of the subjects failed to provide unambiguous answers.

Out of a total of 18 comparisons made for five subjects within the tanker group, eight actual runs were inconsistent with remarks made on the questionnaire following the runs. These inconsistenceis are mainly found for two subjects, one of which exhibited behavior in every run contrary to what he stated he would do in the same cases afterwards. The other subject showed inconsistent behavior in all but one run.

Only three cases of inconsistent behavior were noted in the runs performed by containership masters, who for the most part maintained course and speed through most configurations in conformance with their stated (albeit, statements made afterward) intentions.

The general impression given by both the responses to the graphic representations and actual performance is that the containership group tended to maintain course and speed or make only slight alterations, while tanker masters tend to be very wary of obstructions lining both sides of the lanes.

7.4 CONCLUSIONS

The results of the CAORF simulation study lead to the following conclusions with regard to mariner performance which are associated with offshore resource recovery operations.

7.4.1 TRACK-KEEPING PERFORMANCE

The results of this simulation effort indicate that most masters will generally navigate their vessels well within the confines of the 1 nm wide traffic lanes. There will, however, be exceptions. Occasionally, a ship may wander out of the lane either because of environmental reasons (wind/current) or because of inattention (as occurred in the experiment). That such behavior can occur in the real world is well-corroborated by experience in the Gulf of Mexico. Even more frequently, a vessel can be expected to "wander" within the confines of the traffic lane, actually approaching the edges of the lane until corrective actions are begun by the officer on navigation watch.

7.4.2 TRAFFIC ENCOUNTERS

The presence of traffic crossing the lanes is likely to induce a variety of avoidance maneuvers by vessels navigating in the normal direction of transit within the established traffic lanes. The development of Port Access Fairways which intersect the TSS as does the Port Hueneme Access Fairway, will generate such crossing traffic. Further development of these channel ports, commercially and as bases for oil production support craft, may be expected to significantly increase the levels of crossing traffic and generate situations similar to those simulated. The mariner responses to these situations were, in many cases, erratic and involved excessive maneuvers which are by nature in direct conflict with the purpose of the Traffic Separation Scheme.

The differences between masters of tankers and containerships seems to be directly related to each vessel type's inherent maneuvering capabilities. Tanker masters exhibited more conservative behavior in response to the complex traffic situation, and a greater number of out-of-lane excursions were seen to result. Containership masters were less consistent in their choice of maneuvers and therefore can be said to be less predictable in collision avoidance response, and they did not depart the traffic lane as frequently.

What is readily apparent from these differences is that areas of the routing scheme in which perturbations to the normal traffic flow can be expected to occur with regularity (due to a moderate density of crossing traffic for instance) dictate that adequate maneuvering freedom be available beyond the boundaries of the traffic lane. These areas, wherein a vessel may be compelled to maneuver outside of a traffic lane to comply with the navigation rules in a traffic encounter situation, must be identified early so that guidelines for the siting of objects near the lanes may be developed. While the location of a structure or stationary exploration vessel near the lanes in such areas is not a severe hazard by itself, the infringement on maneuvering freedom outside of the lane boundaries is seen as a contribution to an increased hazard in ship/ship encounters by creating a restricted waters area in what might have been considered previously as open sea.

7.4.3 DRILL SHIP/PLATFORM SITING AND BUFFER ZONES

Both the simulation experiment and the post-run debriefing support the conclusion that with minor differences, masters of containerships and tankers respond similarly to simple arrangements of objects near the established traffic lanes. The minor difference seems to be in terms of distances; acceptable CPA to traffic, passing distances to platforms, etc., are slightly larger for masters of large tankers. The differences noted in performance between these two groups in responding to the drill ship/platform configurations of the Segment B scenarios were usually a consequence of attempts to achieve the required distance parameters. Hence, where we find a tanker master navigating the vessel in a large deviation outside of the channel more frequently than the containership masters it is likely that the small excess in passing distance requirement of the former cannot be achieved within the one mile lane-width (in the opinion of the tanker masters).

As a general observation we can say that the effect of the fixed object on the lane edge perturbs the traffic flow within the TSS. The effect is to constrict the lane width abeam of the object or to offset the lane in its entirely, away from the object. The inclusion of the 500 m Buffer Zone serves to reduce the perturbation effect, but does not completely eliminate it. A larger dimension Buffer Zone would seem to be the answer. However, the determination of just what buffer zone width is necessary to eliminate this perturbation of traffic flow has not been answered definitively by this study. If the subjective answers to the debriefing questionnaire are valid, then distances up to 1 nm

(2,000 m) must be considered. It is the opinion of simulation and operational marine experts associated with this project that stationary objects of a permanent or temporary nature can be located within 1,000 m of the edge of a lane, only if additional mitigating measures are enacted. These additional measures are discussed in Section 9, Conclusions and Recommendations.

The arrangement of parallel "gated" objects straddling the traffic lane elicited the same response from the experienced ship masters. The choice was between a large course deviation around the gated configuration (which would take the ship a substantial distance outside the lanes), or navigating through the gate and maintaining the lane centerline as closely as possible to provide an equal yet less-than-satisfactory passing distance to either side. The choice was nearly unanimous for the latter course of action indicating a uniform acceptance of the risk by all but one of the mariners.

Under these circumstances it is impossible to assign any benefit to the inclusion of a Buffer Zone in the second example (B7) as a result of the performance data. Yet the reluctance with which many of the subjects negotiated the gated arrangements under severe visibility restrictions irrefutably supports the logic of the additional margin of safety (1000 m) provided by the Buffer Zone in this extreme example. If mariners are resigned to passing through the gate, it should be as wide as possible.

A Buffer Zone of some dimension provides a measurable contribution to the safety of navigationin a traffic lane of one mile width. The decrease in frequency of course deviations exhibited in this context smoothes the traffic pattern more in keeping with the intent of the TSS. However, the threshold of zone-width at which fixed objects will have the same effect on vessel traffic as no object at all, has not been determined. Since these results are for vessels navigating in or near the middle of a one mile wide traffic lane it may be hypothesized that the 500 m width Buffer Zone is sufficient to eliminate perturbations if the master chooses to navigate nearer the opposite lane-edge in general practice. This assumption precludes the siting of fixed objects on both sides of a traffic lane in order to prevent performance characterized by slaloming back and forth across the lane.

It is safer to assume normal transits maintaining position in the center of the traffic lane. The objective of eliminating slight course deviations away from lane-edge sited objects could only be met by the establishment of Buffer Zones of greater than 500 m width on either side or by increasing the dimension of the traffic lane itself alone or in conjunction with a Buffer Zone. Either approach would have the same effect.

CHAPTER 8

CONTINGENCY RESOURCE ANALYSIS

8.1 OIL SPILL RESPONSE

8.1.1 FEDERAL AND STATE PLANS AND CAPABILITIES

Both the Federal and State governments have provided for coordinated action on behalf of their agencies to try to prevent discharges of oil and to protect the environment from damage when discharges occur. The Federal plan covers spills of any size while the State plan addresses only (major) pollution incidents.

a. Federal Plan. The Plan provides for a coordinated, on-scene Federal response to all oil discharges through a single agent, the On-Scene Coordinator (OSC), a U.S. Coast Guard officer. The OSC for Santa Barbara and Ventura Counties is headquartered in Santa Barbara. He has been delegated all necessary authority to carry out his responsibility and has a small staff assigned. He is supported by all other Federal agencies through the Regional Response Team chaired by a Coast Guard official in Long Beach, and by the National Response Team in Washington, D.C. A National Strike Force of specially trained experts with special equipment is also available. The OSC has an extensive Local Plan that addresses oil spills of all types in the Santa Barbara Channel. His Plan is supported by both a Regional Plan and a National Plan.

b. Federal Responsibilities and Capabilities. In the event of a discharge, the OSC first determines if the spiller is taking prompt and proper action to remove the discharge (or threat thereof). If so, the OSC monitors progress and provides advice. If not, or the spiller is unknown, the OSC will immediately begin a Federal response action in accordance with his Local Plan. This can involve any and all of the following:

(1) Use of Coast Guard resources and those of other Federal agencies.

(2) Utilize National Strike Force experts and equipment.

(3) Hire private contractors or oil spill response COOPs.

In the Santa Barbara Channel, the Coast Guard and Federal government has immediately available about one mile of harbor boom, two skimmers, and several vessels located primarily in the Port Hueneme area. An extensive communications network is also in place. Additional quantities of boom, skimmers, vessels, helicopters, communication equipment, and manpower are available in the nearby Los Angeles-Long Beach area. The Pacific Strike Team (an element of the National Strike Force) located in San Francisco can dispatch men (pollution and salvage experts) within two hours and special equipment (4,000 feet of high-seas boom, a high-seas skimmer, six cargo-transfer pumping systems, and diving equipment) within four hours. All Pacific Strike Team equipment is air and truck transportable, but vessels would have to be obtained to move the equipment to the spill site. Additional equipment is available from other National Strike Force locations and from the Navy Supervisor of Salvage in Stockton.

c. State of California. The State Plan provides for a coordinated, on-scene State response to a "pollution incident" (a major spill) through a single agent, the State Agency Coordinator (SAC), a Department of Fish and Game official. He is headquartered in Sacramento and has been delegated all necessary authority to carry out this responsibility but has no staff assigned. He is supported by all other State agencies through the State Support Team in Sacramento. In the event of a pollution incident, the SAC works in close cooperation with the Federal OSC to ensure a coordinated response action. If a "pollution incident" has **not** been declared by the State, each individual agency carries out its legal responsibilities in State waters in cooperation with the Federal OSC. The individual State Agency concerns relate to the prohibition of the discharge of oil and the protection of fish and wildlife. The Department of Fish and Game, the various Regional Water Quality Control Boards, and the State Lands Commission are involved. The State owns no oil spill cleanup equipment in the Santa Barbara Channel area, but may contract for cleanup services, if needed, although funds are limited. The Department of Fish and Game has a bird cleaning station that may be delivered from San Francisco.

8.1.2 LOCAL PLANS AND CAPABILITIES

Local plans and capabilities for response to an oil spill associated with offshore activities or shipping, in addition to Federal (U.S. Coast Guard, etc.) and State resources, fall into three categories. These are:

- on-scene equipment;
- spill response cooperative equipment and resources, and existing contingency plans;
- contractor equipment and resources.

The California Coastal Commission has undertaken a separate evaluation of the oil spill response capability extant in California offshore waters. The evaluation includes industry, contractor, and cooperative capabilities. It covers contingency planning at the Federal, State, and local levels, as well as industry and spill response cooperative planning. The evaluation includes a review of the available spill response equipment and its potential performance in the waters of California. Finally, the evaluation includes a review of the cooperatives and industry responses to a number of hypothetical spill cases provided by the Coastal Commission. This work was initiated in August 1980 and is scheduled for completion in February 1982.

8.2 SUPPORT VESSELS

Support vessels in or available to the Santa Barbara Channel fall into three basic categories of:

- supply boats/crew boats
- tugboats
- firefighting or other specially-configured boats.

8.2.1 SUPPLY BOATS

Supply boats are used to transport various materials and equipment from supply based on the mainland to offshore drill ships, rigs, or platforms. These boats are generally between 150 and 200 feet in length, configured with a large open deck space aft, and several tanks for liquids such as water or fuel. Supply boats travel in the speed range of 12 to 14 knots.

To support the existing platforms and drilling operations in the Santa Barbara Channel, there are currently (late 1980) sixteen to twenty supply boats operating out of the Port of Hueneme. In an oil spill response situation, supply boats could be useful in some areas a "vessels of opportunity" to transport or tow spill containment or cleanup equipment to the site of the casualty. From Port Hueneme, a supply boat would require the following approximate times for travel to the listed locations:

• Carpinteria	1½-2 hours
• San Miguel Island	4-5 hours
• Point Conception	4½-5½ hours
• Estero Bay	9-10½ hours

These times do not allow for moving of equipment to Port Hueneme to be loaded, for loading aboard, or arrival of personnel. If equipment to be towed imposed speed limitations on the towing vessel, these times could be much longer.

Crew boats travel significantly faster than do supply boats, and transfer personnel to offshore platforms from bases including Port Hueneme, Carpinteria, and Santa Barbara.

It should be noted that due to the economics-driven utilization rates of both supply and crew boats, there are probably no extra boats readily available to support spill response operations. Given their availability, supply and crew boats could be used to assist spill response operations such as boom towing and deployment, spill tracking, skimmer operation, carrying of oily waste storage tanks, or other activities. As the number of drilling rigs/ships and platforms in the Santa Barbara Channel increases, the number of supply and crew boats will increase, with approximately one to two boats per platform.

8.2.2 TUGBOATS

Tugboats could be used to assist a stricken vessel in the Santa Barbara Channel, such as a ship experiencing propulsion or steering failure. Chapter 6 of this report describes the potential paths of vessels suffering propulsion and/or steering failure at various points in the Channel. The water depth in most of the Santa Barbara Channel prevents effective anchoring of large vessels, so any ship experiencing a power failure would drift with the wind and current until reaching an area of less than about 30 to 50 fathoms (180 to 300 feet). Figure 8-1 illustrates the area of the Channel greater than 30 and 50 fathoms in depth.

Since there are presently several platforms within the area in which a drifting vessel could not anchor, response of one or more tugboats could be necessary.

The nearest tugboats to any area within the Santa Barbara Channel are the U.S. Navy tugs based at Port Hueneme. The Navy has two harbor tugs and one ocean-going tug at Port Hueneme. These tugs are under the direction of the U.S. Navy Construction Battalion Center (CBC) Port Services Officer at Port Hueneme. These tugs could reach areas within the Santa Barbara Channel in roughly the same times as listed above for supply boats.

Further, there is one commercial tugboat normally operating in Port Hueneme by Pacific Towing Company. The characteristics of the Navy and the commercial tugs in Port Hueneme are as follows:

Tug	Length	Screws	Power
USN YTB (2)	110'	Single	2,000 hp
USS QUAPAW (ATF)	205'	Single	3,000 hp
CUYUMUCA	65'	Twin	1,200 hp

Numerous tugboats are available in San Pedro Bay at the Ports of Los Angeles and Long Beach. These tugs are about five hours steaming from Port Hueneme, and therefore, are about five hours further than the times listed above from most points in the Santa Barbara Channel.

There are tugboats available in the San Francisco Bay, about 17 to 18 hours steaming time from Pt. Conception. Further, there are a number of small tugs available in Morro Bay, about five hours north of Pt. Conception, although these tugs are too low-powered for one to be capable of controlling a large ship drifting without power under the influence of wind and current.

Lastly, if an LNG terminal is constructed at Little Cojo Bay near Pt. Conception, this facility will have several high-powered tugboats, at least two of which will be equipped with a towing winch and capable of making up a tow at sea.

The offshore supply boats described earlier are relatively large and powerful vessels. If equipped with a towing bit and if a line of sufficient length is available, these vessels could be used to tow a disabled ship in an emergency situation.

8.2.3 FIREFIGHTING OR OTHER SPECIALLY-CONFIGURED VESSELS

The only fireboats reasonably available to the Santa Barbara Channel area are those based in the Ports of Los Angeles and Long Beach. There are four fireboats in the ports, all with capability in excess of 5,000 GPM (gallons per minute), with the largest being the 18,500 GPM fireboat No. 2 in the Port of Los Angeles. These boats are about 3½ hours steaming time from Port Hueneme (and correspondingly about 7 hours from the far western end of the Channel). The availability of these boats, except in situations of major emergency, is questionable, because their departure of the Port area would significantly lessen the fireboat protection available to the harbors.

Aside from the vessels described in the foregoing, a specially configured vessel available for response to casualties in the Santa Barbara Channel is the "MR. CLEAN," owned by the Clean Seas oil spill cooperative. This boat is a 130' long former supply boat, equipped for response to offshore oil spills, and on standby 24 hours a day at Santa Barbara harbor. The characteristics of the vessel "MR. CLEAN" are as follows:

– length	130'	– beam	36'
– horsepower	1,700	– screws	twin

The equipment to be installed or carried aboard is:

- Cyclonet 100 skimmer and associated equipment
- Vikoma Seapack
- Expandi 43" boom, 2,000 ft
- Goodyear 12" x 24" boom, 1,200 ft
- Komora skimmer (for use in boom containment)
- Floating Storage bag (6,000 gal Dracone)
- Small skiff with outboard motor
- Surface dispersant spray unit
- Separation system 10' x 12'
- Miscellaneous sorbents
- 100 bbl tanks (if additional storage required)
- 10 bbls dispersant

8.3 OIL SPILL PROBABILITY AND TRAJECTORY ANALYSIS

Since a principal reason for establishing a risk management program for vessel traffic and oil platform/drilling operations in the Santa Barbara Channel is ultimately the prevention of oil spills, this section presents a brief summary

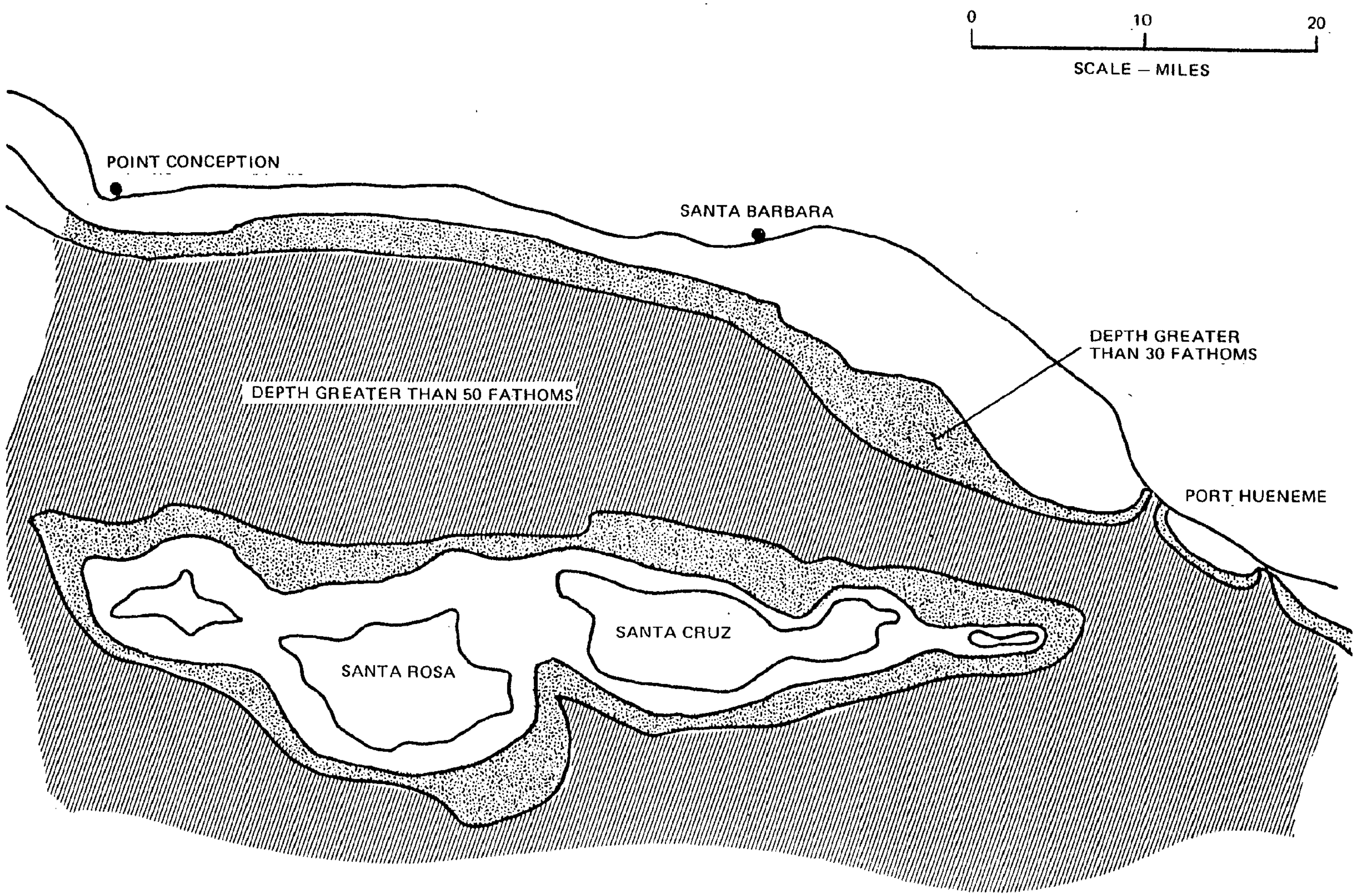


Figure 8-1. Area of Santa Barbara Channel with Water Depth Greater Than 30 and 50 Fathoms

of work which has been done in analyzing the probability of oil spills and spill trajectories in the study area. This section is, in some respects, similar to Chapter 5 of this report, in which vessel casualty statistical data are presented.

In support of the Environmental Impact Statement (EIS) for the Department of the Interior offshore lease sales, the U.S. Geological Survey (USGS) has completed a spill probability and spill trajectory analysis applicable to the Santa Barbara Channel. This analysis for lease sale 48, which includes leases from previous sales, is described in Reference 46.

The analysis has three major phases:

a. Calculation of probability of an oil spill from existing leases, from the prospsed leases (Sale No. 48) and from tanker operations associated with the OCS oil recovery and with transiting tanker traffic.

b. Calculation, with the aid of a computer model, of potential trajectories of an oil spill originating at each of a large number of possible launch points within the study area.

c. Calculation of the probability of an oil spill impacting a (any) sensitive area, as a function of time after the spill.

These three analysis areas are described below.

Spill Probabilities

The probability of oil spills calculations made by the USGS are based on three major assumptions: (a) realistic estimates of future oil spill frequencies can be based on past OCS experience; (b) spills occur independently of eachother; and, (3) spill rate is dependent on volume of oil produced and handled.

Spill frequency estimates were calculated separately for a large number of subdivisions of the existing lease areas, the proposed lease areas (at the time of the study, lease Sale No. 48 was in the "prosposed" stage), and for a large number of segments of potential tanker routes within and through the study area. Oil resources for the area were estimated based on USGS data. Separate estimates of spill frequencies were made for platforms, pipelines, and tankers. Spill frequency estimates were made for oil spills greater than 1,000 barrels in size. These estimates for lease Sale No. 48 combined with earlier leases are tabulated below.

Expected Number of Spills Greater than 1,000 bbls in Lease Sale 48 Area

	Expected No. of Spills	Probability of At Least One Spill
Tanker transportation only of OCS production	11.6	>0.995
Tanker transportation of Alaskan or foreign oil through study area	16.0	>0.995
Combined tanker and pipeline transportation	14.2	>0.995
Platform spills alone	3.7	>0.96

From this table it may be seen that the majority of potential spills arise from transportation of the crude. Platform spills alone account for only 20 to 25 percent of the potential for spills.

Supporting the above type of calculations, BLM has developed statistics from historic experience, as tabulated below:

Historic Spill Occurrence Rates

	Spills Greater Than 1,000 bbls[1]	Spills Less Than 1,000 bbls[2,4]
Platforms	0.0018/million bbl produced	0.000045/bbl produced
Pipelines	0.0023/million bbl transported	0.000015/bbl transported[3]
Tankers	0.0036/million bbl transported	0.000346/bbl transported[3]

(1) Reference 47, Table 2.

(2) Reference 47, Table 3.

(3) Reference 47 states "produced," which has been changed here to "transported."

(4) *It is noted that the spill rates listed for spills less than* 1,000 bbls, although correctly reproduced from Reference 47, are obviously in error, possiby by a factor of 10^4.

Spill Trajectories

The U.S. Geological Survey has developed an oil spill risk analysis model to aid in estimating the environmental hazards of developing oil resources in Outer Continental Shelf (OCS) lease areas. This large, detailed, computerized model analyzes.the probability of spill occurrence, likely paths of the spills, and locations of recreational and biological resources which may be vulnerable. The analysis implicitly incudes estimates of weathering 'rates, slick dispersion, and possible mitigating effects of cleanup.

The probability of spill occurrence is estimated from information pertaining to the volume of oil expected to be produced and the anticipated method and distance of transport. Spill movement is modeled in a Monte Carlo fashion with a sample of 500 spills per season, each transported by monthly currents and winds sampled from wind transition matrices. These matrices, based upon historic wind records and encompassing 41 wind velocity states (eight compass directions by five wind speed classes plus the calm condition),constructed for each season for up to six wind stations. Locations and monthly vulnerabilities of up to 31 categories of environmental resources are digitized within an 800,000 km^2 area. Coastlines can be divided into 100 segments to further define those areas likely to be impacted. Output of the model includes tables of conditional probabilities of impact (i.e., the probability of hitting a target, given that a spill has occurred), as well as the probability distributions for oil spills occurring and contracting environmental resources within 3, 10, 30, and 60 days.

The model provides the Department of the Interior with a method for realistically assessing oil spill risks associated with OCS development. So far, it has been used for analyzing oil spill risks for eight OCS lease sales, and the results have been incorporated into several environmental impact statements. A "real-time" version was also used to forecast the movement of the Argo Merchant oil spill.

Trajectories of 500 hypothetical oil spills were simulated in Monte Carlo fashion for each of the four seasons for each of 71 locations in the lease area (representing potential starting locations for spills arising from both the production and the transportation of petroleum), yielding a total of 142,000 trajectories. Depending upon its shape, each potential spill source was represented as either a single point (e.g., a small lease area), or as a straight line with the potential spills uniformly distributed along the line (e.g., a transportation route). Surface transport of the oil slick for each spill was simulated as a series of straight line displacements of a point under the joint influence of local and seasonal wind and current on the slick for a three-hour period. The local wind transition probability matrix was randomly samples each period for a new wind speed and direction, and the current velocity was updated as the spill changed location in the velocity field. The wind drift factor was taken to be 0.035 with a drift angle of 20 degrees.

The final product of trajectory model runs consists of a large number of simulated oil spill trajectories or pathways which collectively reflect both the general trend and variability of winds and currents, and which can be summarized in statistical terms. It should be emphasized that these trajectories represent only hypothetical pathways of oil slicks and do not involve any direct consideration of cleanup, dispersion, or weathering processes which would determine thequantity and quality of oil that may eventually come in contact with biological populations or other important resources.

The four time periods were chosen to represent the following milestones following an oil spill:

3 days — most of the toxic fractions of the oil will evaporate or dissolve

10 days — sufficient time exists for cleanup measures, such as booms across estuaries, to be employed,

30 days — most of the oil spill will have dissipated,

60 days - the oil spill will probably not be detectable.

The model was designed in a modular fashion, so that it can readily incorporate advances in oil spill modeling techniques. At present, three broad areas of oil spill research are being examined for possible improvements to the model: oil spill spreading and decay, oil spill occurrence, and oil spill damage.

An explicit calculation of oil spill spreading and decay would be a highly desirable addition to the model. (The model employs an implicit scheme for treating oil spill spreading and decay by noting, for each trajectory, the simulated elapsed time between oil spill occurrence and first contact with a target. Thus, the likelihood of an oil spill contacting an environmental resource within, say, three days—before the toxic fractions evaporate or dissolve—can be estimated.) However, besides the inherent difficulty of theoretically describing the long-term behavior of large oil slicks at sea, there are formidable problems in obtaining the necessary data for application of oil spill weathering theories. For example, a model of oil spill decay would require knowledge of specific oil characteristics unknown in untested OCS areas.

Estimation of oil spill occurrence probabilities is an important issue when the model is applied to OCS development plans, as these probabilities are critical in comparing alternative transportation plans. Furthermore, a satisfactory probabilistic treatment of the volume of oil spilled will be needed to estimate spreading and decay effects.

Today, the probabilities of oil spill contacts which are calculated by the model are only an intermediate step in assessing oil spill damages. Additional research is needed to link the model more directly with damage assessments, by using vulnerability indices and similar tools.

A modification currently being implemented in the model is the use of each tract in a potential lease sale as a postulated launch point for an oil spill, rather than groups of tracts as has been used in simulations to date. This more detailed capability is expected to provide greater capability to identify tracts from which a spill would produce a particularly adverse impact.

Spill Impacts

The USGS oil spill analysis includes, as is inferred above, consideration of oil spills impacting sensitive areas of biological, recreational, or other resources, and records the number of instances in which a spill trajectory impacts each area, as well as any shoreline segment.

The resultant information from the program is then expressed as the probability of a spill trajectory impacting each sensitive resource or shoreline segment, as a function of time (3, 10, 30, and 60 days) after the spill.

CHAPTER 9

CONCLUSIONS AND RECOMMENDATIONS

Numerous approaches to risk management for vessel traffic using the Santa Barbara Channel are possible. This program has examined in detail the various aspects of ship traffic levels, existing and potential locations and densities of offshore oil development, existing navigation practices and aids, and a number of potential additional risk mitigation measures.

The aspect presenting the highest risk exposure to ships transiting the Channel is that of ramming of an oil production platform or stationary drilling rig. The existing Vessel Traffic Separation Scheme (VTSS) and near absence of crossing vessel traffic (excluding small recreational boats) makes the threat of vessel collision small. The geography and bathymetry of the Channel, plus the excellent radar navigation made possible by the bluff-like coast of the mainland and the peaks on the Channel Islands, significantly reduce the hazard of grounding.

To minimize the risk of ship ramming of an oil-related structure, the ship simulator experiments conducted during this study have shown that the most effective measure is control over the placement of structures relative to the vessel traffic lanes and safety fairways in the Channel. It has been shown that stationary structures located near, but not actually in, the ship traffic lanes will result in evasive maneuvers by ships travelling the lanes. The maneuvers executed by the ship masters are made so as to produce what they deem is a safe passing distance. For platforms located at the very edge of the traffic lane, vessel masters sometimes maneuver to the opposite edge of the lane, and in some cases maneuvered out of the traffic lane on the side opposite the structure. This course was deemed safe by the vessel masters provided there was no obstruction on the opposite side of the traffic lane to prevent such a safe passing. Structures located at the edge of the buffer zone (500 meters from the edge of the traffic lane) produced lesser evasive passing maneuvers, but many ship masters did make course changes to achieve what they considered a low-risk pass of the obstacle.

When presented with a situation in which structures were located at both sides of the traffic lane, either at the edges of the lane itself or at the edges of the buffer zones, the risk was considered somewhat less than acceptable based on occasional deviations outside the lanes, some reductions in vessel speed and the general responses to the experimental debriefing questionnaire. Such a "gated" situation would only be made worse by the presence of additional structures further from the traffic lanes but in the vicinity of the gate.

When presented with situations in which structures were located on both sides of the traffic lane but separated longitudinally along the lane, ship masters often executed an "S" or slalom maneuver requiring several course changes. At longitudinal separation distances of two miles or less, the obstacles were not treated as separate problems to be passed, but were treated as one obstacle requiring a continuous evasive maneuver. Separations greater than two miles along the traffic lane are required before obstacles are considered and treated separately by ship masters.

The overall, prime, objective of the VTSS (the traffic lanes) is to provide for unimpeded ship navigation, in this case through the Santa Barbara Channel, with as few required course changes as possible. In the long term, any situation which causes a perturbation in the smooth vessel traffic flow through the VTSS is undesirable. However, in the short term, such as the temporary presence of a drilling ship or rig near the traffic lanes, the study has shown that passing maneuvers may be made safely, provided that there is sufficient clear maneuvering space to effect the pass. No obstacles should be in the traffic lanes themselves, but temporary drilling activities may take place in the buffer zones; the study experiments confirmed that such situations do not pose unacceptable risk if there is open sea in which to maneuver past safely. This situation is analogous to road repair at the edge of your front street. For short periods of time, residents can be expected to maneuver safely past or around the work site, if it is adequately noticed (by signs) and marked (by lights, barriers, etc.). As a permanent situation, however, existing for years, such a road work hazard would be unacceptable, creating a permanent perturbation in traffic flow down the street. There would be an unacceptable probability that, in the long term, one of the neighbors would drive into the hole. For structures near navigable waters, there are adequate rules and regulations regarding noticing of their presence and marking of the structures themselves.

The important factor here is the ensuring of sufficient clean sea space for safe passing of obstacles near the traffic lanes. Based on the experiment results described in Chapter 7 of this report, an approximate definition of the "clear maneuvering space" required in the vicinity of an obstacle near the traffic lanes has been derived. That definition is as follows: For any temporary or permanent structure within 1000 meters of a traffic lane, there should be no other temporary or permanent structure on the opposite side of that traffic lane within 1000 meters of the lane for a distance of more than two miles in both directions along the lane. In particular, this recommendation does not preclude the erection of structures within the Separation Zone subject to this same 1000 m exclusion. This "exclusion" zone will allow vessel masters to execute what they deem a low-risk pass, and will allow them to consider each obstacle on an individual basis. The experiment set conducted on the ship simulator was not extensive enough to support definition of greater longitudinal separations, except that spacings greater than two miles should be provided. Separations of three miles or more are suggested. In the long term, structures should not be placed less than 500 meters from the traffic lanes regardless of the location of other obstacles.

This practice of providing maneuvering room by separation of structures may permit exploratory oil drilling in a planned manner prior to erection of permanent production platforms, while preserving the safety of passing vessel traffic.

A number of other risk management measures were examined in the study. These ranged from a complex, full-time monitoring of vessel positions and associated real-time vessel traffic control to simple additions of aids to navigation or changes in operating procedures. They are described briefly in the following paragraphs.

It is technologically feasible to provide electronic equipment aboard every ship such that the ship's position can be transmitted via sattelite relay or UHF radio link to shore-based statations. At such shore stations, the vessel's position and path could be observed on a full-time basis, and communications made to a ship appearing in imminent danger of a ramming or other casualty. Such a system would be akin to air traffic control systems serving airports today. Its application to ships of the world and the necessary monitoring and communication facilities would be extremely expensive. Further, while the U.S. Coast Guard could, in theory, require most vessels to be equipped with the necessary hardware, it does not have the authority to require compliance with maneuvering instructions sent to a ship while it is on the high seas (not in U.S. waters). Virtually all of the VTSS in the Santa Barbara Channel is in international waters. Other complications would arise, such as language barriers and liability. In summary, for vessel traffic at the low levels, present and projected, in the Santa Barbara Channel, such positive vessel traffic control is unnecessary as well as probably unworkable.

Navigation through the Channel using normal ship's radar and radio direction finding may be accomplished with accuracy and relative ease because of the aforementioned area geography and the existing aids to navigation. The addition of RACONS to offshore structures as an aid in their identification by passing ships was analyzed. RACONS are an electronic device which, when stimulated by a ship's radar, will transmit a signal which highlights the position of the platform/drill ship on a radar scope and positively identify the target in question. The placement of RACONS on platforms/drill ships in the vicinity of the traffic lanes, however, has been determined to be potentially counterproductive. First, existing RACONS are capable of operating only with 3 cm (not 10 cm) radars, thus providing only incomplete coverage. Second the presence of multiple RACONS and multiple stimulating ship's radars is likely to create situations of extreme electronic interference on radar scopes and may even cause platform/drill ship positions to be depicted incorrectly on a radar scope. For these reasons, RACONS have been dismissed as a potential mitigation measure for the present time. More practical, intermediate mitigation measures include the placement of radar reflectors on stationary structures and the presence of communication capability on board drill ships. While platforms and drill ships normally present a good radar echo on a radar scope, it has been suggested that the presence of large radar reflectors would further enhance the radar echo of stationary objects to guarantee their observation.

The potential risk associated with the operation of temporary stationary structures near the traffic lane has been a topic of major concern. The test subjects who participated in the simulator research faced the worst possible (yet entirely realistic) situation. They were not warned ahead of time that the object of the edge of the lane was a stationary drill ship, and due to the reduced visibility, the situation remained ambiguous until they approached within 0.5 nm and the drill ship became dimly visible. While the presence of any temporary object near the traffic lane represents a threat, it has been conjectured that mitigating measures might be invoked to reduce the risk involved, especially in view of the relatively small time that the object constitutes a threat (typically, at most a few months for a drill ship). It must be admitted, however, that such proposed mitigation measures only reduce, and do not eliminate, the risk involved. To mitigate the risk associated with temporary structures operating within 500 meters of the traffic lane, the CAORF staff considered recommending that a radar in operation on board 24 hours a day with a qualified radar observer on duty to observe passing ships. This same observer would have been required to have immediate access to VHF radio communication equipment to permit the contacting of ships, as required, which are entering potenially dangerous collision situations. Communication of this sort was expected to provide critical information to passing ships and thus reduce excessive maneuvering on the part of navigation officers in an ambiguous situation. The qualificationss of the individuals on the temporary structures who would have performed such observations/communications tasks, as well as the operattional procedures to be employed, were to be left to the U.S.Coast Guard for specifications. However, in view of the lack of objective data to support the proposed recommendation, and in view of the fact that such mitigation measures would at most reduce and not eliminate the associated risk, this recommendation is specifically not made. Further study should be made to investigate the sufficiency of these proposed mitigating measures and their application to temporary structures located closer than 500 meters to the traffic lanes.

Additional information concerning the movement of drill ships and the placement of platforms can be accomplished via radio communication. The U.S. Coast Guard currently utilizes VHF channel 22A, the "Marine Information Broadcast" to provide information on navigational aid discrepancies, local hazards, etc. Broadcasts are repeated at 1 to 2 hour intervals. Given the difficulties which a ship may experience in receiving its "Local Notice to Mariners" publications, this radio broadcast would serve as an ideal form in which to provide data concerning drilling activities and platform construction in the Channel area.

Concerning the placement of platforms, there are two issues of concern which were not specifically addressed by the current study. These issues include the placement of structures in the extension of the traffic lanes at the northwest end of the Channel area, and the placement of structures near a fairway such as that leading from Port Hueneme, and its natural extension across the traffic lanes. At the northwest termination of the traffic lanes, there are "unofficial fairways" which extend west and north. These unofficial fairways represent the paths normally followed by ships entering/leaving the Santa Barbara Traffic Separation Scheme. As such, they represent areas of relatively high ship traffic in which ship passage should not be precluded by the placement of fixed structures at some future time. Attention must be paid to avoid disruption of this normal flow of ship traffic to the extent possible. With regard to a safety fairway intersection with the traffic lanes, no fixed structures should be permitted within its natural extension to the far lane to avoid disruption of traffic flowing in/out of the port served by the fairway. In fact, it is recommended that no structures be permitted within 1000 m of either the fairway or its extension to provide a margin of safety for ships maneuvering or "cutting the corner" as they navigate into/out of the port served by the fairway.

The idea of requiring a pilot on board ship during a Channel passage has been raised during this study, and subsequently rejected. The Channel is relatively open and free of navigational constraints. Ship traffic is relatively sparse. The type of mitigation measure required involved, not pilotage, but careful attention to the details of the passage itself. Probably a better approach would be to require the presence of the Captain on the bridge or an additional lookout to improve the detection of all potential collision dangers. The practical difficulty with this recommendation is that of enforcement. With foreign ships in international waters, it would be difficult to require implementation of this recommendation.

Discussions with vessel masters and with mooring pilots sailing the Santa Barbara Channel and other areas of offshore oil-related development have noted that significant problems sometimes occur with construction support vessel traffic. During periods of construction of offshore platforms, a number of vessels and tug/barge combinations are frequently in the area. In the Santa Barbara Channel, erection of structures near the traffic lanes could lead to the presence of other vessel traffic maneuvering near the lanes. In order to minimize the uncertainty of course and action which might be associated with such support vessles, it is recommended that as a matter of operational practice, support vessel marshalling or loitering areas be restricted to a quadrant or two quadrants located away from the VTSS with respect to the site of construction. Such a practice would be possible in combination with such regular practices as the Coast Guard's establishment of safety zones around platform construction sites.

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APPENDIX A

SANTA BARBARA CHANNEL RISK MANAGEMENT PROGRAM STRUCTURE

A.1 DEFINITION OF APPLICABLE RISK AREAS

A.1.1 INTRODUCTION

A major factor in assessing applicable risk areas and risk levels in the Santa Barbara Channel is the amount of oil and gas resources. For this program, OCS energy scenario development projections were based on what the oil companies bid and leased in recent lease sales. The maximum activities development projected 47 platforms by the year 2000. This is miniscule as compared to over 1,600 platforms now in the Gulf of Mexico. However, the projection for the Santa Barbara Channel could be understated. The U.S. Geological Survey recently estimated (Table A-1) that the Channel (to 200 meter depth) has a recovery potential of about 1.5 billion barrels of oil and 1.7 trillion cubic feet of gas. On the other hand, Funkhowser (1),* Chevron vice-president for exploration and production recently stated that while the proved reserves for the Channel are 600 million barrels of oil and 0.5 trillion cubic feet of gas, the potential reserves are 6 billion barrels of oil and 13 trillion cubic feet of gas. The inference was that only the "tip of the iceberg" has been discovered so far. If production ultimately comes anywhere near these figures, it will have a profound impact on the number of drill ships/ production platforms. The region at the west end of the Channel and immediately north of Pt. Arguello have particular promise even to depths greater than 200 meters.

The most obvious risk scenarios for the Channel are ship-ship collisions and ship-platform collisions. Two recent accidents illustrate some of the complexities of these scenarios. First, the National Transportation Safety Board (2) recently reported on the June 1979 accident involving the Liberian Freighter REG. SWORD and the Exxon tanker CHESTER off Cape Code, Massachusetts. The major cause of the accident was judged to be the failure of both masters to properly interpret and use radar information. Fog conditions prevailed at the time of the collision. Contributing factors included excessive speed, failure of ships to communicate with each other, etc. More recently, the Texaco tanker, NORTH DAKOTA, rammed a Chevron platform (3) in the Gulf of Mexico on August 21, 1980. The platform was under construction and was illuminated by four lights. Visibility at the time (4:15 A.M.) was 20 miles. The NORTH DAKOTA is a 27-year-old vessel which had a major pumproom explosion in 1973 with loss of life. Although the age of the vessel and the previous accident are not relevant to this accident, nevertheless these are safety factors which accumulate. Probable cause of the accident in this case was human error.

Since human error is the cause of about 85 percent of maritime accidents, major emphasis must be put on reducing or controlling human error. It is sobering to note that one major accident in the Santa Barbara Channel with release of oil, LNG, or other hazardous cargo could likely be considered unacceptable.

Baisuck and Wallace (4) under Coast Guard support have recently developed a framework for analyzing marine accidents. Figure A-1 shows the various stages of a typical accident while Figure A-2 shows potential public impacts to reduce or mitigate the effects of accidents.

In a recent study by the National Academy of Sciences (5) on the safety aspects of LNG in the marine environment, it was noted all LNG risk assessment studies performed to date (June 1980) had overlooked credible accident scenarios. This situation has led the Academy to recommend major emphasis on preventing the accident because the phenomena associated with large scale LNG spills is poorly known. Further, response systems, as they exist, have limited capabilities for any type of major marine accident. Reinforcement for this view is contained in a recent report on oil spill response prepared by the International Tanker Owners Pollution Federation for the European Community Organization (6). As the report states, the majority of recovery equipment has failed to operate satisfactorily in anything but moderately calm sea states and has been

*References for Appendix A will be found on page A-24.

TABLE A-1. REVISED ESTIMATES OF OUTER CONTINENTAL SHELF OIL AND GAS RESOURCES (U.S. GEOLOGICAL SURVEY, RESTON, VIRGINIA) (FEBRUARY 1980)

Area (Water Depth in Meters)	Oil (Billion Barrels)			Gas (Trillion Cubic Feet)		
	Probability			Probability		
	95%	5%	Mean	95%	5%	Mean
So. California Bordland 0-200 m	0.2	2.3	0.9	0.2	2.3	0.9
Santa Barbara Channel 0-200 m	0.6	3.0	1.5	0.7	3.3	1.7
Central and Northern California 0-200 m	0	0.8	0.4	0	0.8	0.4
Washington-Oregon 0-200 m	0	0.7	0.2	0	1.7	0.3

shown to be to be effective for only a narrow spectrum of oil types.

A.1.2 MARITIME RISK MANAGEMENT PROCEDURES STUDY

A 1979 report (7) which was prepared for the National Maritime Research Center in response to the Port and Tanker Safety Act of 1978 covered the entire spectrum of risk management including sabotage, response systems, etc. This study scope was more complete from a total systems point of view than the risk management program initiated by the U.S. Coast Guard in 1976. For the Santa Barbara Channel study, the scope must be limited to the appropriate and applicable risk areas, and by both the time frame and funds available. Clearly, then, the focus should be on procedures for preventing accidents rather than later stage elements.

A.1.3 DEFINITION OF APPLICABLE RISK AREAS

As previously stated, ship-ship and ship-platform/drill ship collisions are obvious risk areas—but not the only ones which may be significant in terms of consequence impact. Oil spills are an area of risk but are derived from a more primary event.

A.1.3.1 Hazardous Cargo Vessels. Aside from any collision scenario, the vessel itself represents a specific risk area if it carries a hazardous cargo such as crude oil, petroleum products, hazardous chemicals, or LNG. An example of this risk potential is the recent accident in April 1980 (8) aboard the tanker AUSTIN bound from Martinez, California to Long Beach, California when it was disabled by an onboard fire off the coast at San Simeon. Fortunately, the situation was controlled onboard before the ship faced a possible grounding. Explosions or sudden structural failures (aging tankers) can also lead to cargo release. Equipment failures such as steering system breakdown (serious casualties due to such failures have occurred in New York and Los Angeles harbors) can lead to a ship or platform collision. A more subtle failure mode in the era of high bunker fuel prices was recently discussed by Pao (9). He pointed out that some bunker fuels are inferior to those of a few years ago and could lead to engine failure in a shipping lane. In the past, the ship itself has been an underrated risk area.

A.1.3.2 Ship-Ship Collisions. This risk area has many scenarios from an event or sequential event point of view. The current vessel traffic separation scheme and safety fairways supply the framework for exercising various scenarios and determining the measure of risk. Following is a number of potential scenarios that represent credible risk areas. Note that risk is here interpreted in terms of public impact. Under this definition, risk to ship personnel, fishing/recreational boats, etc., is not germane to this study. What counts is the effect of the encounter of this type of traffic on a vessel which could release a hazardous cargo or endanger the public on a passenger vessel.

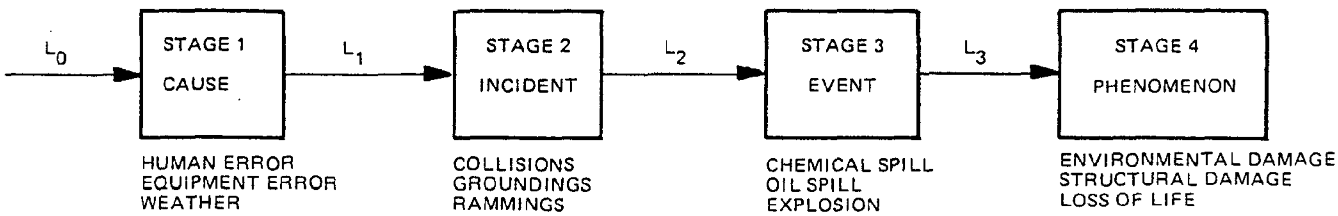


Figure A-1. Stages of an Accident

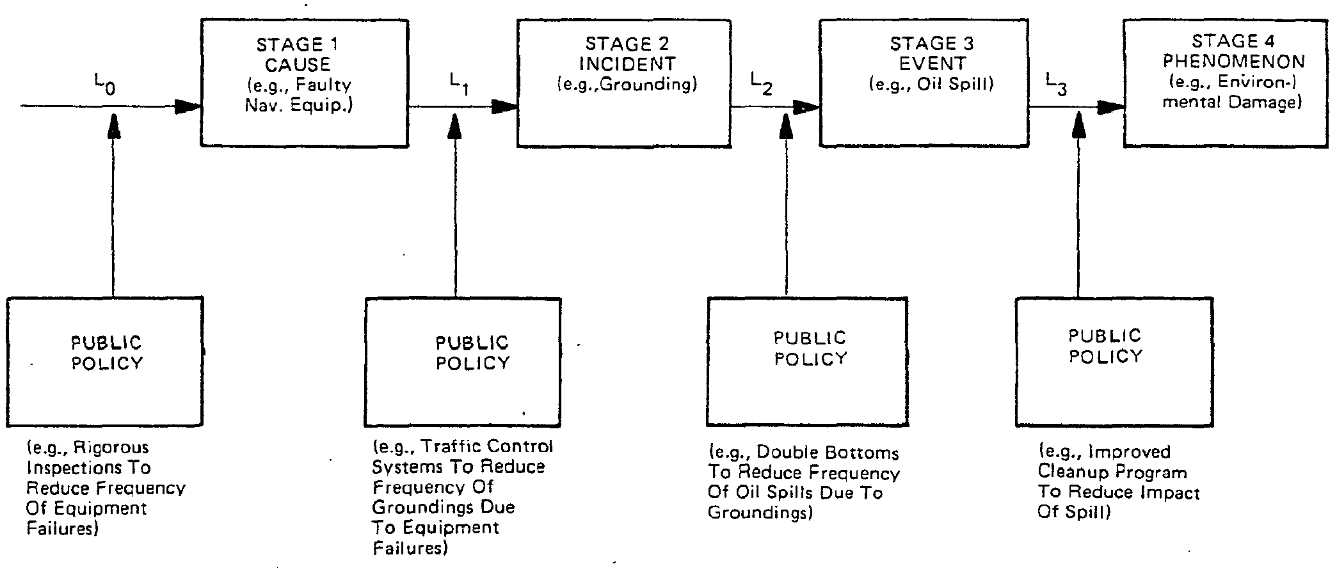


Figure A-2. The Impacts of Public Policy

Some credible scenarios are:

- Two vessels passing – one in wrong lane.

- Two vessels – one overtaking another which has slowed down in a restricted speed zone such as may exist in west end of Channel.

- Two-vessel crossing encounter
  - Ship entering/departing safety fairway
  - LNG carrier crossing traffic lanes
  - Supply boat crossing
  - Fishing vessel crossing
  - Recreational boat crossing.

These are representative scenarios. More complicated scenarios can also occur. An example of a famous complicated event accident in California waters occurred at the entrance to San Francisco Bay in January 1971. This accident involved two Chevron tankers, the S.S. ARIZONA and the S.S. OREGON STANDARD. A chronology of the events is shown in Table A-2. A pre-accident analysis of such an

TABLE A-2. CHRONOLOGY OF EVENTS RELATIVE TO THE COLLISION OF S.S. ARIZONA AND S.S. OREGON STANDARD

Collision: Collision involving the S.S. ARIZONA STANDARD and the S.S. OREGON STANDARD at the entrance to San Francisco Bay on January 18, 1971.

Background: **Dense fog,** 200 to 300 yard visibility. Both vessels were tracked by the **Harbor Radar,** which also **advised** both vessels of the other's passage and intended course.

Notes

1 The ARIZONA bridge officer made some plots of the OREGON's position on his radar screen, but **neglected to plot the associated times.** The OREGON bridge officer **did not maintain a sufficient radar watch** because he was busy with other duties.

2 The ARIZONA master thought he was 175 to 600 yards southwest of the Golden Gate Bridge center span. Harbor Advisory Radar proved that he was actually 900 yards southwest of the center span. The OREGON master thought he was approximately 450 yards due west of the center of the bridge span; Harbor Advisory Radar proved he was 150 yards southwest by west of the center of the bridge. **These errors put the vessels on collision course.**

3 Neither vessel heard the other's fog signals **due to high noise level** created by the diaphone and fog horns on the Golden Gate Bridge.

4 The ARIZONA made several attempts to contact the OREGON via **radiotelephone, but to to avail.**

5 Both vessels were traveling **at immoderate speeds** for the visibility conditions. They could have gone slower and still maintained steerage-way.

6 There is no indication that the ARIZONA appreciated the seriousness of the situation and took any action.

7 The OREGON master saw the ARIZONA on radar at 0.8 mile, and tried to contact it via radiotelephone. However, he **selected the wrong radiotelephone channel.**

8 There is no indication that a passing maneuver was attempted.

9 The OREGON master visually saw the ARIZONA just prior to contact, and ordered engines full astern, but **too late to avoid collision.**

accident would have yielded a very low probability that it could occur since it required a chain probability of individual low probability events. Yet, it did occur.

A.1.3.3 Ship-Drill Ship/Platform Collisions. As previously indicated, the total number of platforms may increase significantly beyond present estimates if the Channel oil potential proves out. The actual number of platforms is not as important as their regional density and proximity to shipping lanes and safety fairways. It is because of this concern that the U.S. Coast Guard (10) established a 500-meter zone around structures being constructed in the Santa Barbara Channel. The example given in the Federal Register notice is platform GRACE which is within 2 miles of the traffic separation lanes. This platform has just gone into production at the rate of 1,000 barrels per day. Peak production of 13,000 barrels daily will be reached in 1984. Other high-priority areas include the Hueneme field near the Port Hueneme fairway, the Sockeye field astride a traffic lane, and production near the likely fairway for the LNG terminal at the west end of the Channel. Figure A-3 shows the location of the Sockeye field astride the northbound sea lane while Chapter 2 of this report shows projections for a substantial amount of drilling and platform activities near or on an extension of the existing traffic separation scheme.

Typical accident scenarios include:

- Ship impacting platform near fairway intersection with sea lane (human error).
- Ship impacting platform near or between sea lanes (human error).
- Ship impacting platform due to evasive maneuver such as close encounter with supply boat.
- Ship impacting platform due to equipment failure.

Within the hierarchy of platform accidents, LNG carriers and passenger ships pose special areas of risks and should be analyzed accordingly.

A.1.3.4 Ship Groundings. Ship groundings can occur due to navigational errors, weather forces, and wave forces (high sea states). Worldwide there have been numerous groundings with subsequent breakup and major oil spills. Even LNG carriers have gounded. The latest (EL PASO-PAUL KAYSER) took place near Gibralter (due to evasive maneuver) in 1979. The double bottom prevented rupture of the inner containment system. It was subsequently offloaded and refloated. New oil tankers such as the 188,500 DWT ARCO ALASKA (used in Alaska to Long Beach run) and the SOHIO-AVONDALE 165,000 DWT class of tankers have double bottoms. However, for some years into the future single bottom tankers will continue to operate in the Channel.

Some typical scenarios include:

- Severe storm grounds tanker (or LNG carrier) on coast.
- Equipment failure causes ship grounding.
- Foreign tanker grounded by navigation error.
- LNG carrier or tanker grounded due to evasive maneuver to avoid vessel or platform.

A.1.3.5 LNG Carrier Operations—West End of Channel. LNG carrier operations is treated as a special area of risk for it carries the highest safety number index of any class of ships. The National Academy of Sciences called for special treatment for these ships in order to prevent an accident which could lead to catastrophic consequences. Table A-3 shows that this class of ship has not been accident free. In fact, in 1979 there were four incidents compared to a total of seven in the previous 15-year period. This is not too surprising since LNG carrier voyages are much more frequent (also there are more carriers) than in the earlier years. Further, some of the new containment designs have yet to prove themselves at sea. The recent difficulties with the Kayser urethane foam system for El Paso LNG carriers built at the Avondale yard is a good example.

The LNG "risk factor" is accentuated by operations in what is likely to be a high density ship operation and platform development in the west end of the Channel. Some typical accident scenarios are shown in Table A-4.

Some typical scenarios from the table include:

- LNG carrier impacted by oil tanker—spill size up to 65,000 cubic meters in about 400 seconds.
- LNG carrier impacts platform—spill size of 33,000 cubic meters (one tank) in about 1,000 seconds.
- LNG carrier grounding—rupture of two tanks with spill of 76,000 cubic meters in 500 seconds.

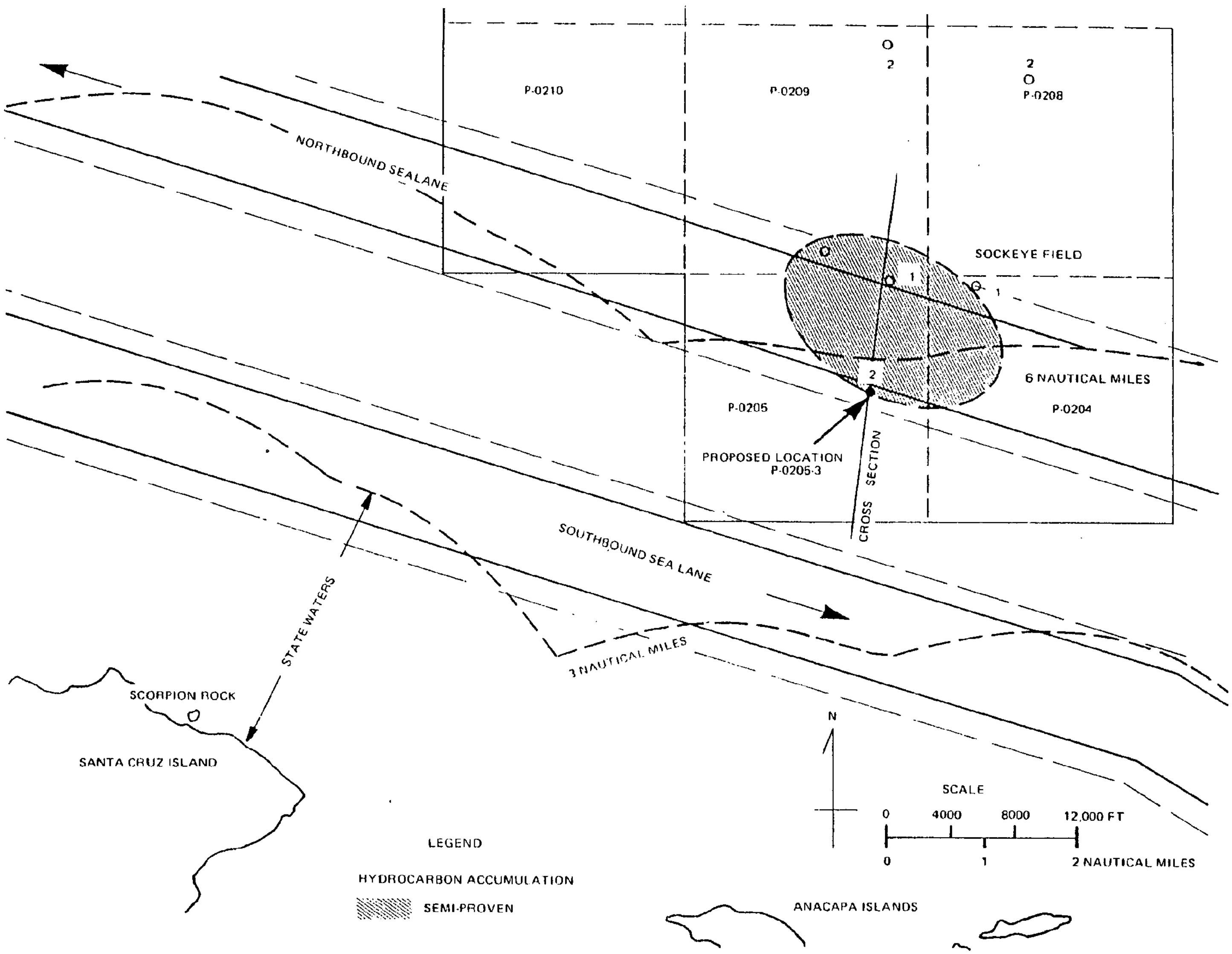


Figure A-3. Location Map Sockeye Field and Proposed P-0205-3 Site

TABLE A-3. ACCIDENT RATES DURING 1967-77

	Oil Tankers*	Gas Ships**
Vessels	3,572	120
Ship years	32,695	696
Accidents	753	5
Accident rate/100 ships at risk	2.3	0.73

*More than 10,000 dwt.
**More than 10,000 cu. m.

Source: Poten and Partners, Inc. from Inter-Maritime Consultative Organization data.

THE SAFETY RECORD OF LNG/LPG SHIPS

Type Incident	Number of Incidents 1979	1964-79	Cargo Leakage	Cargo Fire
LNG				
Collision while underway	0	1	0	0
Struck while moores	0	1	0	0
Contact with stationary object	0	0	0	0
Grounding	1	1	0	0
Explosion/fire on board	2	3	0	0
Cargo spillage	1	1	1	0
Total	4	7	1	0
LPG				
Collision while underway	1	10	0	0
Struck while moored	0	5	0	0
Contact with stationary object	2	4	0	0
Grounding	2	8	0	0
Explosion/fire on board	0	9	0	0
Cargo spillage	0	1	1	0
Total	5	37	1	0

Source: Poten and Partners, Inc. from Lloyd's List data.

TABLE A-4. ACCIDENT SCENARIOS FOR LNG TANKERS

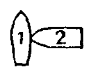
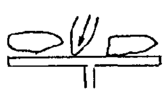
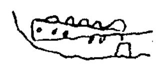
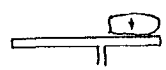
Location	Type Accident	Closing Speed (Knot)	Damage	Spill Volume ($M^3 \times 10^3$)	Spill Character	Spill Time
In Or Near Port Area	Two LNG Tankers 	No. 2 < 5	1-2 Tanks *Fuel Oil	25 - 65	Initial Rate not High	> 400 sec.
	< 90° ± 50°	No. 2 > 5	1-2 Tanks *Fuel Oil	25 - 65	Initial Rate High	< 400 sec.
		< 5	No Rupture	–	–	–
	Angle < 35°	> 5	1-2 Tanks	25 - 65	Tanks Open Immediately	< 400 sec.
	One LNG Tanker One Oil Tanker	Same as two LNGs				
	LNG OIL  Reverse Case	< 5	Oil Only	0	–	–
		> 5	–	–	–	–
	LNG into Oil Rig	Ram > 5	Minor Tank Rupture	33	–	> 1000 sec.
		Broadside < 5	One Tank Punctured Below Surface	33	Hole Underwater	> 1000 sec.
	Stray Ship into Offloading Pier 	< 5	Ruptured Lines Only	~0.1	Function of Line Sizes	< 200 sec.
	Seismic-waves, Tsunami, etc.	Slow	No LNG Rupture	–	–	–
	LNG Ship Sinking	0	LNG Tanks Must Rupture	~165		–

TABLE A-4. ACCIDENT SCENARIOS FOR LNG TANKERS (Continued)

Location	Type Accident	Closing Speed (Knot)	Damage	Spill Volume ($M^3 \times 10^3$)	Spill Character	Spill Time
On Any Shore	Grounding-Broadside 	Any Speed	All Tanks May Rupture on Bottom	~165	Efflux Path Restricted on	15 min. to Hours May Open Sequentially
	Grounding-Head In 	< 5	No Rupture	–	–	–
		> 5	2 Fwd Tanks + Oil	~76	Fwd Tank Fast Efflux Other Slower	1st < 400 sec. 2-3 > 500 sec.
	Offloading Pier Encounter Broadside 	< 5 Adrift	No Lines or Tanks Ruptured	–	–	Probably Stopped by Dolphin Piling
At Onshore Terminal Area	Trestle Pipeline or Equipment Ruptured	–	Both Main LNG Lines Open	1.8 - 3.5	Slow-Mashed Pipe End Drain	> 100 sec.

A.1.3.6 Military Operations. Military and space operations now occur at the Vandenburg Air Force Base. A significant increase in activities including shuttle launches is expected in the next two decades. This activity occurs in the west end of the Channel with most of the launches over water to the south-southwest. A probabilistic risk analysis has been carried out by the Air Force which yielded "acceptable risk" results. Nevertheless, the Air Force receives hold-harmless agreements from oil and gas operators through the Bureau of Land Management. This is a requirement to carry out drilling production operations. Despite the calculated low probabilities, an accident can happen.

Several potential scenarios include:

- Launch debris impact on ship disables ship causing it to impact another ship or platform.
- Ship impacts tow system for shuttle spent stage as it crosses traffic lane for Port Hueneme destination.

Figure A-4 shows the range geometry for shuttle launches while Figure A-5 shows the operational scenario for locating and towing the SRB-2 spend stage to Port Hueneme.

A.1.3.7 Drill Ship/Platform Operations. There are two different areas of risk with drill ship/platform operations. The first is concerned with spills from both the well and the ship if the ship rams the structure. The second is concerned with the drilling/production operation itself. The first type has already been discussed. The second type has been the concern of the U.S. Geological Survey. USGS initiated a risk management program as far back as 1969. The action was triggered by the famous blowout at Union Oil's platform A in the Santa Barbara Channel in January 1969. Although the Channel incident was the first significant oil spill resulting from the drilling of nearly 8,000 wells on the OCS from 1953 to 1969, it brought prompt action to improve drilling and production operations which continue to this day. Passage of the OCS Land Act Amendments in 1978 provided one additional distinctive feature. Namely, the implementation of the Best and Safest Technology (BAST). During the past two years, USGS has been applying BAST by organizing a supporting research program to enhance safety. Implementation of BAST to channel operations is strongly indicated to reduce the risk of oil spills. Figure A-6 shows the BAST procedures as now being applied by USGS (11)

A.2 IDENTIFICATION OF APPROPRIATE RISK ANALYSIS PROCEDURES OR TECHNIQUES

A.2.1 INTRODUCTION-RISK ANALYSIS TECHNIQUES

A variety of risk analysis procedures or techniques have been applied to the determination of the likelihood of ship casualties and the consequences. One class of techniques is based on probabilistic mathematical models. Typically, the assumption is made that ships operate in a random fashion, as in gas theory, and a mathematical function is applied which yields a probability number for the collision. This measure, however, does not deal with the consequence of the collision. Such an approach was used in the Pacific Lighting sponsored LNG carrier operation studies in 1975-76 and recently by Westec in a number of environmental impact reports (marine safety section) dealing with drilling in California state waters. Another recent application of the method was used by Energy Analysts, Inc. (12) for the Pelican Island (Galveston, Texas) oil terminal project. In assessing the risk for the Galveston ship channel, the assumption was made that casualties can be descirbed as occurring in random time and fitted by a Poisson function. Using worldwide casualty data and local accident records, the probability of accidents was measured. Consequence of an accident was determined by a collision intensity parameter using the well known Minorsky relationship. The results of the analysis were used as a basis for determining the safety of the project. It is of interest to note that because of a rash of accidents in or near the Galveston area, the Coast Guard has recommended making (August 1980) the VTS system mandatory along the entire Houston ship channel and environs.

The major problem with the mathematical analysis approach is how to quantify the key human factor variable. Since human error accounts for about 85 percent of marine accidents, the U.S. Coast Guard has **not** seen fit to rely on mathematical models for rule making.

Pizzo et al. (13) in their deepwater port risk assessment study for the U.S. Coast Guard used a number of mathematical techniques. For oil spills, the Poisson function and the negative binomial distributions were considered. Based on the work of the MIT group under Devanney who analyzed oil spills of the eastern U.S. coast and the Gulf of Alaska, the negative binomial distribution was used. This model used a mixture of casualty types each of which behaved according to a Poisson process. Using worldwide casualty data, regression analysis was applied to determine

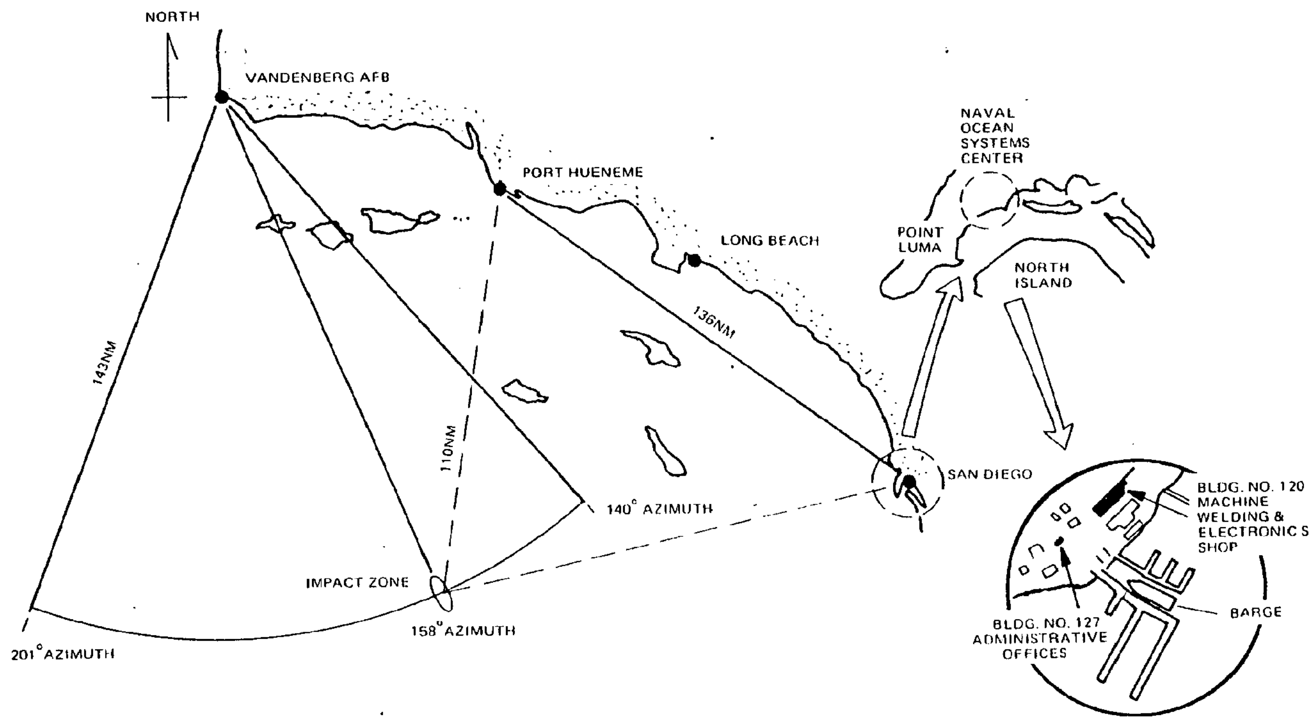


Figure A-4. Range Geometry

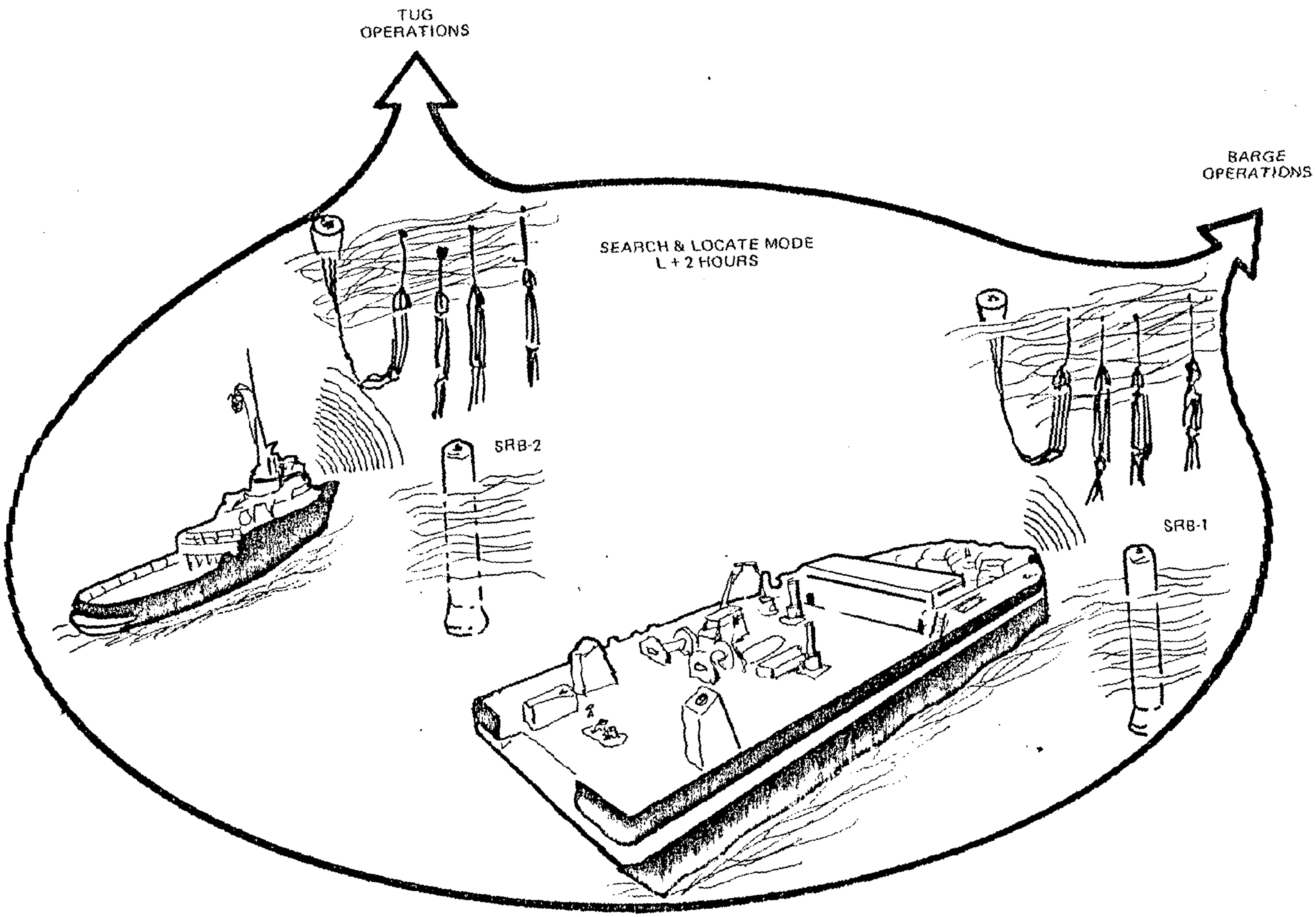


Figure A-5. Operational Scenario

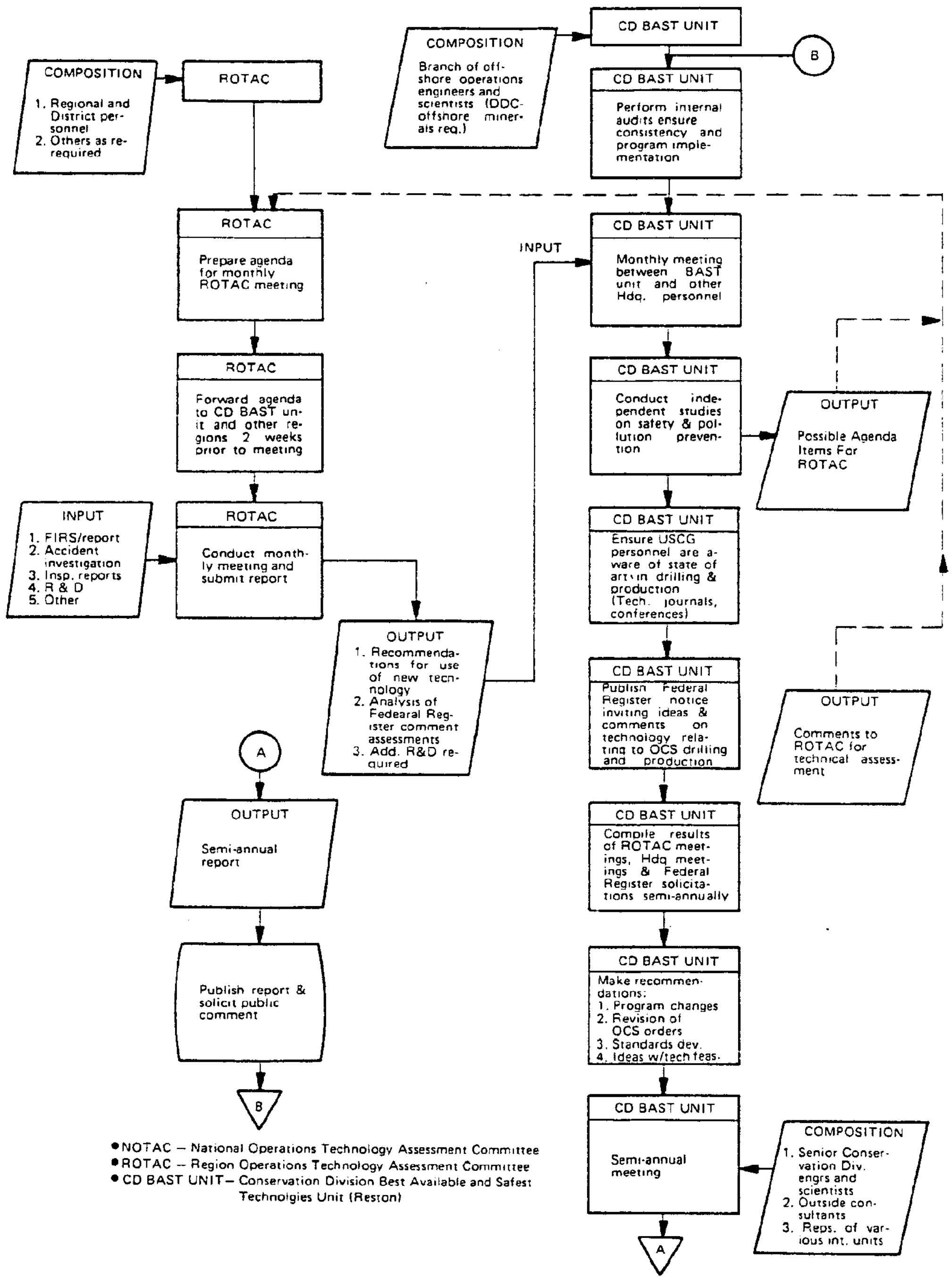


Figure A-6. BAST Procedures Flow

both causal and predictive reasons for vessel casualties, vessel spills, and volumes spilled. Some of the results of this analysis is presented in Section 2.6, the development of the statistical data base. In the deepwater port study, mathematical analysis was complemented by judgment analysis and fault tree analysis. To obtain a realistic fault tree model, available analytical techniques were compared to results obtained from analyzing a set of accidents. The modified fault tree model included the following: (1) inclusion of time dependence, (2) non-binary nature of many accident causes, and (3) grouping techniques for causative factors to reduce complexity.

A differential mathematical approach for calculating a maritime risk criterion number has been presented by der Tak and Spaans (14) of the Netherlands Maritime Institute. The need was generated by increasing traffic in the North Sea and the approaches to Dutch harbors. The analysis is part of the attempt to find the best regulatory solution to the overall traffic problem. Criteria applied included traffic density, course and speed distribution of traffic, and the danger class rating of ships. Rather than base the model on random ship movements, total traffic was partitioned into ship flows in lanes. In each lane, traffic volume was divided into different danger classes. A ship domain (elliptical regions of danger) concept was used in the anlaysis. From this analysis, a traffic simulation model was developed and supplemented by a display system. Criteria numbers were calculated for a number of traffic control methods (such as separation lanes) and checked visually with the computer-generated visual display.

Another strategy for optimizing marine traffic safety has recently been put forth by Goodwin and Richardson (15) of the London Polytechnic Group. This approach is based upon an empirical model using a safety factor index. Essential features of this model are: (1) each ship has a safety number assigned to it ranging from 0 to 6. A low number denotes relatively minor consequences for any casualty while a high number indicates disastrous consequences. Under this model, a large cargo ship was rated a 1, a large tanker a 3, a large passenger vessel a 4, and a large LNG carrier a 5, (2) the total of the safety factor numbers for all ships within a controlled area at any time should not exceed a certain level, and (3) when a ship is within a controlled area, navigational responsibilities would still remain with the ship although a recommended speed might be indicated.

Captain Dan Charter, formerly Chief, Port Safety and Law Enforcement Division, U.S. Coast Guard headquarters, has recently (16) compared a number of "twentieth-century" techniques for determining the risk of collision. In considering the effectiveness of Navaids (particularly collision avoidance aids), he analyzed the results of two major research efforts conducted in the U.S. and compared these results with an investigation carried out by the marine operations unit of the British Liverpool Polytechnic.

The two U.S. studies were: (1) research carried out at the Computer Aided Operations Research Facility (CAORF), National Maritime Research Center, Kings Point, New York, and (2) the offshore vessel traffic management study (OVTM) carried out by the Transportation Systems Center, DOT, Cambridge, Massachusetts. This latter study was mandated by the Ports and Waterways Act of 1978 in regard to a study of positive vessel traffic monitoring systems. Charter compared these two studies because they offered two different approaches to assessing the risk of collision. CAORF offers a ship bridge simulator technique where personnel performance can be measured as a function of the scenarios and availability of different Navaids. The OVTM study examined a broad range of technological devices and systems for preventing tank vessel collisions, rammings, and groundings in offshore waters. To determine the effectiveness of these devices/systems, 34 operational features were evaluated and estimates made of the expected effectiveness of each feature in preventing accidents. Charter compared the casualty analysis of this study to CAORF results in judging the effectiveness of collision avoidance equipment. Application of the OVTM results required judgmental factors because of the small statistical data base.

A.2.2 RECOMMENDATION OF APPROPRIATE RISK ANALYSIS TECHNIQUES

Pure mathematical techniques are not recommended for two reasons: (1) the fact that human error plays such a dominant role in accidents, and (2) mathematical measures of safety are not used by the U.S. Coast Guard in rule making. The recommended techniques are: (1) Study selected scenarios in CAORF using both on-line and off-line simulation, (2) Empirical analysis of the statistical casualty data base using judgmental factors, and (3) Application of fault tree analysis.

A.2.2.1 Computer Assisted Operations Research Simulator. CAORF Simulators are a proven and growing technique for studying human factors under a variety of conditions. Current applications are not only to ship operations but also to cargo handling and even offshore platform operations.

During 1979, CAORF was used to study ship control/maneuverability, grounding/collision avoidance, bridge system design, and training/certification research (17).

In this program, the most appropriate scenarios for the Santa Barbara Channel based on risk area priorities should be examined. The highest priority scenarios are not necessarily all the accidents that may occur. In fact, in the real world of casualties, major accidents have occurred in what might be considered low priority scenarios. This is mainly a factor of unpredictable human error. Finally, cost considerations preclude examination of all but a limited number of scenarios.

A.2.2.2 Analysis of Statistical Casualty Data Base—Judgmental. This semi-empirical approach makes use of the data base generated (see Chapter 5) since data for the Santa Barbara Channel is very sparse. A safety factor index system such as used in the deepwater port program (see Figure 5-10 of Chapter 5) and by Goodwin and Richardson of the London Polytechnic states size of ship, class of ship, speed, traffic density, platform/drill ship density, weather conditions, etc., should be used on a weighted basis. Fog is one of the key parameters. A recent analysis of the casualty record in the Dover Strait (18) during 1979 revealed that fog played a major role in six out of the ten collisions which occurred during the first 10 months of 1979, even though traffic was monitored by radar and regular broadcasts were made to ships. Another key factor is vessel speed in terms of collision intensity. For a high risk factor ship such as an LNG carrier, impact speed of a striking vessel becomes an important parameter in terms of damage to the LNG carrier. Figure A-7 shows this relationship. Note that even a 20,000-ton vessel proceeding at a slow 7 knots would still have enough penetration capability to rupture the inner containment system with major consequences.

A.2.2.3 Fault-Tree Analysis. Fault-tree analysis for a select number of scenarios will add insight into the degree of risk as well as examine scenarios not covered by CAORF. These scenarios would include:

- West end channel scenario involving LNG carrier, tanker, and production platforms.
- LNG carrier, safety fairway, and production platforms.
- Vessel grounding due to weather or loss of steering.
- Vessel internal failure such as explosion.

Methods applied will be similar to those used in the U.S. Coast Guard deepwater port study. A good example of the method applied to an accident in California waters is the ARIZONA STANDARD/OREGON STANDARD accident on the approaches to San Francisco Bay in January 1971. Figure A-8 shows the top-level fault-tree for the accident. Shaded boxes indicate an event or condition that applies to the accident. Figures A-9 through A-14 shows the analysis for specific safety factors. For platform events, including ship collisions, a similar analysis applies.

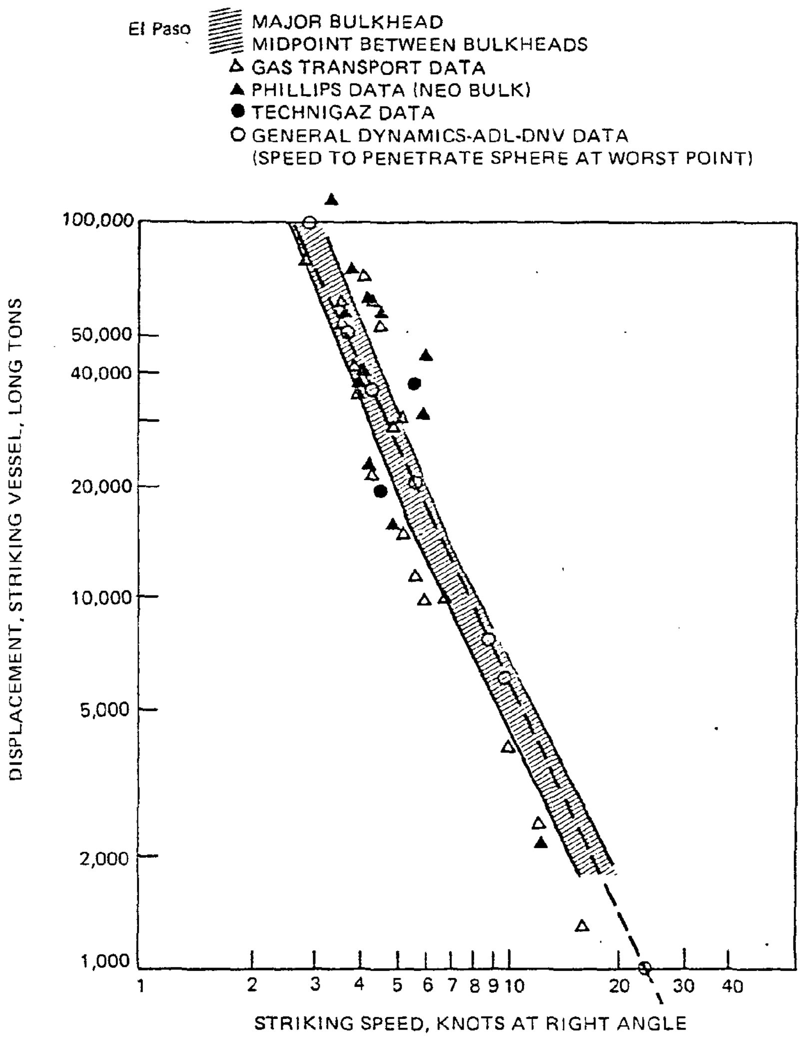


Figure A-7. Striking Vessel Displacement vs. Normal Impact Speed to Reach the Inner Hull of Large LNG Carriers (71,500 – 130,000 m^3)

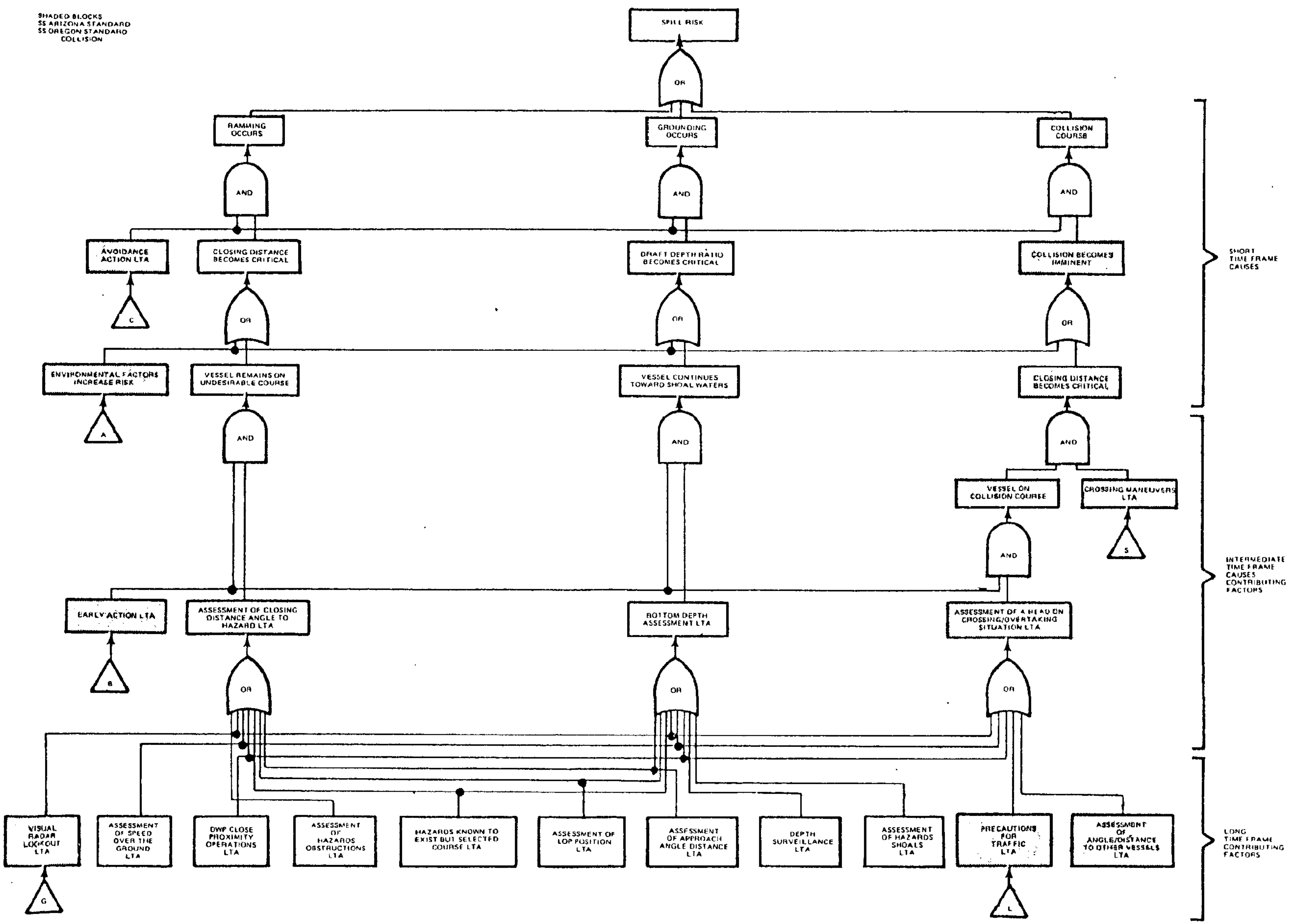


Figure A-8. Top Level Fault Tree

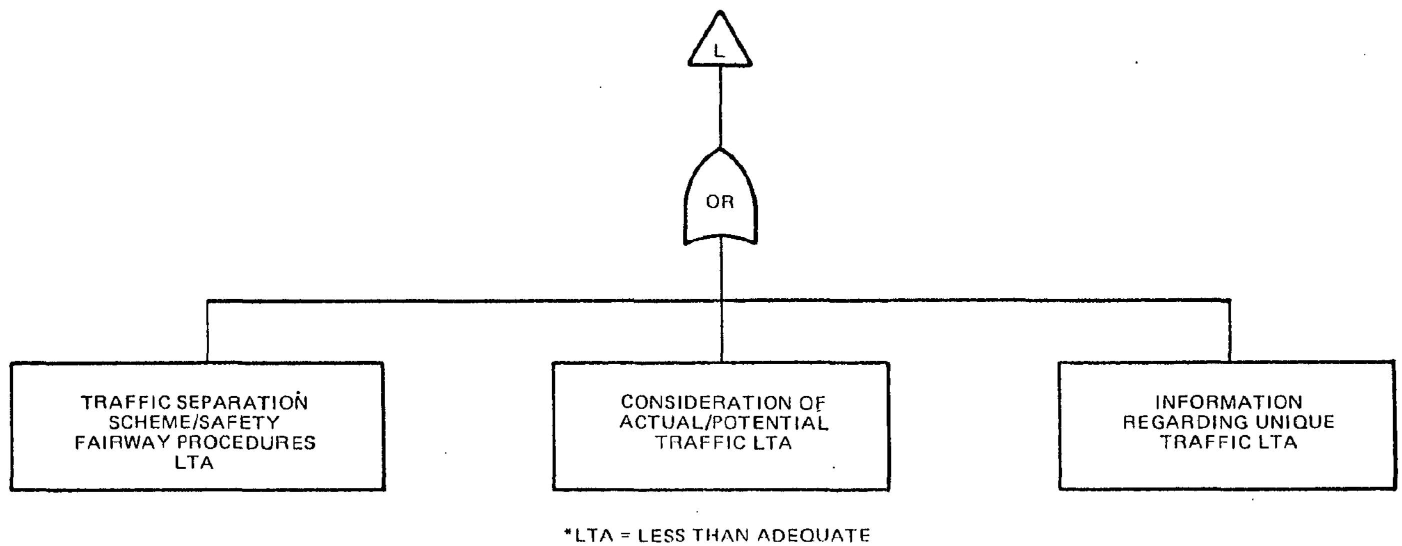


Figure A-9. Precautions for Traffic-LTA

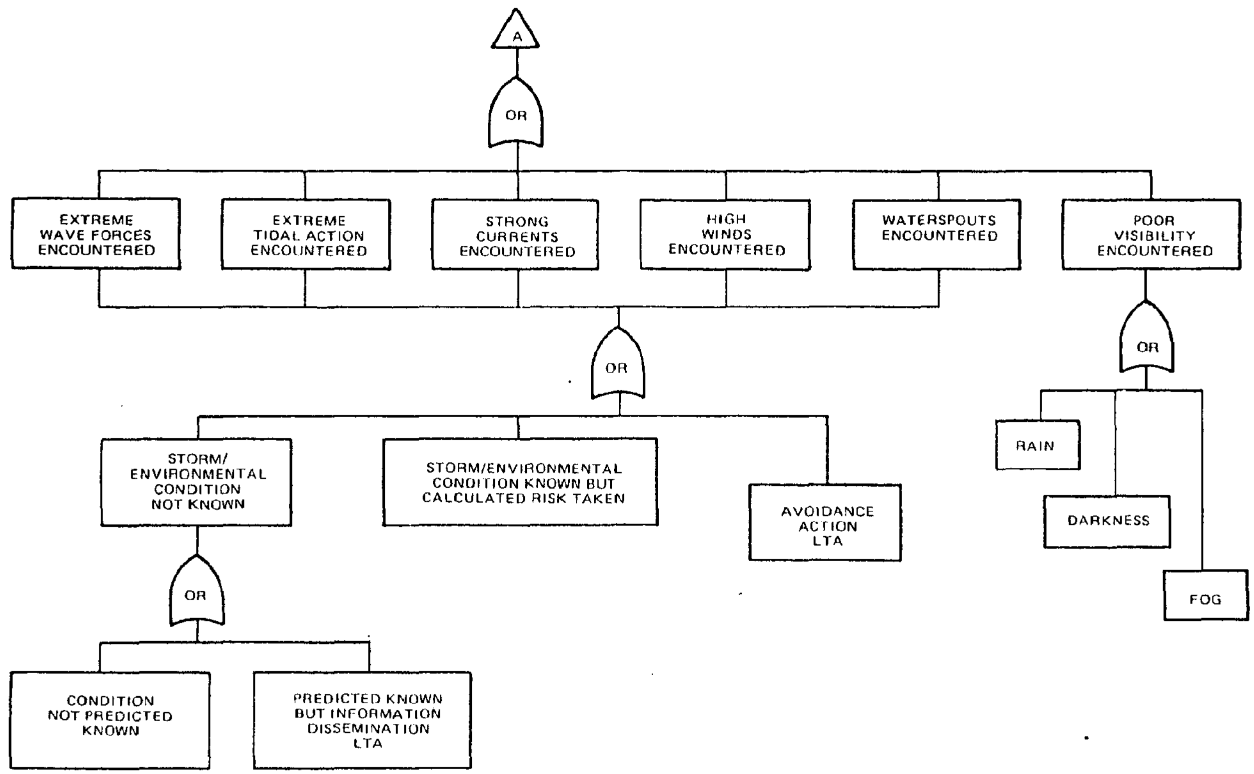


Figure A-10. Environmental Factors Increase Risk

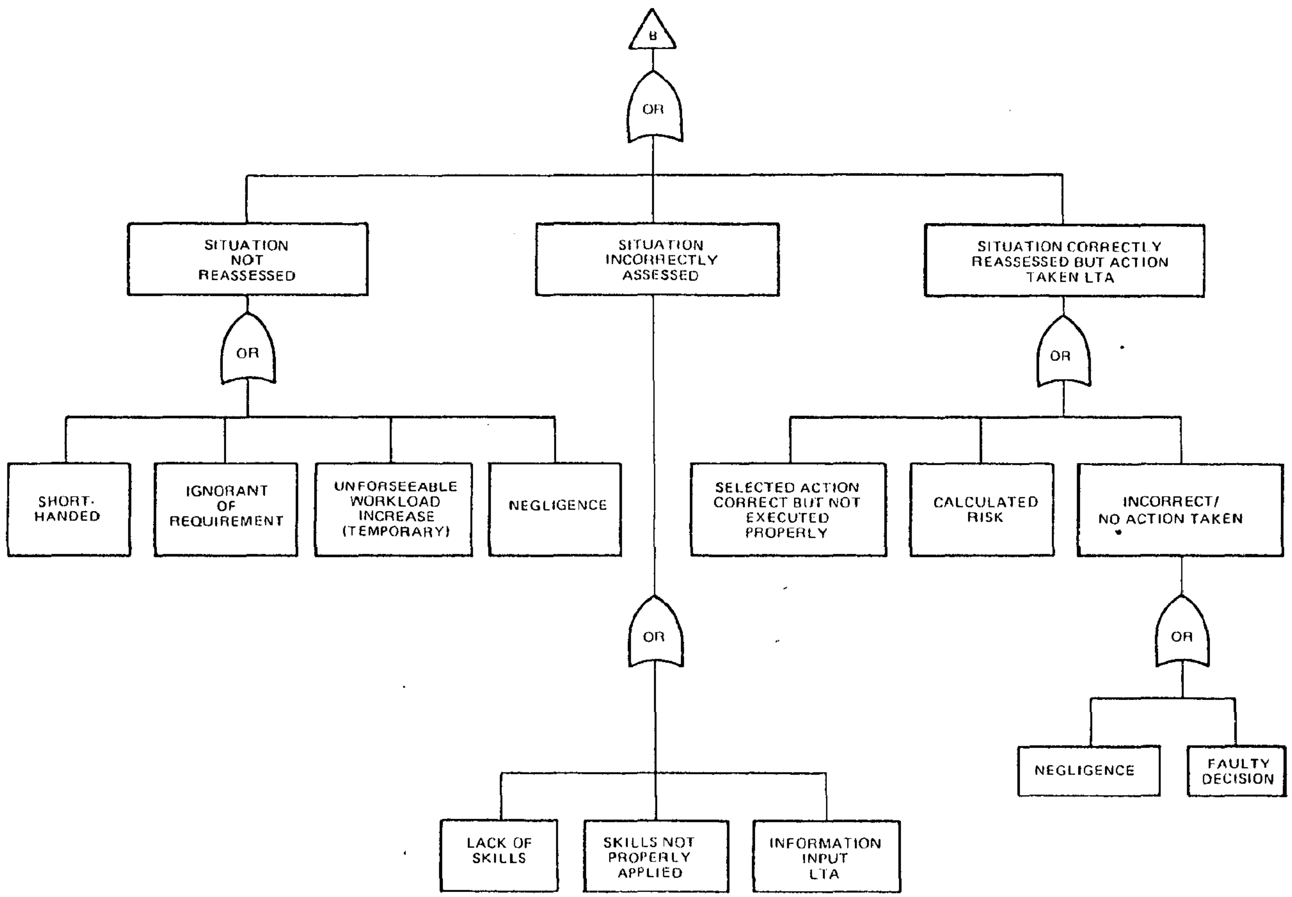


Figure A-11. Early Action-LTA

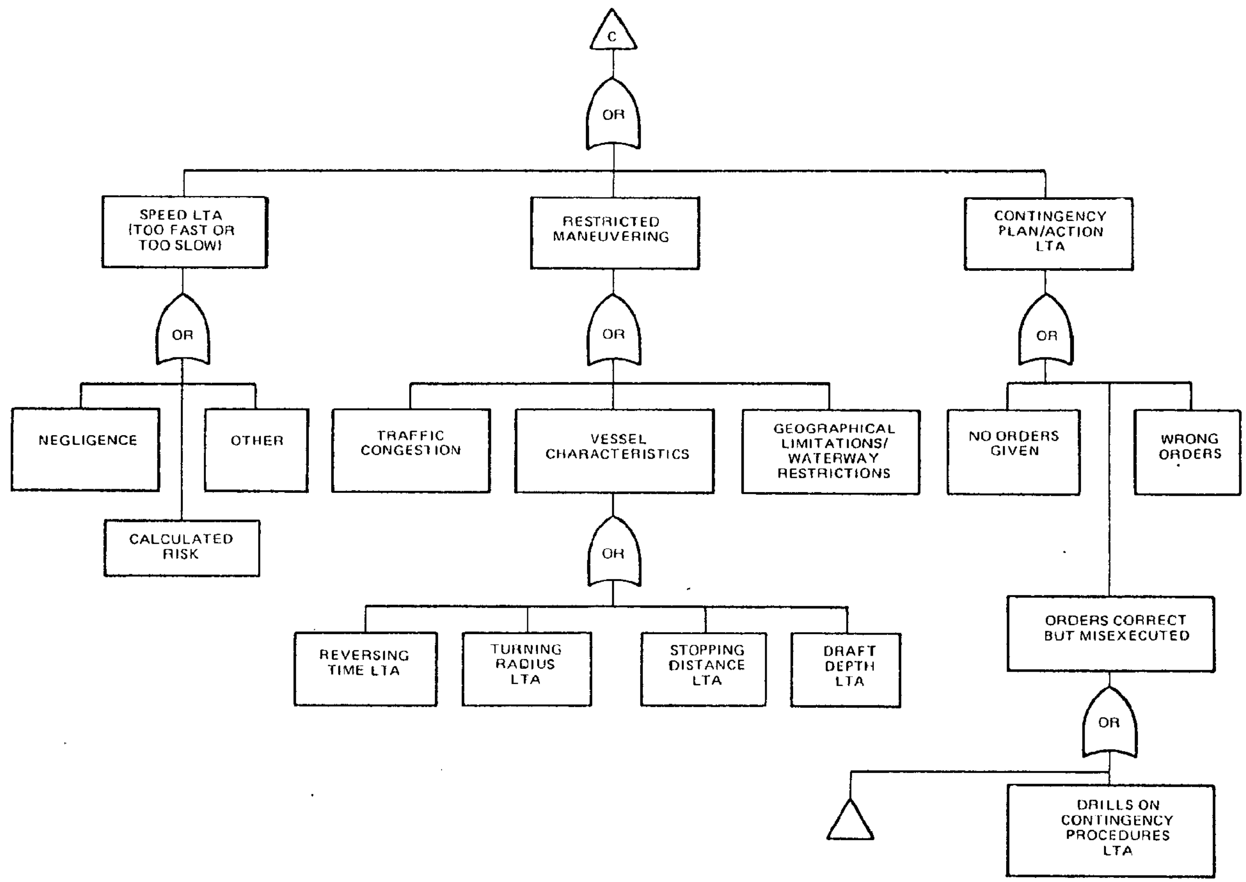


Figure A-12. Avoidance Action-LTA

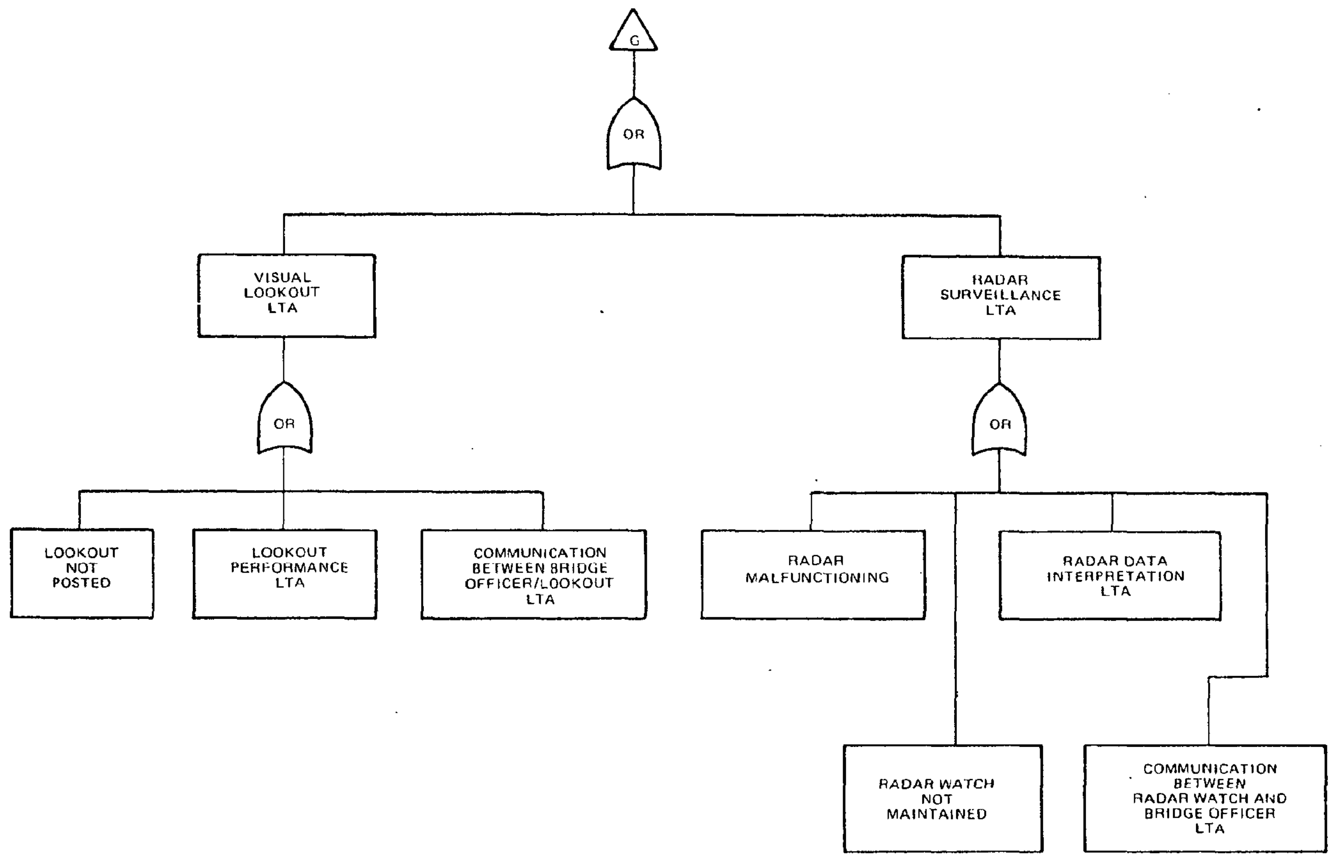


Figure A-13. Visual/Radar Lookout-LTA

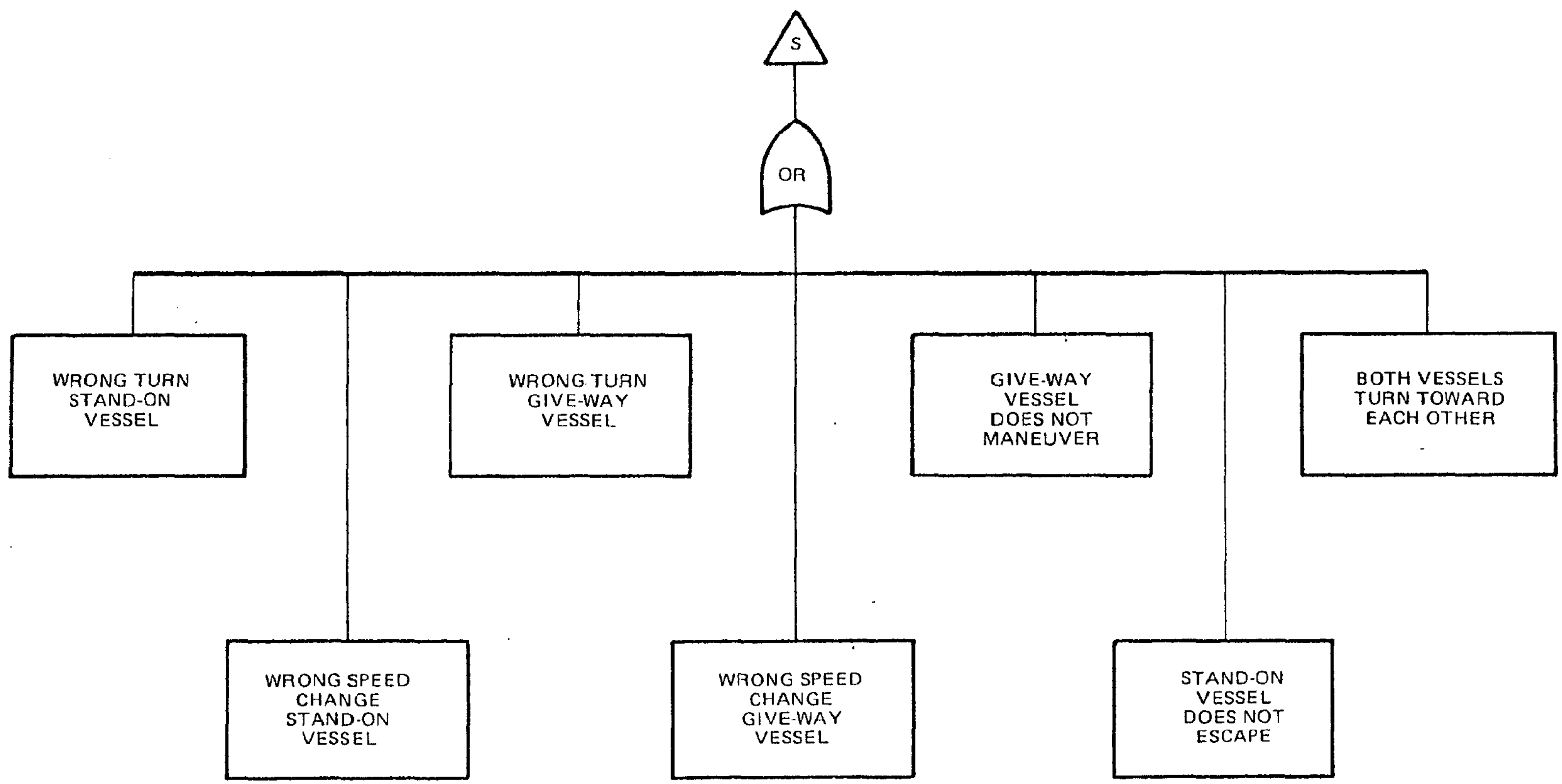


Figure A-14. Crossing and Overtaking Maneuver-LTA

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APPENDIX B

NOTES ACCOMPANYING CHART OVERLAY SCENARIOS

FOR THE SANTA BARBARA CHANNEL RISK MANAGEMENT PROGRAM

B.1 OVERVIEW

The purpose of these OCS Development Scenarios is to determine what kinds of obstacles oil and gas development will create for ship traffic in the Santa Barbara Channel. They are not intended to be a forecast of the future because the actual future number and locations of offshore oil and gas facilities is unknown at this time. Each scenario is merely designed to serve as the realistic but hypothetical basis for experiment sets involving computer simulations of activity in the Channel. Information obtained from the simulations will be used to analyze the risk of ships colliding with drill ships, platforms, and other oil and gas related obstructions in the Channel, and recommend appropriate measures to mitigate the risk. This discussion is to accompany nine chart overlays showing the scenarios.

B.1.1 SCOPE OF THE SCENARIOS

The scope of the scenarios covers all OCS-related activity between 1980 and 2000. However, not all twenty years are portrayed individually. Instead, three separate years are shown on the charts. 1984, 1989 and 2000 were chosen because they represent the peaks in projected oil exploration, platform construction and oil production, respectively. These overlays are, essentially, "snapshots" of activity frozen in time, rather than records of ongoing events. Each chart shows cumulative net development that has occurred up to that point, as well as current constructin or exploration activities. For example, platforms under construction on the 1984 chart appear in the production phase on the 1989 chart. Also, any platforms that may have been built between 1984 and 1989 are on the 1989 chart. Oil and gas development in the state tidelands are not examined in this study.

B.1.2 CONTENT OF THE SCENARIOS

B.1.2.1 Number of Platforms. There are three scenarios. Two are concerned with the most probable number of platforms that are likely to be built. These are both considered nominal schemes. The third scenario deals with the maximum number of platforms that might be constructed. Estimates for both the most probable and the maximum numbers were taken from the Final Environmental Impact Statement written prior to lease sale 48 (1)* and, also, considers the impact of the subsequent proposed lease sales.

B.1.2.2 Placement of Platforms. Although the EIS for lease sale 48 gave possible numbers of platforms, it did not indicate where they would be build. Consequently, a set of criteria was devised for figuring out which tracts in the Channel were the most likely to be developed. This was done by combining different variables such as water depth, bottom conditions and price paid for the tract to see both where the resources might be and where platforms could be built. Background information needed to do this was provided by the U.S. Geological Survey, the Bureau of Land Management and the State Office of Planning and Research.

B.1.2.3 Rate of Construction. A similar technique was used to estimate a plausible rate of construction for each scenario. Both physical factors and lease conditions can influence how soon a given field will be developed. For example, tracts with very deep water will not be developed as soon as those with shallower water. This is because the technology for deep water platform construction is still in the exprimental phase. Therefore, it will be a while before these platforms will be built in any quantity. Further discussion of technology and water depth is contained in Section B.2.3.

*References for Appendix B will be found on page B-15.

B.2 CRITERIA MAPS

Before the full OCS scenarios were developed, all of the available information about oil exploration and development in the Santa Barbara Channel was compiled and put on several maps. These became the criteria maps because the information on them was later used as criteria for both distributing platforms throughout the Channel and for creating a time frame for construction. Included are a variety of details ranging from water depths to the proximity of recently-leased tracts to existing fields. This section will include a discussion of these criteria and their implications for oil development.

B.2.1 TRACTS DRAWING HIGH BIDS

Until a lease sale has occurred, there is almost no way for the general public to know where oil-bearing formations might be in the Channel. However, the industry has access to proprietary information about the geology of the area. From this they are able to decide where the oil probably is and will place their bids at the lease sale accordingly. Therefore, for the purposes of this study, tracts drawing the highest bids were considered to have the greatest potential for having oil resources (Figure B-1). For this reason, tracts drawing the top eight sliding scale royalties and the top nine fixed royalties have been labeled on the criteria maps (2).

B.2.2 PROXIMITY OF TRACTS TO EXISTING FIELD

Generally, oil-bearing formations in the Channel tend to run in an east/west direction (3). During the last lease sale, all of the tracts which were on either the east or west side of tracts with known fields drew very high bids. Both facts indicate that these tracts are likely to have oil on them. They are also shown on the maps.

B.2.3 WATER DEPTH

Water depth has no relationship to the presence of oil in a particular area. But it does have a great deal of relevance in considering good platform construction sites and the time frame in which they are constructed. Tracts with less than 100 fathoms (600 feet) of water are the easiest places to put a platform; anything with water between 100 and 200 fathoms (600-1200 feet) is judged to be difficult for construction. Water depth over 200 fathoms (1200 feet) will require innovative platform construction techniques and, hence, will be the last to be developed.

The following table provides industry estimates for the depth capabilities of the three basic techniques for offshore oil recovery, fixed platforms, compliant towers, and subsea completions.

FORECAST OF DEPTH CAPABILITIES

Year	Fixed Platforms	Compliant Towers	Subsea Completions
1980	1,020′	1,000′	1,000′
1981	1,100′		
1982	1,200′	1,500′	1,500′
1983	1,300′		
1984		1,800′	2,000′
1985			
1986			
1987			2,500′
1988	1,400′		
1989			
1990	1,500′	2,000′	3,000′

Exploratory drilling depths are already well beyond those required in the Santa Barbara Channel. Currently (1980) the industry already has the capability of drilling in deeper water than the record-setting well of 4,876 feet which The Offshore Company drilled for Texaco off Canada. There is an interesting prospect of 6,000 feet of water in the Baltimore Canyon area on the U.S. Eastcoast, and chances are that an exploratory well will be drilled at that depth within the next year. Drilling and production at such depths will not likely come within the next decade. Exploratory drilling, however, now at about 6,000 feet capability, may reach 8,000 feet by 1980.

As far as fixed platforms go, when complete this year, Chevron USA's Garden Banks platform will stand 140 miles offshore in the Gulf of Mexico in 685 feet of water. This structure will cost $43 million, complete with deck installations, will have a height of 772 feet, and an overall weight of 17,000 tons. Drilling and producing equipment will bring the overall cost to a level approaching $100 million. It should be noted that the soaring prices of gas and oil, as well as engineering advances have increased the economic depths of these fixed platforms.

Tension leg platforms and guyed towers will be installed within the next few years and will give fixed type platform structures competition. Greater water depths anticipated in the North Sea and off Australia will probably utilize these new type units which have been thoroughly tested with

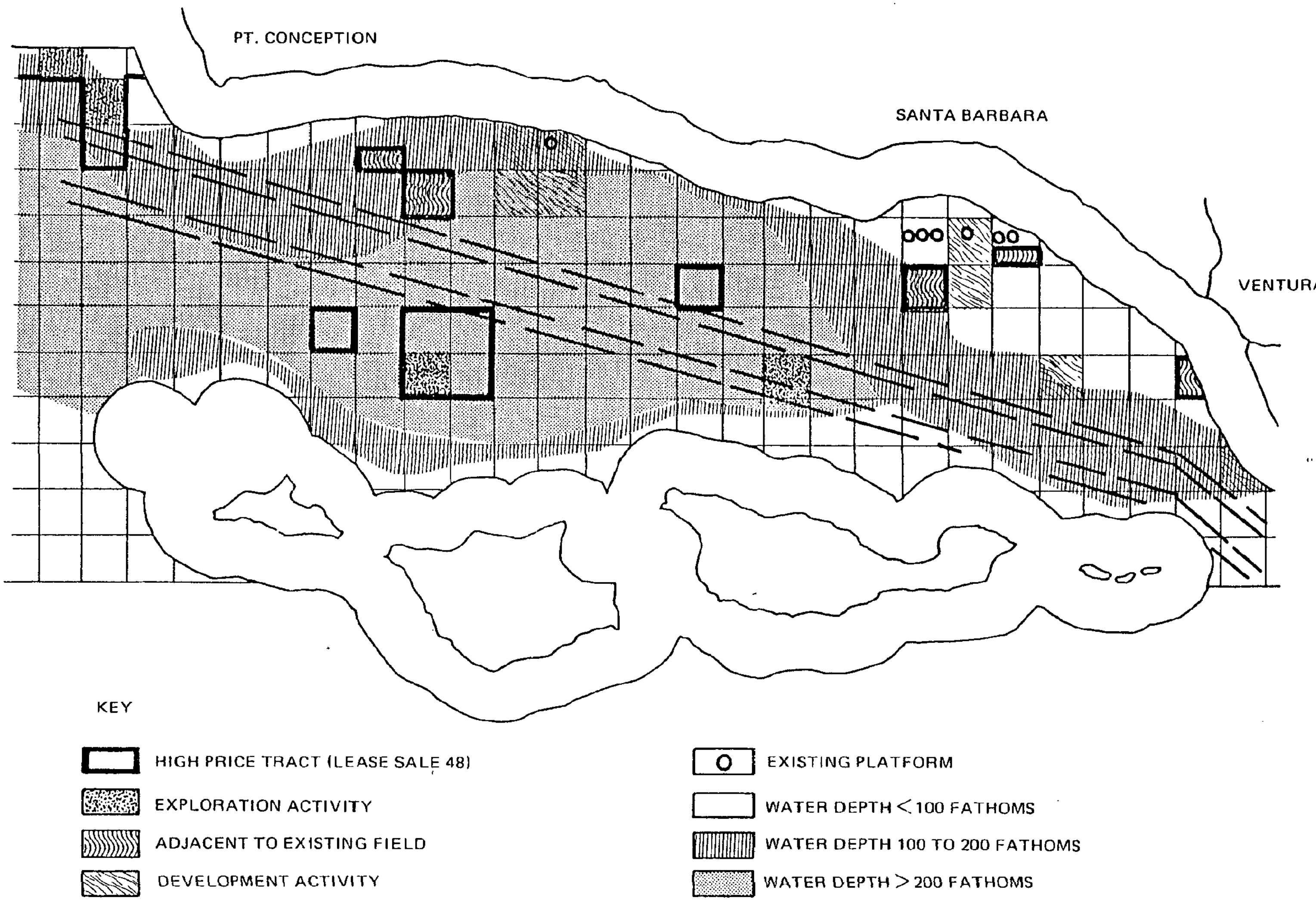


Figure B-1. Criteria for Distribution of OCS Development Projection

large scale models but as yet are untried in actual oil field service.

The number of subsea completions has grown steadily, more than doubling in the past five years. The growing acceptnce of subsea completions as a viable production alternative has gotten its greatest boost from the rough water areas of the North Sea, where costs for fixed platforms have priced many fields out of the development market.

The wider acceptance of subsea completions in the North Sea has led to increased use elsewhere as well. Single well completions tied to production to a converted tanker are being used offshore Spain and Italy to produce fields with life expectancies of three to five years. The use of mobile production systems to tap marginal fields and bring production onstream early is another production trend.

As early as 1962, Chevron and Texaco constructed 25 subsea completion trees in the Santa Barbara Channel in 248 feet of water. In 1967, two subsea completions equipped for gas lift were constructed in the Santa Barbara Channel by Chevron in 60 feet of water. The record depth for subsea completions currently (early 1980) is 620 feet, accomplished by Petrobras in the Enchova Field off Brazil.

B.2.4 GEOLOGIC BOTTOM CONDITIONS

The geologic conditions of tracts sold in lease sale 48 are shown on the second map (Figure B-2). Although most of the tracts have some adverse bottom conditions, they are not usually severe enough to preclude platform construction. Three tracts do have particularly bad geo-hazards. In the stipulations for lease sale 48, it was stated that operators intending to place structures on tracts 316, 321 or 338 must demonstrate that the structures will be able to withstand any fault movement that might occur (4).

B.2.5 TRACTS DELETED FROM LEASE SALES

After the large oil spill in 1969, the Department of the Interior created an ecological preserve on tracts due west of the Dos Cuadras field. A buffer zone was also created around the Channel Islands. All of these tracts were deleted from lease sale 48. Now the Department of the Interior is thinking about eliminating the ecological preserve and offering these tracts in the next Southern California lease sale (scheduled for 1982).

B.2.6 TRACK NUMBERING SYSTEM

Figure B-3 shows the lease number of all tracts that have been leased in the Channel. All tracts are given numbers before a lease sale. After the sale, they are then given a lease number. The lease number appears on all of the USGS maps and are also used to identify tracts being discussed in this study.

B.2.7 EXISTING PLATFORMS AND FIELDS

A separate map (Figure B-4) was included in this section to show where platforms are presently located in the Channel.

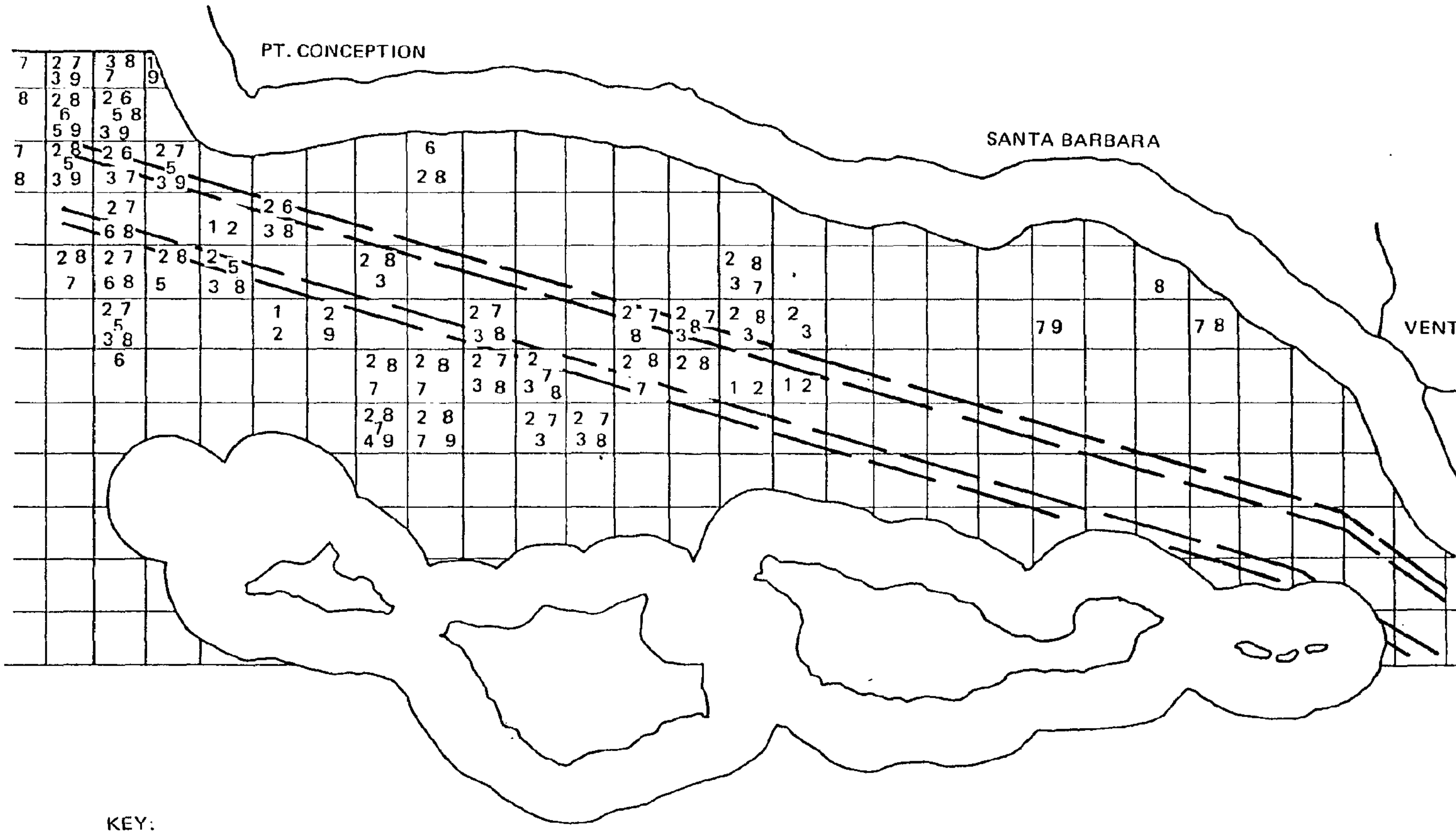
B.2.8 VTSS SHIPPING LANES AND FAIRWAYS

Because the purpose of the overall study is to evaluate risks arising from the proximity of shipping and oil activity in the Channel and to recommend appropriate risk reduction measures (such as separation), no effort is made in these scenarios to keep the projected activity out of known shipping lanes and fairways.

B.3 EXPLORATION IN THE SANTA BARBARA CHANNEL

In addition to the criteria maps, an exploration scenario map was also created for the Channel. It was used as additional information in developing the "snapshots." Included were both tracts leased in 1968 and 1979 as well as tracts that may be leased in the future. There are three more lease sales coming up which will affect the Channel. The first is lease sale 68 and it is slated for June of 1982. After it, are lease sale 73 in 1983 and lease sale 80 in 1984. Essentially, both the leased tracts and those that are likely to be leased were divided into three categories. Each category represents a certain period of time. Although information from the criteria maps was used to do this, the divisions are still somewhat arbitrary. This map is not designed to show any drill ship locations, but merely to indicate a sequence in which the tracts are likely to be explored. However, an estimate was made of how many drill ships would be operating during each time period (see Table B-1).

Using Figure B-5 and an estimate of two months to explore a tract with a drill ship, estimates can be made of the time any drill ship will be in a tract that overlaps the traffic lanes. The estimates are presented below.



KEY:

1	STABLE SEAFLOOR (NO HAZARDS)
2	DEEP WATER, AT LEAST ONE POINT ON THE TRACT IS UNDER 100 FEET OF WATER
3	SLUMP/CREEP
4	STEEP SLOPE; GREATER THAN 7
5	MAJOR CANYON/CHANNEL
6	MINOR CHANNEL
7	SHALLOW FAULTS
8	SHALLOW GAS
9	SEEPS

Figure B-2. Geologic Bottom Hazards of the Santa Barbara Channel

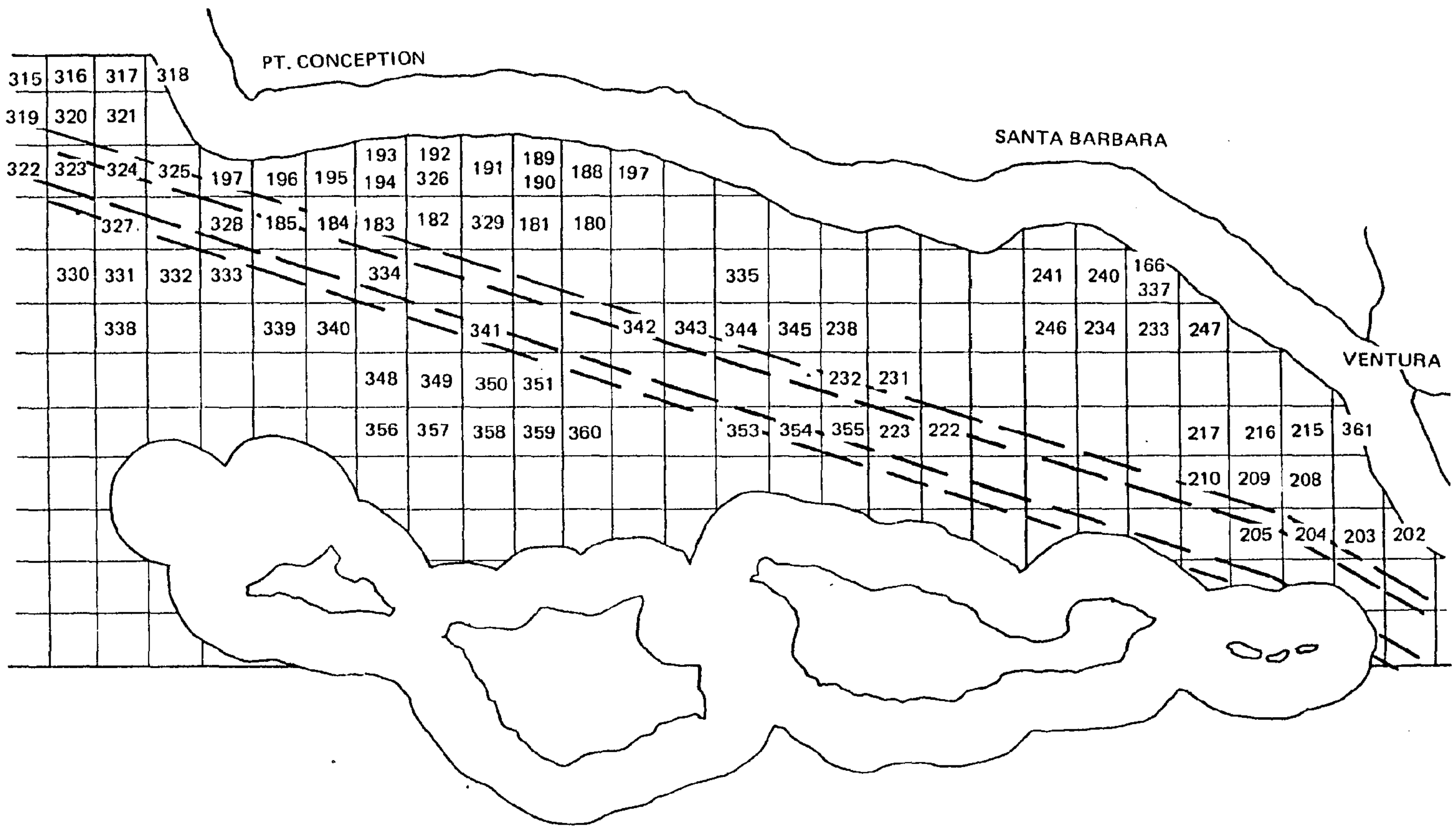


Figure B-3. Leased Federal Parcels with "OCS P" Lease Numbers

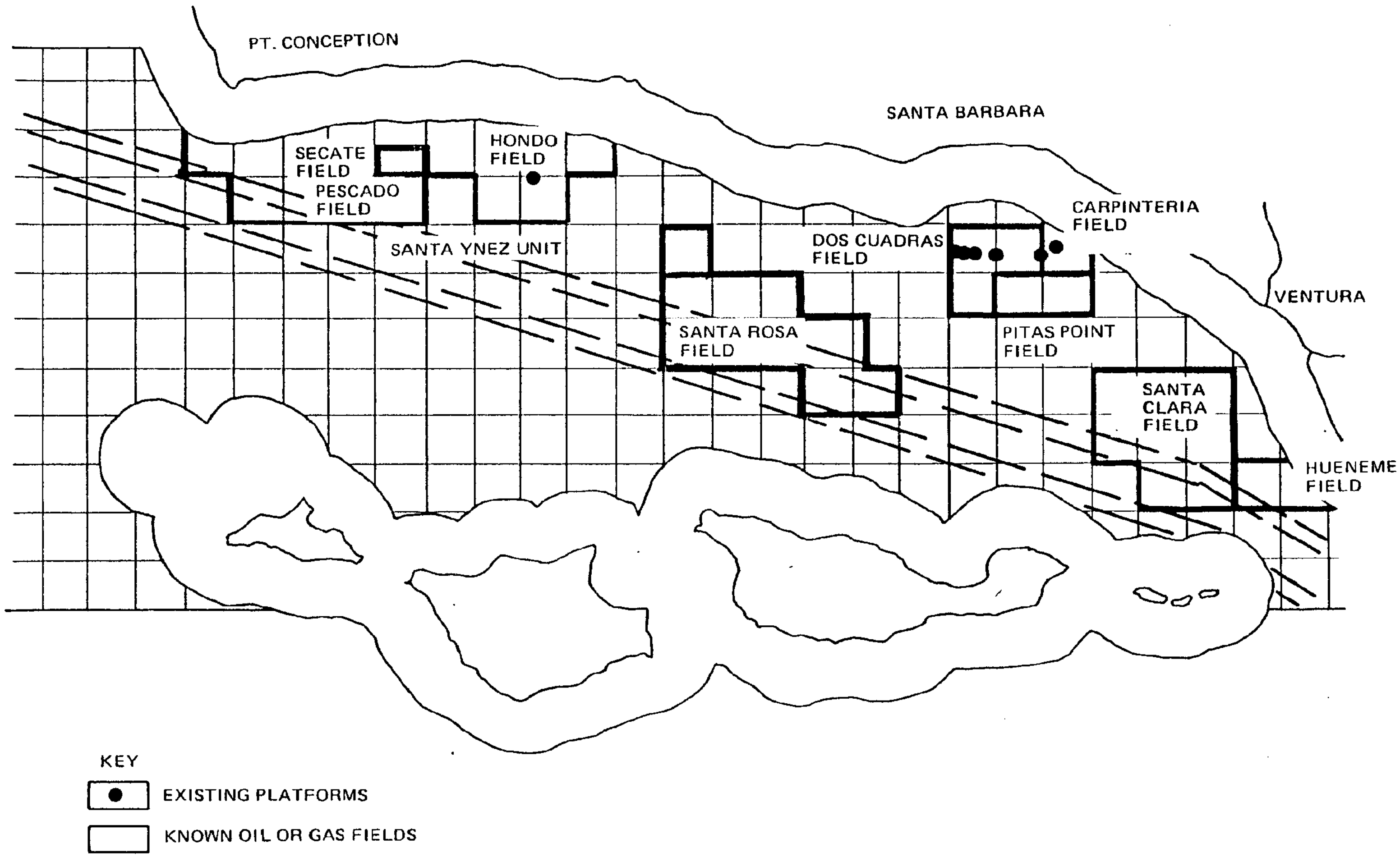


Figure B-4. Existing Platforms and Fields

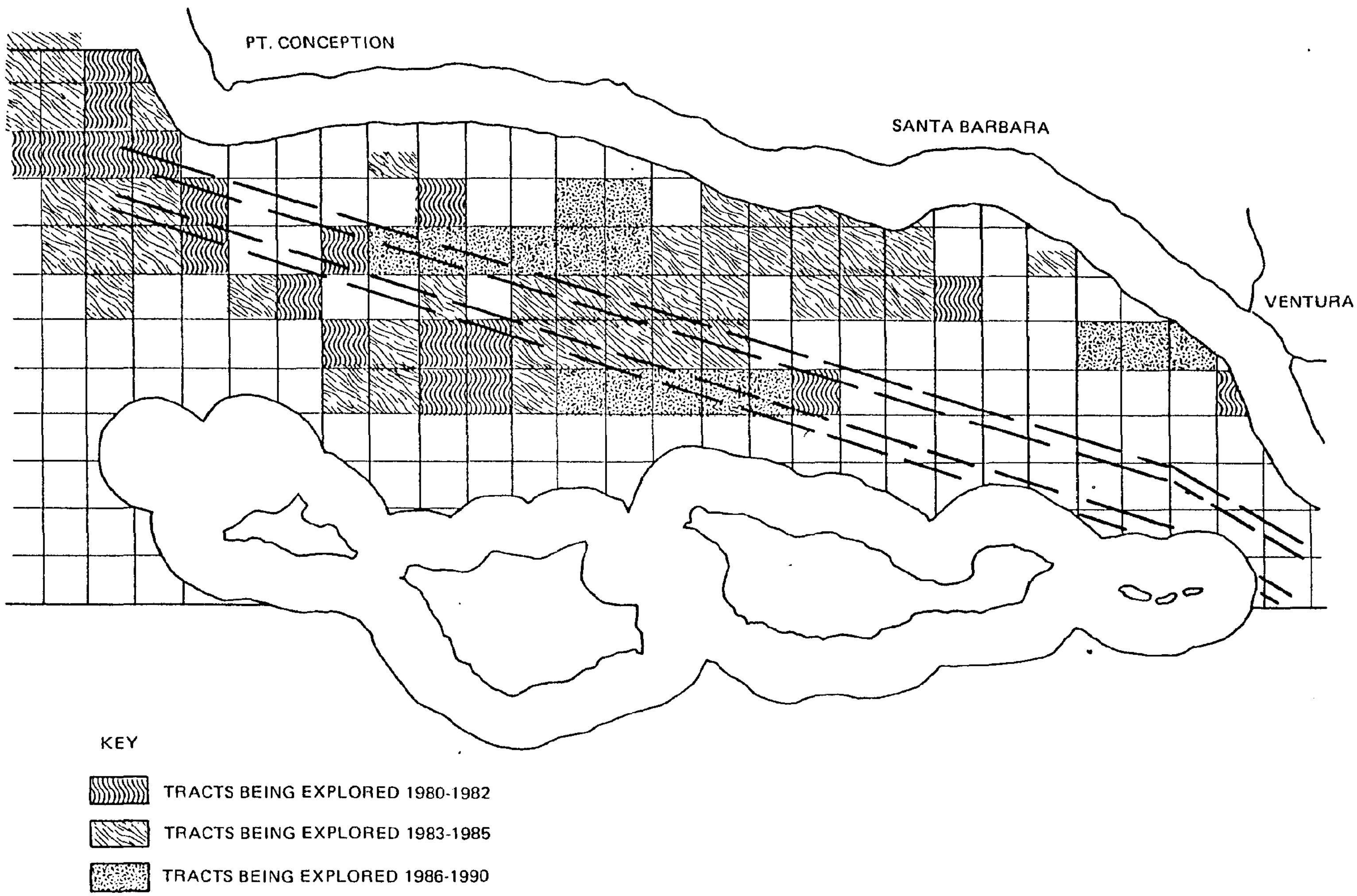


Figure B-5. Phases of Exploration for Santa Barbara Channel

TABLE B-1. EXPLORATION IN THE SANTA BARBARA CHANNEL FROM 1980 TO 1990

Year	Number of Ships	Number of Tracts Being Explored
1980-82	3	18
1983-85	4	41
1986-90	2	13

NOTE: This table assumes that drill ships will spend about 60 days per tract.

B.3.1 1980-1982

During the first time period, 1980-1982, about 18 tracts will be explored. Two of these were leased in 1968 and exploration is just now being finished. The majority of the tracts drew very high bids in lease sale 48 and the oil companies will be eager to see what kinds of resources they may have gotton. The rest of the eighteen tracts belong to smaller oil companies who did not pay as much as Mobil or Chevron but still want to explore their areas quickly. Three drill ships should be able to handle the 18 tracts in two years assuming they spend about 60 days per tract.

Seven of the 18 tracts overlap the traffic lanes. This means that there will be a drill ship in or near traffic lanes for approximately 14 months of this three-year window. (This really represents drill ship-months which could result in two drill ships in the area for seven months or any combination thereof.)

B.3.2 1983-1985

Between 1983 and 1985, exploration in the Channel should be at its peak. The rest of the tracts leased in 1979 will be explored before the leases expire in 1984. Also, tracts sold in 1982 are likely to have drill ships on them. It will take four drill ships to cover the approximately 41 tracts which are expected to be explored in this period.

Thirteen of the 41 tracts overlap the traffic lanes in this case. This results in 26 drill ship-months for this three-year window.

B.3.3 1986-1990

By 1986, most of the promising tracts will already have been explored. Only 13 tracts will be left to be sold in the last two lease sales.* The level of activity is expected to drop off considerably as the prospect of finding new oil decreases. Only two drill ships would be needed to finish up all of the exploratory drilling projected by 1990.

Eight of the remaining 13 tracts to be explored during this five-year time period overlap the traffic lanes. This results in 16 drill ship-months in or near the TSS.

B.4 SCENARIO "A"

The first of the three scenarios represents nominal development of the Channel's petroleum resources. Each "snapshop" (1984, 1989 and 2000) in the scenario portrays the level of activity which could conceivably occur during that year. It is important to remember that these snapshots were meant to represent one day rather than the entire year. Drill ships have been shown at locations likely to be explored during that year. However, these locations have no special significance other than to help set the stage for the simulations. The methods used for calculating how many platforms are shown in each "snapshot" will be discussed in the description of each chart.

B.4.1 NOMINAL RECOVERY FOR 1984

By 1984, activity in the Santa Barbara Channel will be gaining momentum. Exploratory drilling may have reached its peak and construction of platforms on tracts sold prior to 1979 should be almost finished. Also, production drilling will probably be underway in many places if permits are not unduly delayed. It is estimated that the total numbe of platforms will have increased from seven in 1980 to eighteen. According to **The Report on Offshore Oil Drilling Activity in Southern California** (5) put out by the State Office of Planning and Research in 1977, this number of platforms will complete development of the tracts purchased in 1966 and 1968. Although it is possible that one or two additional platforms will be built on these particular tracts, the chances are not very great.

B.4.1.1 **Platform Construction.** In all likelihood, Exxon will have almost completed developing the Hondo unit by 1984. Its offshore storage and treatment (os&t)/marine

*This assumes that the tracts in the Channel Islands buffer zone will not be offered.

terminal facility will probably be in place next to the Hondo platform. Two other platforms, in tracts 190 and 192 will probably be in the development phase. One will be draining the Sacate field and the other will be augmenting the Hondo platform. A third and fourth platform may be under construction in tracts 182 and 181. Tract 182 covers the Pescado field and 181 is part of the major Hondo find. It is likely that these platforms will be tied together by a series of pipelines and, possibly, subsea completions. For the time being, it is assumed here that all crude will go to the os&t platform and then be transported by tanker to the refineries. However, Exxon has agreed to explore the possibility of building a processing plant at Las Flores Canyon, then sending the oil through a pipeline to Chevron Carpinteria and on southward. If they carry out these plans, the os&t at Hondo will be phased out. Also, at the Dos Cuadras field, Sun Oil will probably have completed its proposed platform on tract 240, but development drilling should be underway. Crude will be pipelined to shore via the existing network going from Dos Cuadras field to Mobil Rincon. Development of the Pitas Point unit will probably also be close to completion. This may be accomplished by placing two platforms in tract 234. Texaco has anticipated building them since 1977. Chevron will probably be in the process of building one platform in each of three tracts. All three tracts, 215, 216 and 217, comprise the Santa Clara unit and have been credited with oil discoveries since the early 1970's.

B.4.1.2 Exploration. Exploration activity in the Channel will be at its peak from 1982-1985. Most of this activity will probably be centered in the western part of the Channel. The "A" chart for 1984 shows four drill ships which are indicated by "X's." As a reiteration of earlier information, these specific locations are only a few of the possible places the ships could be. The decision to put them on these tracts was arbitrary.

B.4.1.3 Construction of the LNG Terminal. The LNG Terminal at Point Conception could be under construction by 1984. Most of the facility will be located on shore. However, construction of the trestle used for unloading tankers could increase activity in the Channel. Also, after the facility is complete, LNG tankers will be crossing the TSS to get to the trestle.

B.4.2 NOMINAL ACTIVITY FOR 1989

In 1989, exploration of oil resources in the Channel will be almost complete. However, a number of platforms will be under construction and there will also be some production drilling.

B.4.2.1 Platform Construction. Up until 1984, all of the hypothetical platforms have been placed on tracts where oil discoveries have been made. However, none of the tracts from lease sale 48 or those to be sold in future sales have been explored. Consequently, the criteria map will be used extensively in picking platform locations. Ten platforms are calculated as sufficient to handle the resources of lease sale 48 located in the Channel. In the Final Environmental Impact Statement (FEIS) (1) for the sale, it was estimated that 10 platforms would most probably be able to handle the resources in the Channel area. After the FEIS came out, the USGS revised its estimate of resources in the sale area downward by a considerable amount. However, the oil industry seemed to have a different opinion. The oil companies' bidding behavior at the sale indicates that they thought the Channel has extensive potential resources. Therefore, for the purposes of this study, the number of platforms projected for the Channel was not reduced.

Two platforms have been projected for construction on tracts which will probably be sold in lease sale 68. These are the only projections made for development on unleased tracts. They were made because the industry has shown a great deal of interest in these tracts and they are all close to either producing fields or areas with very high potential for oil development. The number of platforms was derived from a one per tract formula with the assumption that these were all high potential tracts.

Five tracts from lease sale 48 will probably have platforms on them by 1989. The only one which could be in full production will be on tract 361. Shell made a high bid for this tract; it is in relatively shallow water and is also adjacent to a known field. So, it could be built at a relatively early date.

Chevron's tract 359 will probably have a platform on it. They paid a very high price for it and will be hoping to find a sizeable field. Because the water is very deep and it is quite a distance from the shore, this platform may require an offshore storage and treatment facility (os&t) with a marine terminal. For purposes of this study, the os&t unit is assumed to be similar to the converted tanker being used by Exxon at the Hondo field.

A second Chevron platform may be on tract 317. It may be in the development phase by 1989 and will also handle drilling for the Mobil tract 321 located just south of it. Both of these tracts drew very high bids in lease sale 48, so their respective owners are probably anticipating good-sized reserves. Tract 317 will be used as the construction site because its bottom conditions are not as hazardous as those of 321. These tracts are not far from shore, but they are quite a distance from any existing land facilities. For the purposes of this study, it will be assumed that a new land facility will be built at Jalama Creek. From there a pipeline will carry the crude to Las Flores Canyon and on to the refineries further south.

Chevron may have a third platform under construction on tract 345. They paid a high royalty for it in lease sale 48 and will probably have discovered a field in the early 1980's. However, platform construction will have been delayed because of the greater water depth. Transport of the crude will be done via pipeline to the Mobil Rincon.

In order to complete development of the Santa Ynez unit, Exxon is likely to put a platform on tract 329. They made a high bid on it in lease sale 48 and may need the platform to further develop the Hondo field.

Two other platforms could be under construction in 1989. They are both in tracts which are presently (1980) in an ecological preserve. However, people from the oil industry have been pressuring the Department of the Interior to put these tracts up for sale. If they are sold, there is a good chance they would be developed. The oil industry would not be clamoring for them if there was no chance of finding oil. Also, these two tracts are adjacent to a currently-producing field (Dos Cuadras).

B.4.2.2 Exploration. Exploration in the Channel will probably be almost finished by 1989. The few remaining tracts will probably be scattered around in the central part of the Channel. Drill ships shown on the map indicate several of the possible locations.

B.4.2.3 Pipeline Construction. One final change in the Channel may be facilitated by the completion of the pipeline between Las Flores Canyon and Chevron Carpinteria. The Exxon os&t will no longer be necessary. This is based on the assumption that the new pipeline will be designed at a capacity to handle all the crude coming from these four places as well as the product coming from Jalama Creek.

B.4.3 NOMINAL ACTIVITY FOR 2000

The Santa Barbara Channel will probably have reached its peak level of oil production by the year 2000 (see Table B-2). Exploratory drilling may have been completed several years earlier and development drilling more recently. Since 1989, five additional platforms will probably have gone into operation. All of them will be in deep water which is why they were designated the last to be developed.

TABLE B-2. NOMINAL ACTIVITY LEVELS IN THE SANTA BARBARA CHANNEL 1984 TO 2000

	1984	1989	2000
Platforms in production phase	8	18	28
Platform with development drilling	8	2	–
Platforms under construction	2	5	–
Number of drill ships	4	2	–
Offshore storage and treatment facility/marine terminal	1	1	–
LNG terminal	0	1	1

B.4.3.1 Platform Construction. Tracts 315 and 318 are both in the block of tracts off of Point Conception that drew very high bids in lease sale 48. If the oil companies are correct in guessing that there is a large field in this area, then these platforms will probably be necessary to fully develop it. The tract just to the east of tract 321 is also part of the Point Conception field. It was deleted from lease sale 48 because of its terrible bottom conditions but may be sold later as a result of pressure from the industry.

The other two platforms could be constructed on tracts 348 and 351. They are in the other block of tracts which drew some of the highest bids in lease sale 48. However, there may be fewer platforms in this area than off Point Conception because the water is deeper so it will be more cost-effective to unitize the field.

B.5 SCENARIO "B"

Scenario "B" is an offshoot of the nominal resource recovery Scenario "A." It is intended to demonstrate that although Scenario "A" has given the most likely platform locations, there are other plausible places for these platforms. Most of the platforms projected for tracts sold prior to lease sale 48 will probably be built where they are pictured. The fields under these tracts have been delineated for some time and the oil companies know what will be needed to develop them. However, platform locations projected for tracts sold in lease sale 48 and later sales are more variable.

B.5.1 SCENARIO "B" SCHEME FOR 1984

All but one of the platforms anticipated to be in place by 1984 are shown where they have been planned. The one platform which could be built in another location is in the Santa Clara unit. Chevron will probably build two platforms on tracts 216 and 217, but the field may not turn out to be as big as they expect. In this case, no platform would be built on tract 215. At the same time, reserves discovered in the southern part of the unit could warrant construction of a platform on either 205 or 204. Since there is no information available to suggest that one tract would be a better production site than the other, the platform has been arbitrarily placed on 205.

B.5.2 SCENARIO "B" SCHEME FOR 1989

Most of the new platforms in the 1989 scenario have variable locations. There is also one tract which has not been considered a highly-probable platform location but could conceivably have a platform on it by 1989, No. 197. Tract 197 is in the far western part of the Santa Ynez unit and has been credited with an oil discovery since 1968. Further exploration of the area or changing economic circumstances may cause Exxon to decide that this area should be developed.

Also in the Santa Ynez unit, Exxon may decide that it is not necessary to build a platform on tract 329 in order to fully develop the unit. However, since Chevron owns tract 326, they may not want to unitize with Exxon in order to get their oil out of the ground. Instead, they may build their own platform.

In the Point Conception area, tract 321 may have a platform on it as well as the one on 317. Tract 321 drew a higher bid in lease sale 48 than 317, but its bottom conditions are very poor. If there is a very large field in tract 321, the second platform may be necessary regardless of bottom conditions. Another possibility may be that a platform could only be built on 320 which would then develop the oil for both tracts by directional drilling.

Platforms on tracts 358 and 345 have not been moved in this scenario. Tract 358 drew a very high bid and has comparable bottom conditions to anything around it. After looking at all the platform locating criteria, there is no reason to assume that it could be located elsewhere. In the case of tract 345, it drew a much higher bid than anything around it. If the owner really thinks there is oil in the area, it is more likely to be on 345 than any place else.

There may be one platform instead of two in the series of tracts, now an ecological preserve, just west of the Dos Cuadras unit. If the field is only big enough to warrant one platform, then it could be closer to the Santa Clara unit. Any smaller amounts of oil located closer to the Dos Cuadras field could be developed using the already-existing platform.

It is possible that Shell will not put a platform on tract 361. The field they expected to find may not materialize. Instead, Chevron may build on tract 337 to drain some of the Carpinteria resource.

B.5.3 SCENARIO "B" SCHEME FOR 2000

Variations of the platform sites projected for 2000 include moving three platforms and eliminating one. The platform initially placed in tract 315 could be moved over to tract 316. This would depend on the size and location of the oil-bearing structure that might be out there. Also, instead of building a platform in tract 318, Chevron may put one in tract 324. Bottom conditions on 324 are not very good, but the site of the field may warrant the extra engineering needed to construct a platform there. At the same time, the owner of tract 321 may decide it is not a good place for a platform. There may not be enough oil to justify the cost of development on difficult bottom conditions.

In the southern part of the Channel, tract 348 drew much higher bids than any of the tracts around it. It is possible that a platform could be built on any one of these tracts. However, this would not have a significant impact on navigation in the Channel. Consequently, in this scenario, the platform has been left on tract 348.

It is possible that tract 354 may have a platform on it instead of 351. Exxon may not want to consolidate facilities with Chevron if the site and shape of the field require this change.

B.5.4 TRANSPORT OF CRUDE

Alternate schemes for processing and transporting of crude have also been indicated on these maps. The leases for sale 48 stipulate that oil should be pipelined to shore for processing whenever it is feasible. But it may turn out that several fields are in too deep water or are too far from existing landfalls, or both, for pipelines to be economical. This will result in more extesnive use of os&t platforms with marine terminals. Consequently, there would be an increase in the number of tankers passing through the Channel.

B.6 MAXIMUM RESOURCE RECOVERY SCENARIO

The third scenario shows what the Channel could look like if the maximum estimated resource levels exist. See Table B-3 for maximum Activity levels in the Santa Barbara Channel.

B.6.1 MAXIMUM RECOVERY FOR 1984

The EIS for lease sale 48 states that 18 additional platforms could be built on tracts leased in 1966 and 1968. There are currently seven producing platforms on these tracts, and eleven more have been projected for construction in the nominal development schemes for these tracts. For maximum development in these tracts, it is assumed that an additional six platforms would be needed, for a total of 24.* These platforms are likely to be built in two fields, three in the Santa Ynez unit and three in the Santa Clara unit. Both units have known reserves as well as potential resources that could require additional platforms. The only other place where these platforms might go is on the Santa Rosa unit. However, extensive exploration has been done in this area without finding any sizeable resource.

B.6.2 MAXIMUM RECOVERY FOR 1989

It was estimated that a maximum of 21 platforms could be built on tracts sold in lease sale 48. Ten platforms were considered the most likely number necessary to develop these tracts. For maximum recovery, then eleven more would be needed. Between 1984 and 1989, most new oil development will probably be off the coast of Point Conception, based on the criteria discussed earlier. There may also be some construction in several other areas. One platform could be in tract 358 and another in tract 354. At the same time, two more platforms might be under construction in two tracts which are now part of the ecological preserve.

TABLE B-3. MAXIMUM ACTIVITY LEVELS IN THE SANTA BARBARA CHANNEL 1984 TO 2000

	1984	1989	2000
Platforms in production phase	8	25	45
Platforms with development drilling	11	7	–
Platforms under construction	5	8	–
Number of drill ships	4	–	–
Offshore storage and treatment facility/marine terminal	1	–	–

B.6.3 MAXIMUM RECOVERY FOR 2000

By 2000, construction of new platforms will probably be finished. There may be several more new platforms west of Point Conception. Also, one more platform could be in the unit north of Santa Rosa Island and one more could be in the field next to the Santa Rosa unit.

B.7 DETAILS OF VESSELS AND PROCEDURE FOR OIL EXPLORATION AND DEVELOPMENT

B.7.1 EXPORATION

Exploratory drilling in the Santa Barbara Channel will be done from dynamically-positioned drill ships. See Table B-4 for typical vessel dimensions. When these ships move to location, it will generally take between two and four days for them to get positioned correctly. Then for about a week things are done just as if a platform was being installed. Blowout prevention stacks, well templates and other structures are placed on the ocean floor. At this time, supply boats shuttle back and forth 24-hours a day. After everything is in place the drilling begins, a supply boat will only be needed once every day or day-and-a-half. In addition, at least one smaller boat will stand-by at all times. Sometimes, particularly in the case of bad weather, there could be as many as three of these smaller boats on hand.

*The FEIS does not give a maximum resource estimate for the earlier lease sales, but a USGS post-sale estimate (February 1980) gives high (5% probability) estimates, more than double the FEIS. High estimates for the Channel as a whole, implying increased production from the 1966 and 1968 leased tracts.

TABLE B-4. TYPICAL OFFSHORE SUPPORT VESSEL
TABLE OF CHARACTERISTICS FOR SANTA BARBARA CHANNEL

Type of Vessel	Length	Beam	Draft	Displacement	Crew Size	Speed
Drill ship	400 ft.	65 ft.	21 ft.	11,220 tons	up to 78	12 knots
Supply vessel	180-190 ft.	36-40 ft.	10-16 ft.	1,500-2,000 tons	8-11	12 knots
Crew boats	140 ft.	28-30 ft.	10 ft.	–	5-6	14-18 knots
Barges	250 ft.	50-60 ft.	11-12 ft.	4,000-4,500 tons		
Pipeline laying barges					20-40	
Tug	140 ft.	28 ft.	15 ft.	1,000-1,500 tons	6-9	5 knots

B.7.2 PLATFORM INSTALLATION

Platform installation will take six weeks or more. First, the structural part of the platform will be brought to the site by barge. Cranes and pile drivers will also be brought out on barges. Each barge will require at least three tug boats. The top part of the platform, including drilling equipment, will arrive on from two to four more barges. During installation, supply boats are operating on a 24-hour basis.

B.7.3 DEVELOPMENT DRILLING

Once the platform is up and development drilling has started, supply boat activity will drop to about one run a day. This could last anywhere from one to two years.

B.7.4 PLATFORM PRODUCTION

When a platform is ready to go into production, about one month is needed to remove the drilling hardware and install production equipment. Two barges will go out to the site. One will have a crane and the other will take out pipeline risers, etc. and bring back the drilling equipment. When the platform gets set up and running it will only need one supply boat every two or three days.

B.7.5 SUPPLY BOAT OPERATIONS

After arriving at a supply base, supply boats have a turn-around time of 12 to 24 hours. Some of the time depends on how well-equipped the supply base is. All vessels are loaded differently according to company policy and supply base operations. Deck cargo is the easiest to load if a good crane is available. Fuel is the most critical item, then bulk, and then water. When the supply boats get out to the platform, it only takes about six hours to unload.

B.7.6 PIPELINE LAYING BARGES

There are two different types of pipe laying barges. Economic factors are generally the main consideration in choosing which type of barge will be used for a particular job. The first type is set up to store and weld pipe on board. It requires two tugs to move it. Anchor positions are changed after approximately 120 feet of pipe has been laid. One or possibly two supply vessels will be used to carry pipe and supplies to the barge. They will make about one trip every two days. If things are going very well, this pace may be accelerated slightly. The second type of barge is about the same size at the first and is also moved by two tug boats. The difference is that it carries pre-welded pipe on a giant reel. However, it can only handle pipe up to 8" in diameter. Since the pipe is already welded, this cuts down on the amount of time the barge is in operation. A smaller boat can accommodate the supply needs of the barge with one trip every two days. Only a small vessel is required because the barge already has all the pipe it will need. A third construction method for subsea pipelines is the "bottom-pull" approach, in which pipe lengths are welded together in a yard on shore and towed out to sea by heavy tugs.

REFERENCES — APPENDIX B

1. Final Environmental Impact Statement for Lease Sale 48; January 1979, Bureau of Land Management.

2. Oil and Gas Journal: "The Santa Barbara Channel OCS Hotspot in OCS Lease Sale 48"; July 9, 1979, page 48.

3. Conversation with Allen Lind, State Office of Planning and Research.

4. Conditions of Lease Sale 48, Appendix C, "Geohazard Stipulations," page A-43.

5. Offshore Oil and Gas Development: Southern California: OCS Project Task Force/Office of Planning and Research, Volume One; October 1977.

APPENDIX C

SANTA BARBARA CHANNEL VESSEL PROJECTION

C.1 SANTA BARBARA CHANNEL VESSEL TRAFFIC PROJECTION

The projection of commercial merchant vessel traffic described in this Appendix represents an update of the vessel traffic analysis and projections contained in Reference 1* which was completed in 1977 and based largely on data available through 1976.

There are two prime factors in the update, which cause the projected numbers of ships transiting the Santa Barbara Channel to increase by about 28%, to values in the 14 to 22 ships per day range.

These two factors are, first, a recent and extensive Coast Guard vessel route survey which determined that an increasing percentage of ships are using the Santa Barbara Channel Traffic Separation Scheme (TSS) as opposed to alternate routes outside the Channel Islands, and second, a significant new dry bulk cargo movement projected between the Port of Los Angeles and the Far East.

These factors and their numerical effects are described in the following paragraphs.

C.1.1 ROUTE SELECTION

As described in Section C.2 of this Appendix, which presents the results of an extensive 1979 U.S. Coast Guard survey of vessel routing to and from the ports of Los Angeles and Long Beach, a higher percentage of the ships bound to/from ports in the Far East, Hawaii, and the coast of North America north of Los Angeles are actually using the Santa Barbara Channel TSS (as opposed to selecting a route outside the Channel Islands) than were using the TSS in 1976. The shift in route selection is such that only about 1/3 as many vessels are going outside the Santa Barbara Channel as were selecting that "outside" routing in 1976.

*References for Appendix C will be found on page C-10.

The 11th U.S. Coast Guard District believes that the routing trend indicated by the survey is valid, and attributes the change to policies of the various shipping companies and ship operators. Such policy changes may be due to any of several factors, including increased emphasis on preventing collisions at sea, to which use of a TSS certainly contributes, maturity and increased acceptance of the Channel TSS (the Channel TSS is now approximately twice as old as it was in 1976), decrease in numbers of "tramp" vessels, and other factors.

The following table indicates the increase usage of the Santa Barbara Channel TSS from 1976 to 1979.

SHIPS USING THE SANTA BARBARA CHANNEL TSS AS OPPOSED TO ALTERNATE ROUTES

	1979*	1976**
SBC TSS	93%	77%
Through Channel Island	7%	23%

*Appendix C, Section C.2.
**Reference 1, 1976 data, page 2-11.

C.1.2 DRY BULK CARGO PROJECTIONS

The most significant change in the projections of vessel traffic at Ports of Los Angeles and Long Beach since the vessel traffic analysis of 1977 (1) is the increase in the projected dry bulk trade. Of this trade, the projected movement of coal to Japan and other areas of the Far East has increased due to the worldwide oil supply situation and prices for crude oil.

The Port of Los Angeles, which in 1976 planned for, at most, an increase in the throughput capacity of their existing dry bulk terminal at Berths 49-50, has recently included in their Master Plan (2) a major new coal handling facility on the south side of Terminal Island. This new facility will have five times the capacity of the expanded existing facility (3).

The new coal handling facility will generate additional dry bulk carrier vessel traffic in the Santa Barbara Channel, beginning between 1980 and 1990. For use of the methodology of Reference 1, section 3.1.3, an increase in the outbound dry bulk volume from the Port of Los Angeles, consistent with the planned capacity of the planned terminal, has been assumed as follows:

	1990	2000	(000 short tons)
Maximum	10,000	15,000	(annual)
Nominal	8,000	12,000	

This increase will result in additional dry bulk cargo vessel traffic through the Santa Barbara Channel as follows:

Additional dry bulk vessels through SBC

	1990	2000	
Maximum	494	641	(annual)
Nominal	312	382	

C.1.3 TOTAL SANTA BARBARA CHANNEL PROJECTED TRAFFIC

Adjusting the numbers of vessels through the Channel by the change in percentage of route selection described above, and adding the projected dry bulk traffic results in the following table of vessel traffic (Reference 1, Exhibit 1.2.2-2, page 1-8):

Max/Nom. No. of Ships through Santa Barbara Channel to/from ports of LA/LB (annually)

	1980(1)	1990(2)	2000(2)
Liquid bulk carriers	1558/1224	1812/1341	2076/1474
Containerships	1111/846	1293/906	1474/966
Breakbulk carriers	1413/1123	1220/870	1075/725
Dry bulk carriers	701/556	1376/1037	1269/829
Other ships(3)	676/519	664/471	1413/834

(1) Same as Exhibit 1.1.2-2, Reference 1, adjusted only for route changes.

(2) From Exhibit 1.1.2-2, Reference 1, adjusted for route changes and additional dry bulk carriers.

(3) Includes auto carriers, neo-bulk carriers, passenger ships, etc.

The projected volume of vessel traffic generated by the Port of Hueneme through the Santa Barbara Channel is projected to remain the same as shown in Exhibit 1.1.2-3, Reference 1, which is summarized below.

Max/Nom. No. of Ships through Santa Barbara Channel to/from Port of Hueneme (annually)

	1980	1990	2000
All type ships	225/220	690/440	625/420

Adding together the vessel traffic generated by the major ports of Los Angeles and Long Beach and that to/from the Port of Hueneme, the following daily figures are derived:

Max/Nom. No. of Ships through Santa Barbara Channel on a Daily Basis in Each Direction

	1980	1990	2000
All type ships	15.7/12.4	19.3/13.9	21.7/14.4

C.2 U.S. COAST GUARD VESSEL ROUTING SURVEY

During the period May, 1979 through Mid-January, 1980, the U.S. Coast Guard 11th District conducted a vessel routing survey for commercial vessels calling at the ports of Los Angeles and Long Beach. The work was carried out in connection wih the Port Access Route Study by the Coast Guard in accordance with the Port and Tank Vessel Safety Act of 1978.

The survey is intended to identify the sailing routes taken by merchant vessels in the vicinity of the Southern California coast, as a function of the origin or destination of the ships' voyages. Specifically, the object of the project is to determine the extent of the usage of the Santa Barbara Channel and the Gulf of Santa Catalina Traffic Separation Schemes (TSS), and of routes passing north of Santa Catalina Island and/or outside the Santa Barbara Channel Islands.

The survey began with the boarding of a large number of vessels and completing a questionnaire with the following areas of information:

- Type of ship and descriptive data
- Last and Next Port of Call
- Route taken to LA/LB and reasons for choice
- Navigational problems encountered enroute LA/LB, if any
- Intended route for departure
- Comments on existing TSS and other subjects

In order to establish voyage origins and destinations for vessels which would lead to the logical use of each of the possible access routes to the ports of LA and LB, the Coast Guard divided the earth's surface into four areas.

Area A: The North American West Coast north of Los Angeles, including all of Alaska. Vessel origins or destinations in this area would logically result in use of the Santa Barbara Channel TSS.

Area B: Western Pacific ports, including Japan, China, Singapore, and the Indian Ocean ports including the Persian Gulf. Vessels from this area could use the Santa Barbara Channel TSS, but would require a turn maneuver when entering the TSS at Point Conception.

Area C: The South Pacific, including Oceana (Australia, New Zealand, etc.), and the Hawaiian Islands.

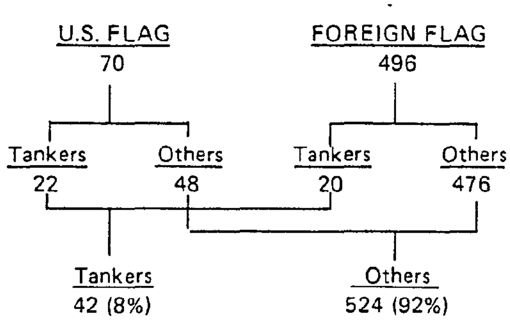
Area D: San Diego, Central and South America, and all Atlantic and European ports from which vessels transit the Panama Canal. All vessels traveling to or from ports in this area would logically use the Gulf of Santa Catalina TSS.

The Coast Guard survey resulted in recording of data for 566 vessel arrivals at LA/LB, and for 540 departures. Arrival information exceeds that for departures because some ship's masters were not sure of their next port of call and thus could not specify their depature route. A total of 49 boarding surveys were discarded due to lack of LPOC/NPOC or route information.

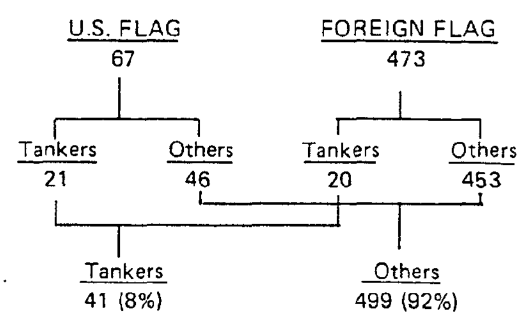
The results of the boarding surveys at San Diego, Port Hueneme, and the various coastal sea berths in Southern California are not included in this section of this report.

This study includes United States and foreign flag vessels, and covers tankers and other ships, in numbers as shown on the chart below.

ARRIVALS



DEPARTURES



This survey did not include a representative percentage of tankers, since the 8% tankers is well below the normal 25 to 30% of vessel calls at the ports of LA/LB which are tankers. An earlier boarding survey was conducted by the 11th USCG District in 1977. That study was done in connection with a tanker boarding and inspection program by the Coast Guard following the rash of tanker accidents in 1976-77. That survey covered a much higher proportion of tankers (54%) than did this 1979 survey.

C.2.1 ANALYSIS OF RESULTS

The analysis of the results of the routing surveys has been based on the four geographic areas described above. Tankers are broken out as a separate category, as are U.S. and foreign flag ships.

The possible approaches to/from LA/LB are divided into four routes:

1. Santa Barbara Channel Traffic Separation Scheme (TSS)

2. South of San Miguel, Santa Rosa, Santa Cruz, and Anacapa Islands. North of Santa Barbara and San Nicholas.

3. South-East of San Nicholas and Santa Barbara Islands and North-West of San Clemente and Santa Catalina Islands.

4. Gulf of Santa Catalina TSS.

The incidence of vessel usage of these four routes is shown in Table C-1, as a function of which of the four geographic areas the voyage originated or was destined. As may be seen, the vast majority of Area A traffic (96%) uses the Santa Barbara Channel TSS, and nearly as large a percentage (86%) of vessels to/from Area D use the Gulf of Santa Catalina TSS.

Table C-1 also shows the route usage as a function of geographic origin and destination for tankers only, and for U.S. and foreign flag vessels. Only one significant difference in route usage may be seen because of the type or flag of the ships; foreign flas vessels to/from Area B (the Far East) use a route between the islands rather than the SBCTSS with a significantly higher frequency than do U.S. flag vessels.

Table C-2 illustrates, for all vessels, the routing choices as determined from the 1979 boarding survey, from the 1976 boarding survey which was heavy on tanker data, and for the combination of the two surveys. When the two surveys are combined, the tankers then represent 20% of the total number of ships surveyed. This is reasonably close to the 25 to 30% of vessels calling at Los Angeles and Long Beach which are tankers. These figures are given in the chart below.

1979: All ships	1106,	tankers	83	=	8%
1976: All ships	427,	tankers	231	=	54%
combined:	1533		314	=	20%

An overall route summary is given in Table C-3. From this table it is seen that approximately 2/3 of the vessels surveyed use the SBCTSS on either or both of their incoming or departing routes, while less than 15% (14% in 1976, 10% in 1979) use a route anywhere between the islands.

It appears from Table C-3 that there was a lower incidence of usage of the routes outside the islands in 1979 than in 1976. The size of the data base is large, and it may be postulated with 95% confidence that vessel usage of routes outside and between the islands (routes 2 and 3) has decreased from 1976 to 1979. The differences in the proportion of tankers included in the two years of data may cloud this conclusion somewhat, although on an overall vessel basis it appears to be the case.

There were seven foreign flag ships which did not use the GSCTSS when approaching LA/LB from the south. Several of these noted that they sailed closer to the coast than the TSS.

C.2.2 ROUTE CHOICES

The boarding survey included asking the ship masters (or mates) their reasons for the choice of route to LA/LB. The answers are tabulated below:

Reason	No. of Replies
Shortest Distance	423 (75%)
Like to use the TSS	62 (11%)
Scheduling or berth availability	56 (10%)
Weather considerations	10 (2%)
Vessel traffic considerations	8 (1%)
Tides	2 (–%)

TABLE C-1. 1979 USCG ROUTING SURVEY, PORTS OF LA/LB

To/From	Area A		Area B		Area C		Area D	
All Vessels								
SBC TSS	436/447 =	96%	264/325 =	81%	16/52 =	31%	0/282 =	0%
Route 2	12	3%	19	6%	6	12%	14	5%
Route 3	5	1%	16	5%	14	26%	23	8%
GSC TSS	0	0%	26	8%	16	31%	245	87%
For Tankers								
SBC TSS	35/42 =	83%	6/13 =	46%	4/6 =	67%	0/22 =	0%
Route 2	3	7%	0	0%	0	0%	0	0%
Route 3	4	10%	4	31%	2	33%	2	9%
GSC TSS	0	0%	3	23%	0	0%	20	91%
For U.S. Vessels								
SBC TSS	75/80 =	94%	14/14 =	100%	7/18 =	39%	0/25 =	0%
Route 2	3	4%	0	0%	3	17%	0	0%
Route 3	2	2%	0	0%	5	27%	2	8%
GSC TSS	0	0%	0	0%	3	17%	23	92%
Foreign Flag Vessels								
SBC TSS	355/367 =	97%	250/311 =	80%	9/34 =	27%	0/257 =	0%
Route 2	9	2%	19	6%	3	9%	14	6%
Route 3	3	1%	16	5%	9	26%	21	8%
GSC TSS	0	0%	26	9%	13	38%	222	86%

TABLE C-2. COMBINED DATA FROM 1976 AND 1979 ROUTING SURVEYS

To/From Area	Route	1979		1976		Combined	
A	SBC TSS	430/477 =	96%	152/164 =	93%	582/611 =	95%
	Route 2	12	3%	7	4%	19	3%
	Route 3	5	1%	5	3%	10	2%
	GSC TSS	0	0%	0	0%	0	0%
B	SBC TSS	264/325 =	81%	90/131 =	69%	354/456 =	78%
	Route 2	19	6%	17	13%	36	8%
	Route 3	16	5%	13	10%	29	6%
	GSC TSS	26	8%	11	8%	37	8%
C	SBC TSS	16/52 =	31%	10/25 =	40%	26/77 =	34%
	Route 2	6	12%	4	16%	10	13%
	Route 3	14	26%	6	24%	20	26%
	GSC TSS	16	31%	5	20%	21	27%
D	SBC TSS	0/282 =	0%	0/107 =	0%	0/389 =	0%
	Route 2	14	5%	3	2%	17	4%
	Route 3	23	8%	5	5%	28	7%
	GSC TSS	245*	87%	99	93%	344	88%

*Includes seven vessels use southerly approach to LB, but not adhering to the GSC TSS.

TABLE C-3. OVERALL ROUTE USAGE ANALYSIS

	1979		1976		Combined	
SBC TSS	710/1106 =	64%	252/427 =	59%	962/1533 =	63%
Route 2	51	5%	31	7%	82	5%
Route 3	58	5%	29	7%	87	6%
GSC TSS	287	26%	115	27%	402	26%

C.2.3 NAVIGATIONAL CONSIDERATIONS

The survey requested reporting of any navigational considerations or problems encountered enroute LA/LB. A relatively small number of replies were provided by the vessel masters or mates. These are tabulated below.

Problem or Consideration	No. of Replies
Recreational vessels crossing path	74 (13%)
Fishing vessel traffic	46 (8%)
Oil structures in/near TSS	14 (2%)
Aids to navigation problems	3 (–%)
Navy ship traffic	1 (–%)

C.2.4 OTHER COMMENTS RECEIVED

A number of the ship masters interviewed during the routing survey provided additional comments concerning navigational problems or routes to LA/LB. Thirty-one of these comments were significantly different enough from the categorization supplied on the questionnaire to warrant separate summary.

The comments are listed in Table C-4, with annotation as to the type and flag of ship making the comment.

TABLE C-4. COMMENTS RECEIVED FROM SHIP MASTERS

Comment	No. rcvd.	U.S. Flag tkr	U.S. Flag other	For. Flag tkr	For. Flag other
1. Suggest bigger and/or brighter buoy at entrances to LA/LB	5			1	4
2. Extend TSS northward to San Francisco	5	1			4
3. Keep drilling rigs out of/away from TSS	5		4		1
4. Make TSS wider	3				3
5. Would travel south of Channel Islands if TSS not in Santa Barbara Channel	2		1		1
6. Suggest checkpoint on Anacapa Island	1	1			
7. Does not comply with TSS	1				1
8. Suggest move SBC TSS outside of Channel Islands	1				1
9. Make entrance buoys at LA and LB different in appearance	1				1
10. Area RDF is not very good	1				1
11. Experienced traffic problem at north end of SBC TSS	1				1
12. Need more specific TSS in area of port entrance	1	1			
13. Suggest use of a traffic circle at LA/LB similar to that at New Orleans	1				1
14. Would like pilot aboard in SBC TSS	1				1
15. GSC TSS too close to Navy operations	1				1
16. Suggest channel 20 or 22 VHF for ships' use only	1				1

REFERENCES — APPENDIX C

1. Draft Vessel Traffic Analysis, John J. McMullen Associates, Inc. for California Public Utilities Commission, December 1977.

2. Port of Los Angeles, Port Master Plan, July 1979.

3. Port of Los Angeles, Coal Handling Capabilities, February 1979.

APPENDIX D

SANTA BARBARA CHANNEL RISK MANAGEMENT PROGRAM

TASK 1.3 CLIMATOLOGICAL DATA EXTRACTS

PREFACE

This document contains a compilation of extracts from previous studies which provide statistics and descriptions of the climatology of the Santa Barbara Channel. It is intended to be used as a source of information for assignment of realistic weather and sea conditions during the risk management study trials or runs at the Computer Aided Operations Research Facility (CAORF).

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17 April 1980

SECTION D-1

DATA EXTRACTS FROM CLIMATOLOGICAL STUDY, SOUTHERN CALIFORNIA OPERATING AREA

The following charts are extracted from **Climatological Study, Southern California Operating Area,** prepared by the National Climatic Center (NCC) for the U.S. Naval Weather Service, Fleet Weather Facility, San Diego, California, in March 1971.

Monthly isopleths illustrating the following climatological and oceanographic conditions are presented:

(1) Percentage frequency of occurrence of wind speed 11-21 knots

(2) Percentage frequency of occurrence of wind speed $\leqslant$ 6 knots and $\geqslant$ 34 knots

(3) Mean air temperature

(4) Mean sea surface temperature

(5) Prevailing current direction and mean current speed (knots)

(6) Percentage frequency of occurrence of wave height $>$ 2 feet and $>$ 6 feet

(7) Percentage frequency of occurrence of wave height $>$ 9 feet and $>$ 12 feet

The final section contains maps illustrating percentage frequencies of occurrence of various ranges of visibility (nautical miles) within four 1/2-degree quadrangles which encompass the Channel.

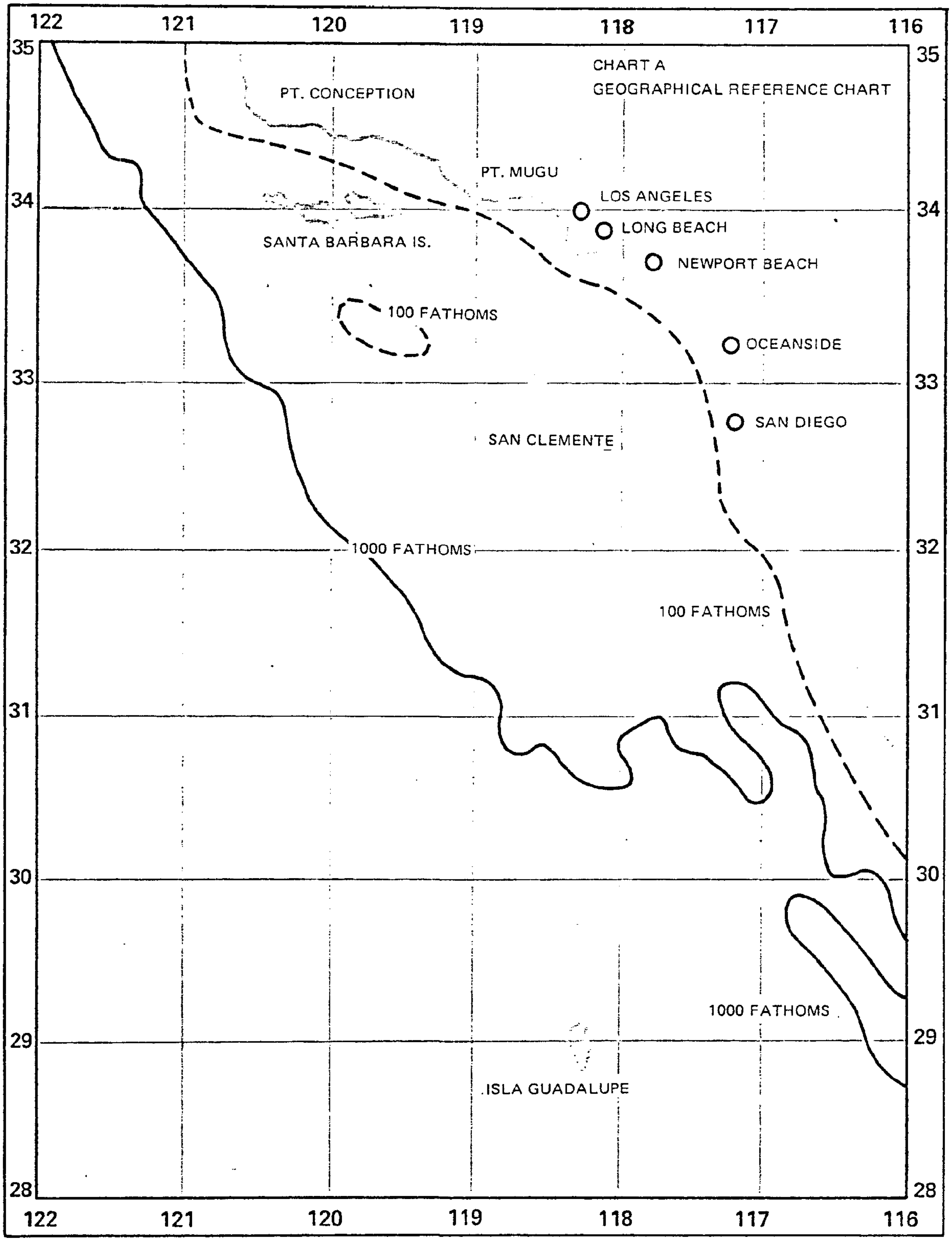


CHART A
GEOGRAPHICAL REFERENCE CHART
PT. CONCEPTION
PT. MUGU
LOS ANGELES
LONG BEACH
NEWPORT BEACH
SANTA BARBARA IS.
100 FATHOMS
OCEANSIDE
SAN DIEGO
SAN CLEMENTE
1000 FATHOMS
100 FATHOMS
1000 FATHOMS
ISLA GUADALUPE
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28

Percentage Frequency of Occurrence of Wind Speed 11-21 Knots

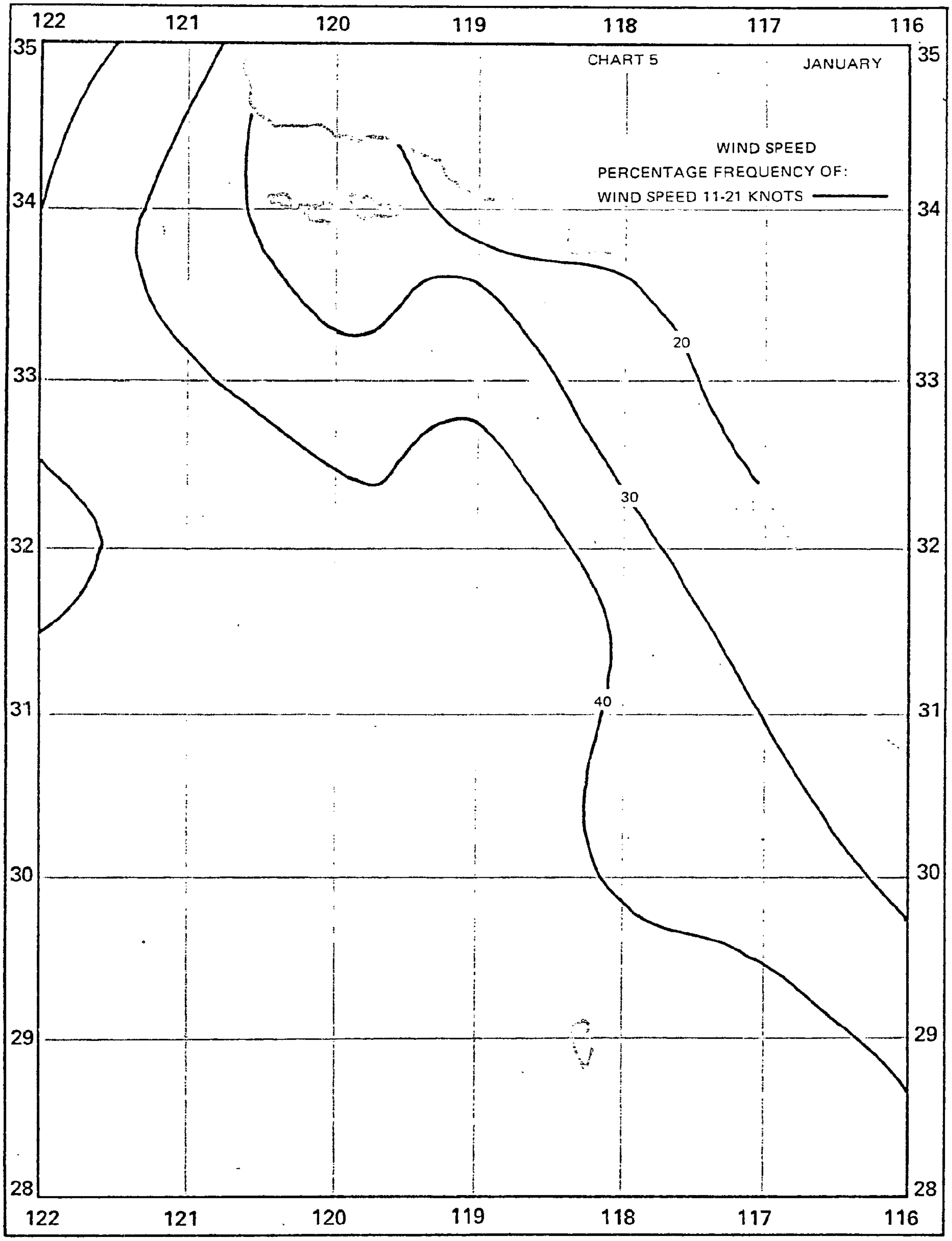


CHART 5
JANUARY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
20
30
40
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28

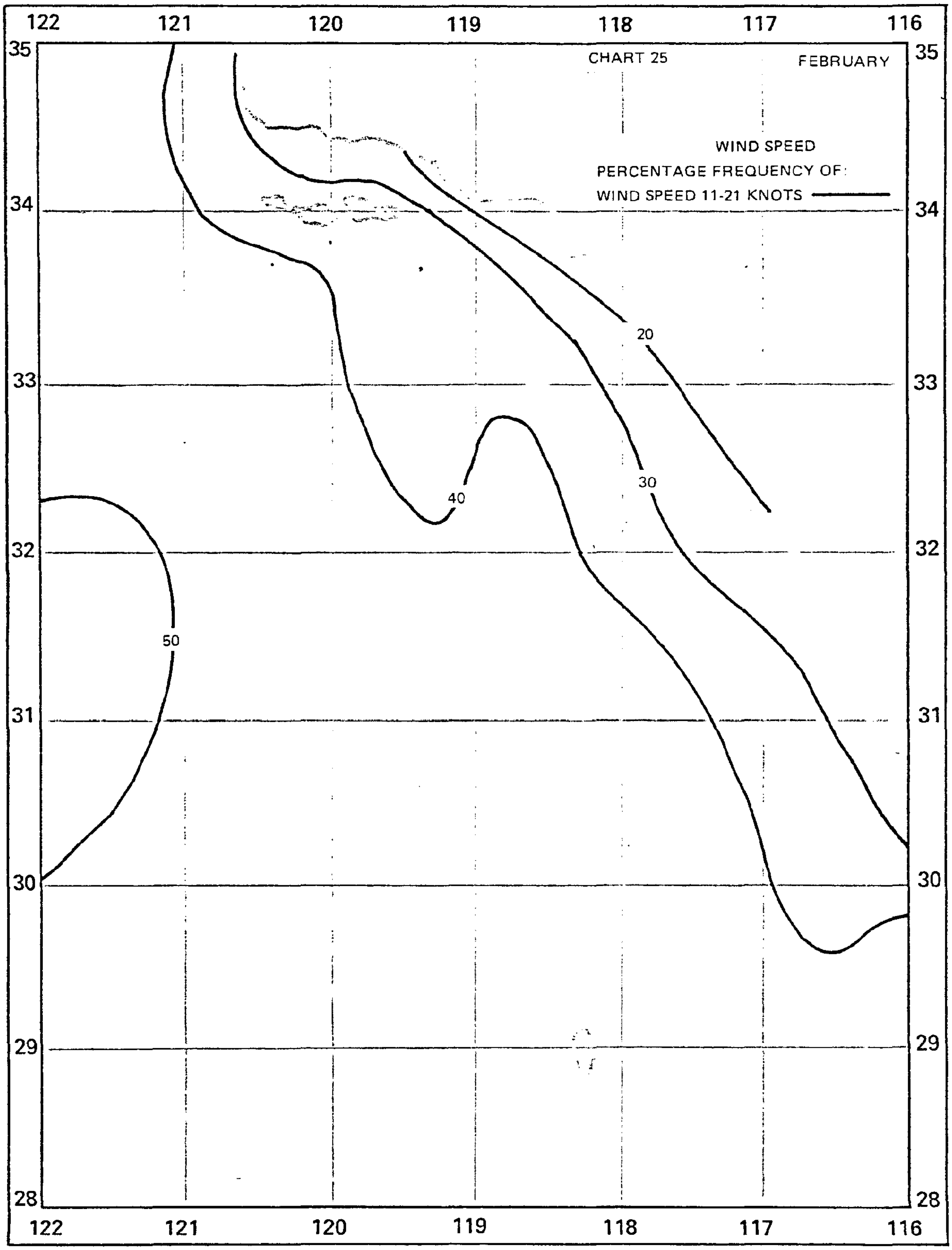
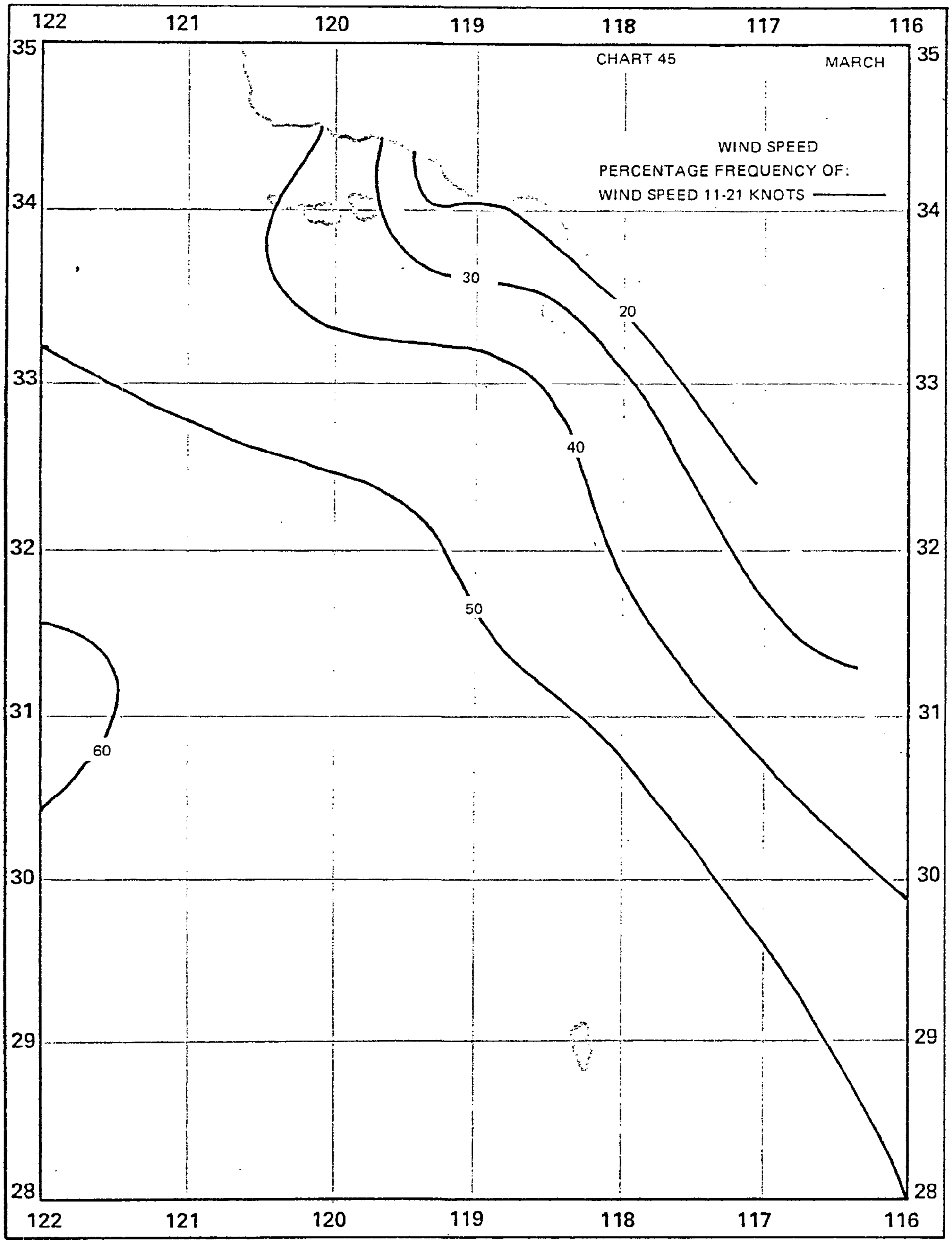


CHART 25
FEBRUARY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
30
40
50


122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 45
MARCH
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
20
30
40
50
60

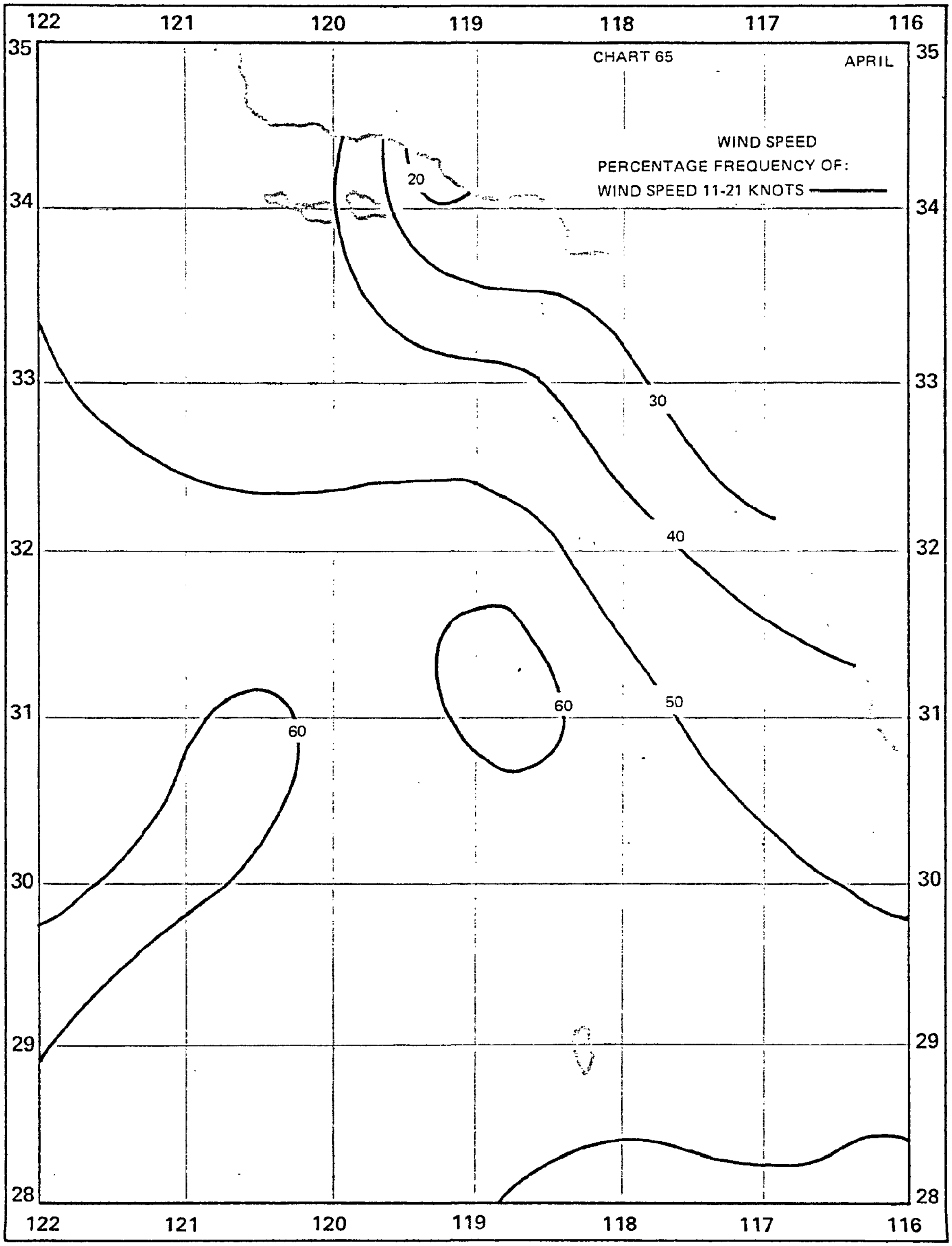


CHART 65
APRIL
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
30
40
50
60
60

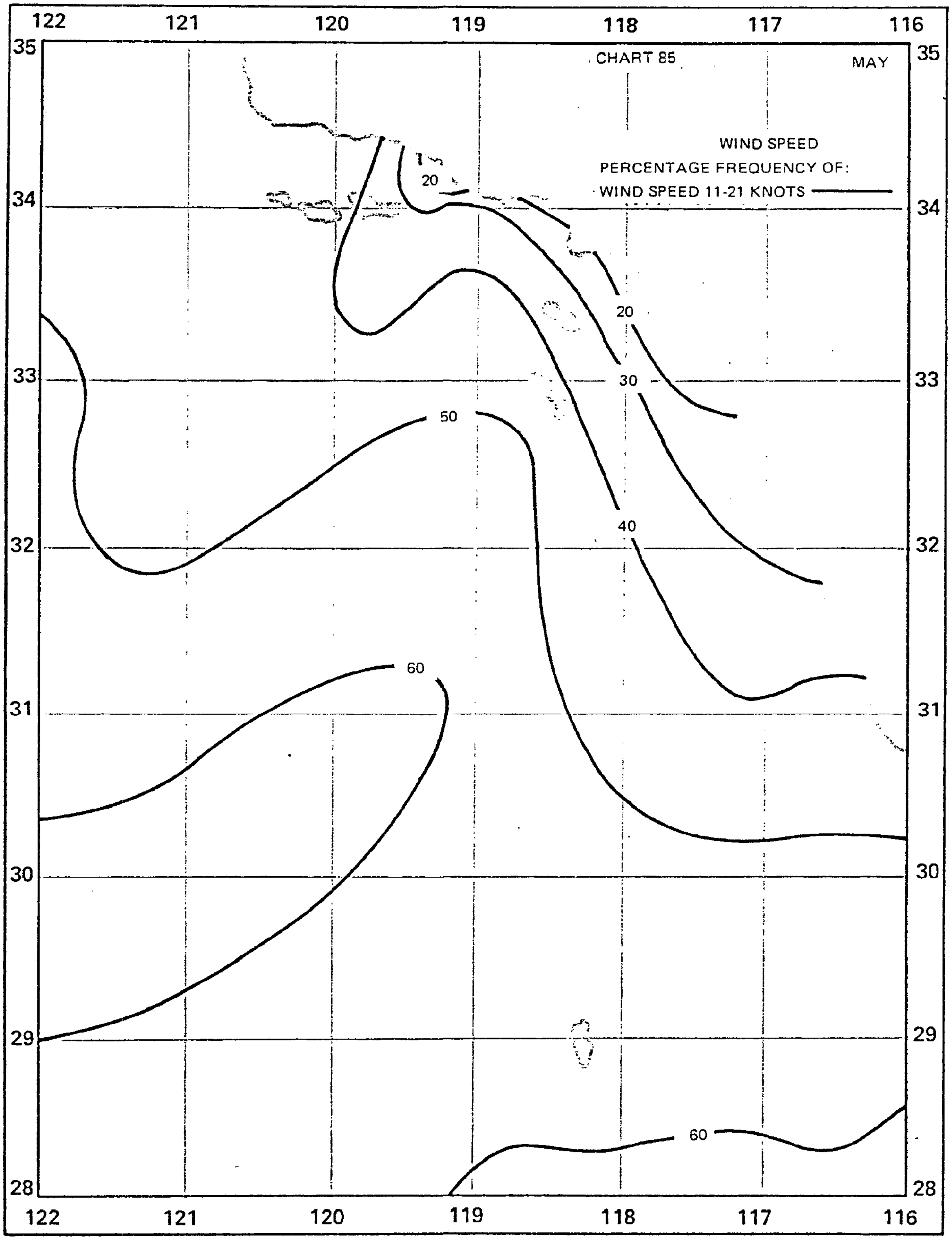


CHART 85
MAY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
20
20
30
40
50
60
60
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28

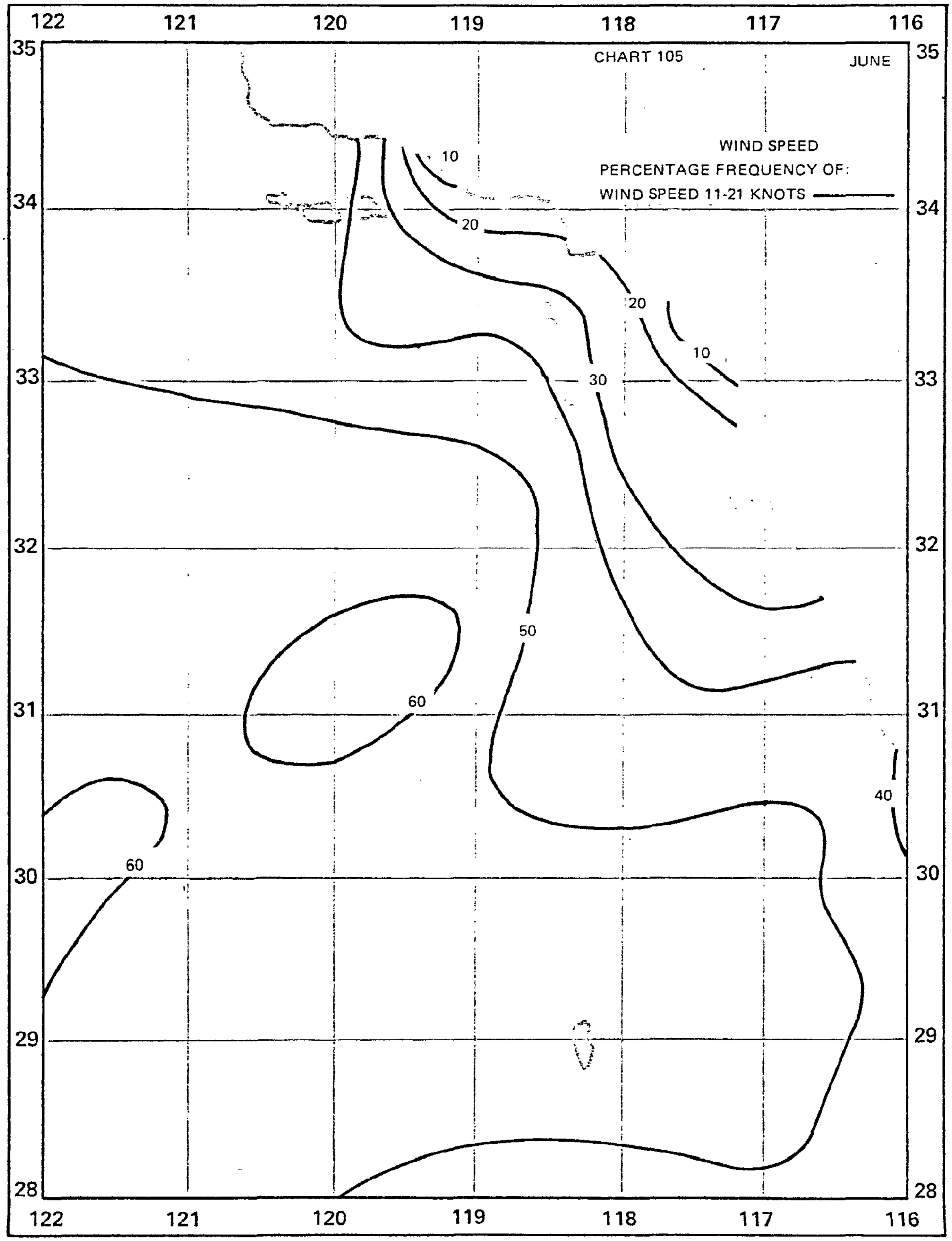


CHART 105
JUNE
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
10
20
30
50
60
40

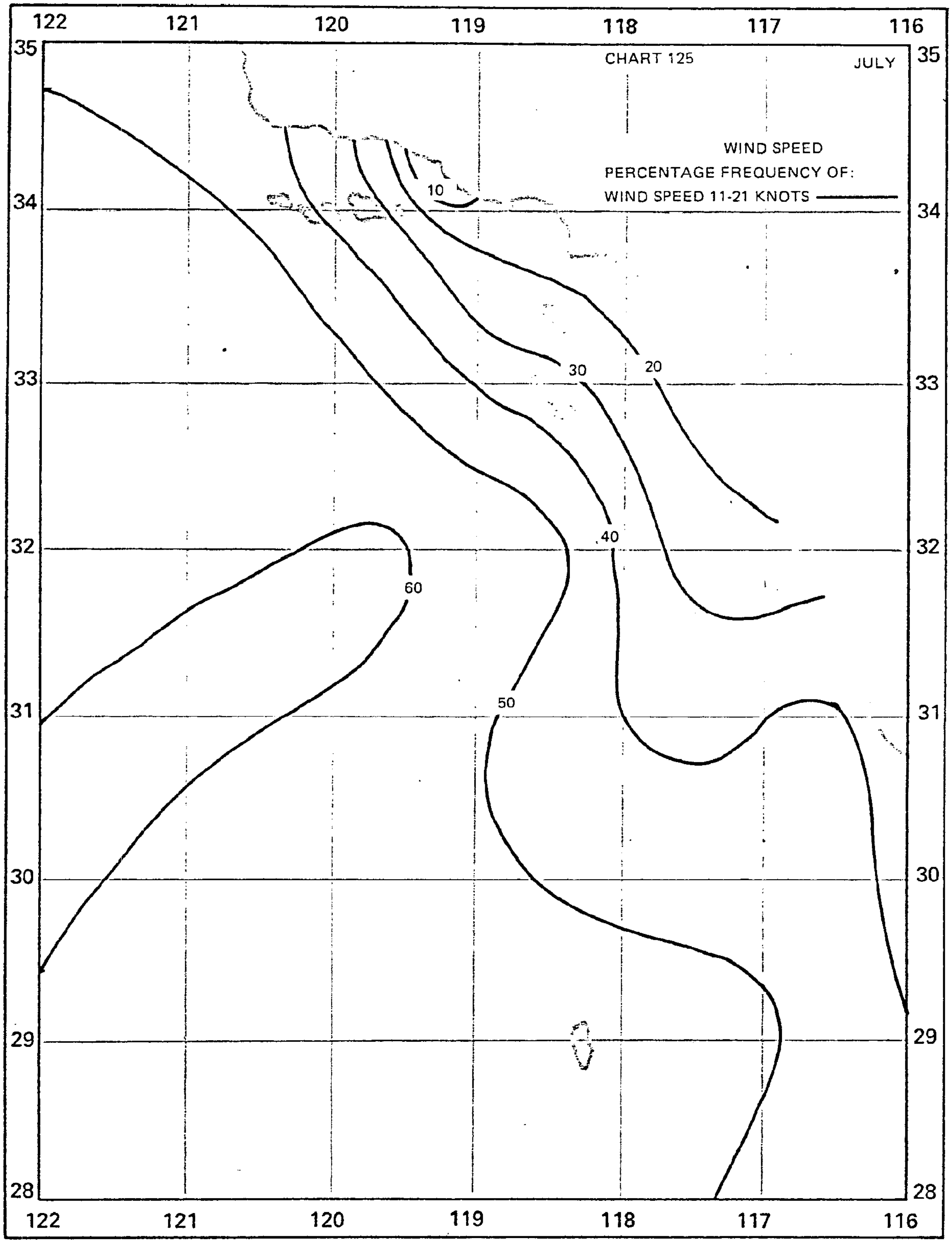


CHART 125
JULY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
10
20
30
40
50
60

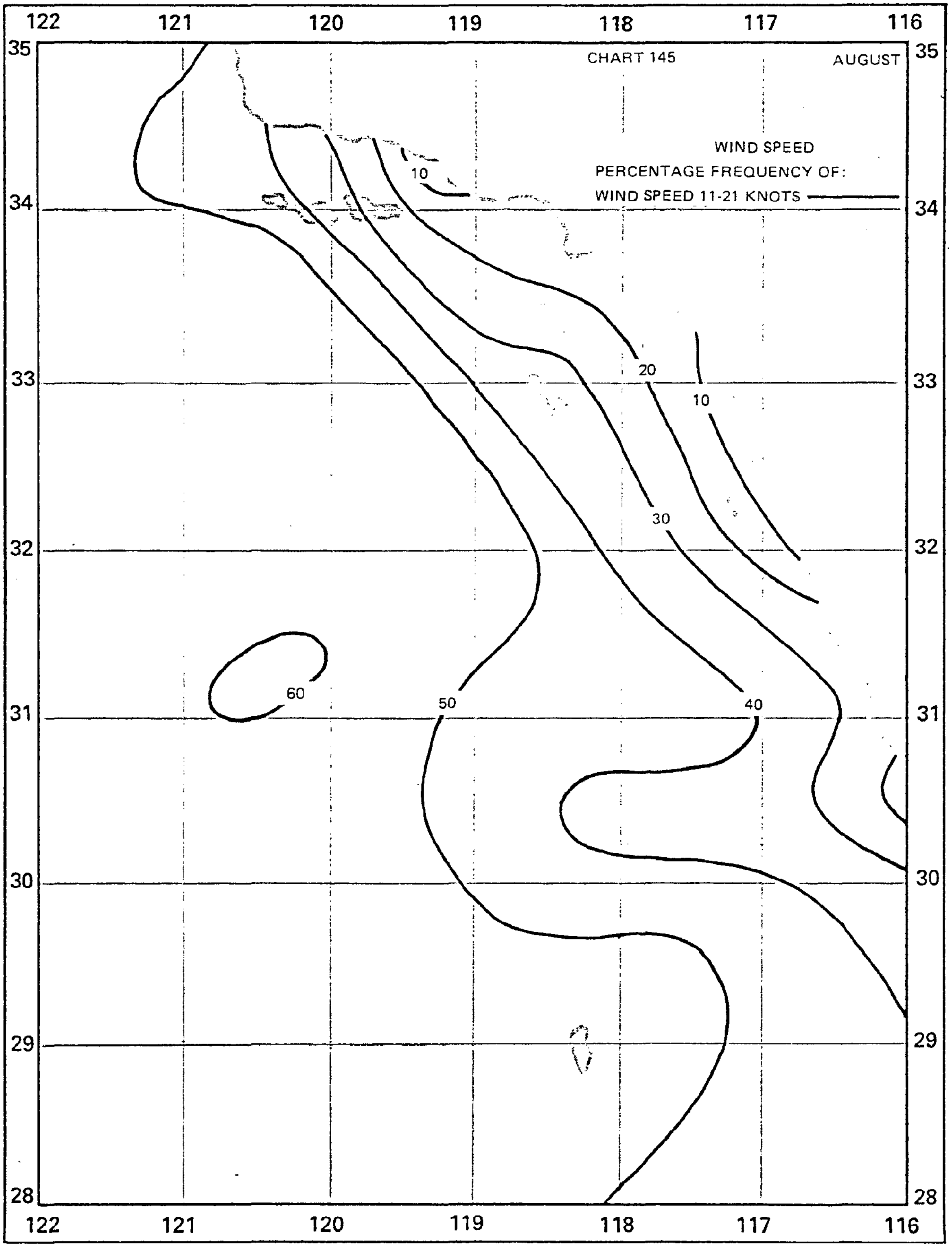


CHART 145
AUGUST
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
10
20
10
30
60
50
40

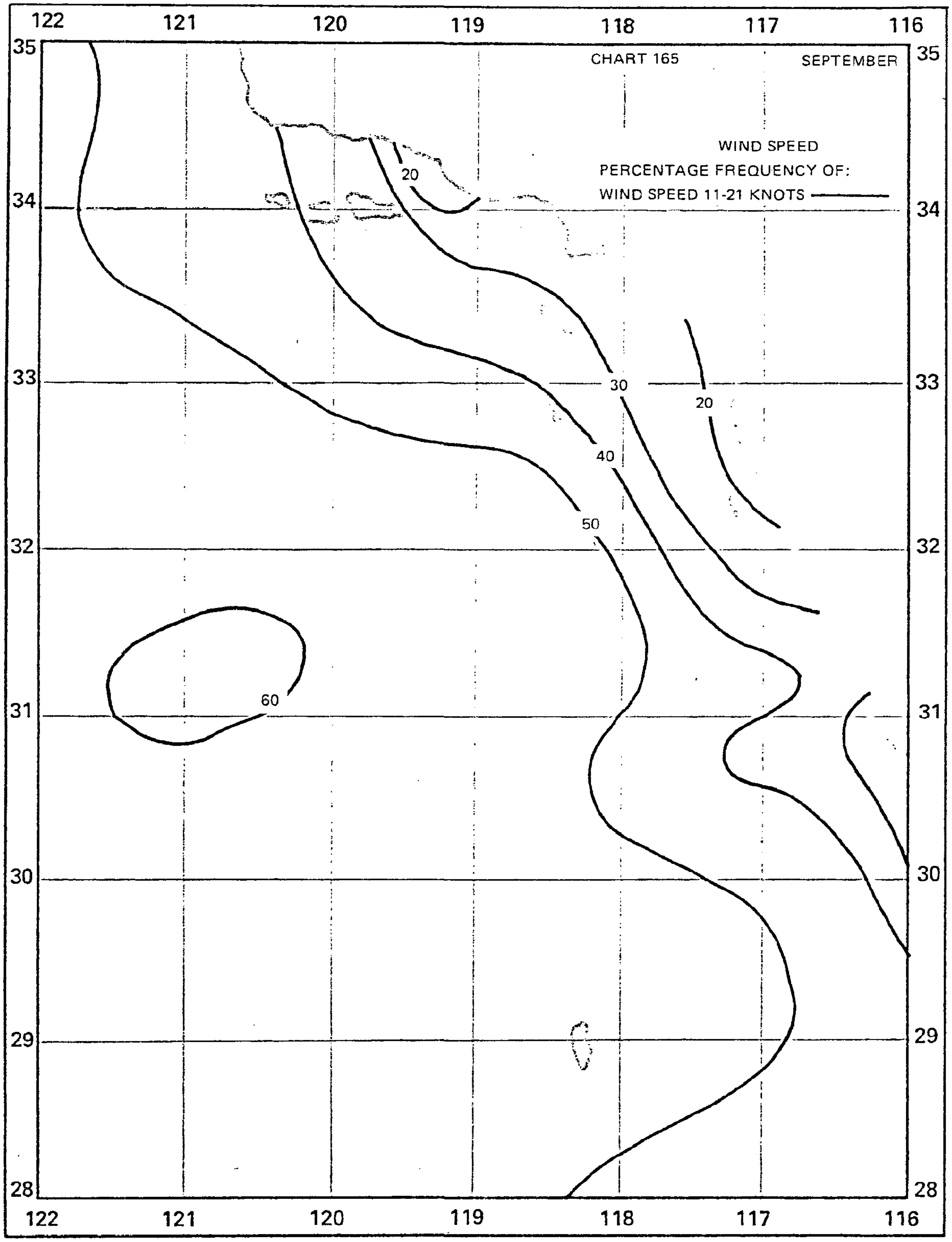
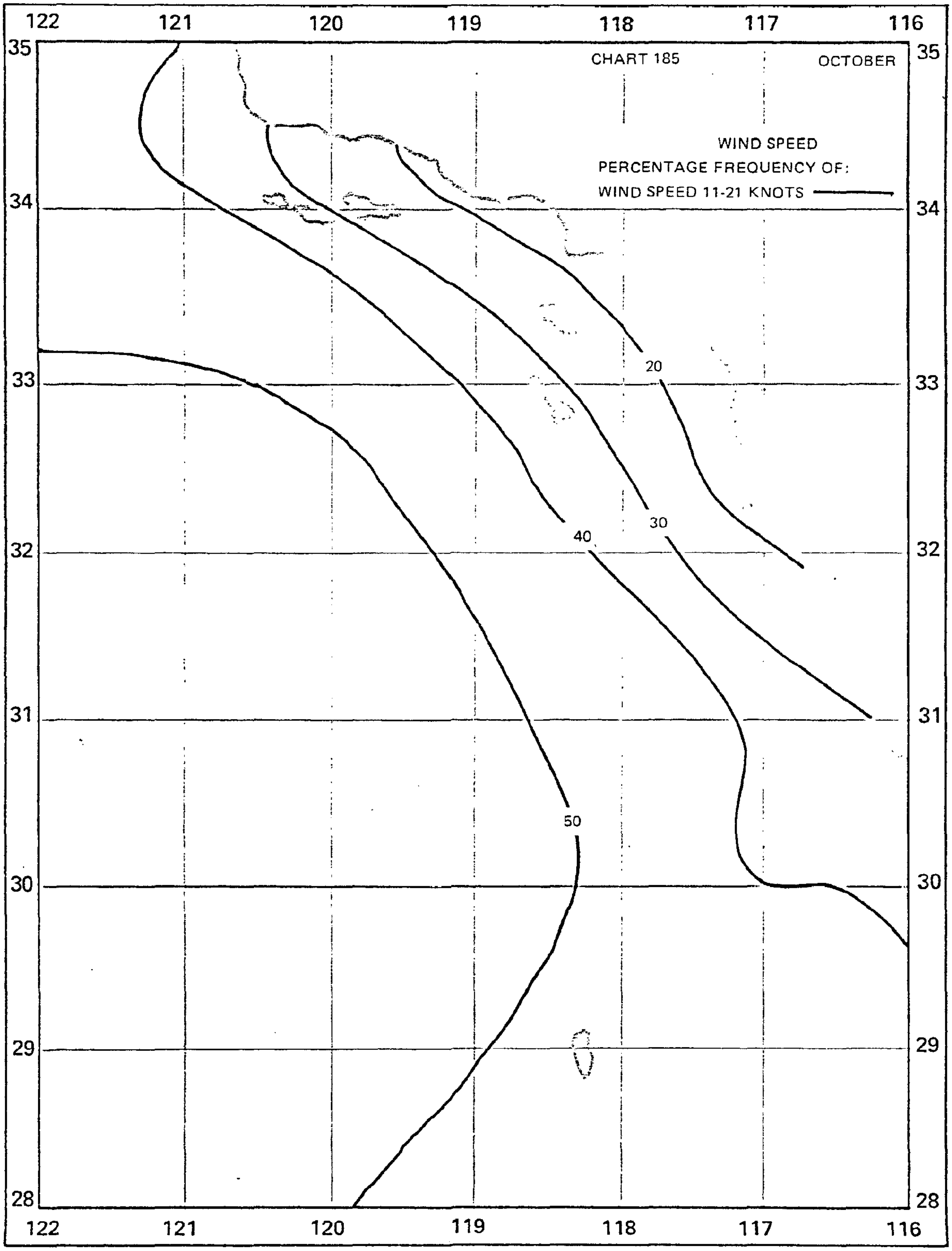


CHART 165
SEPTEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
20
30
20
40
50
60
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28



122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 185
OCTOBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
20
30
40
50

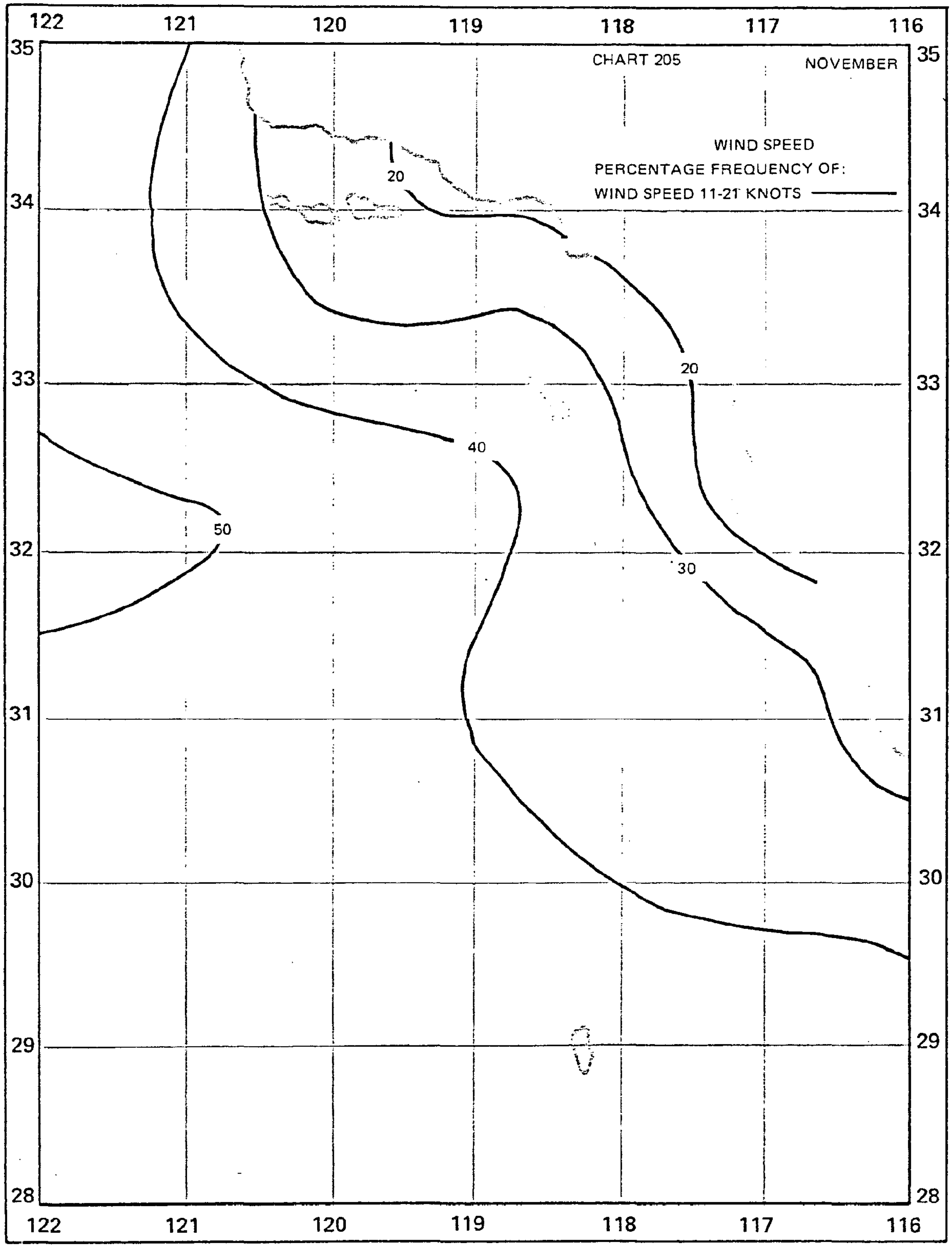
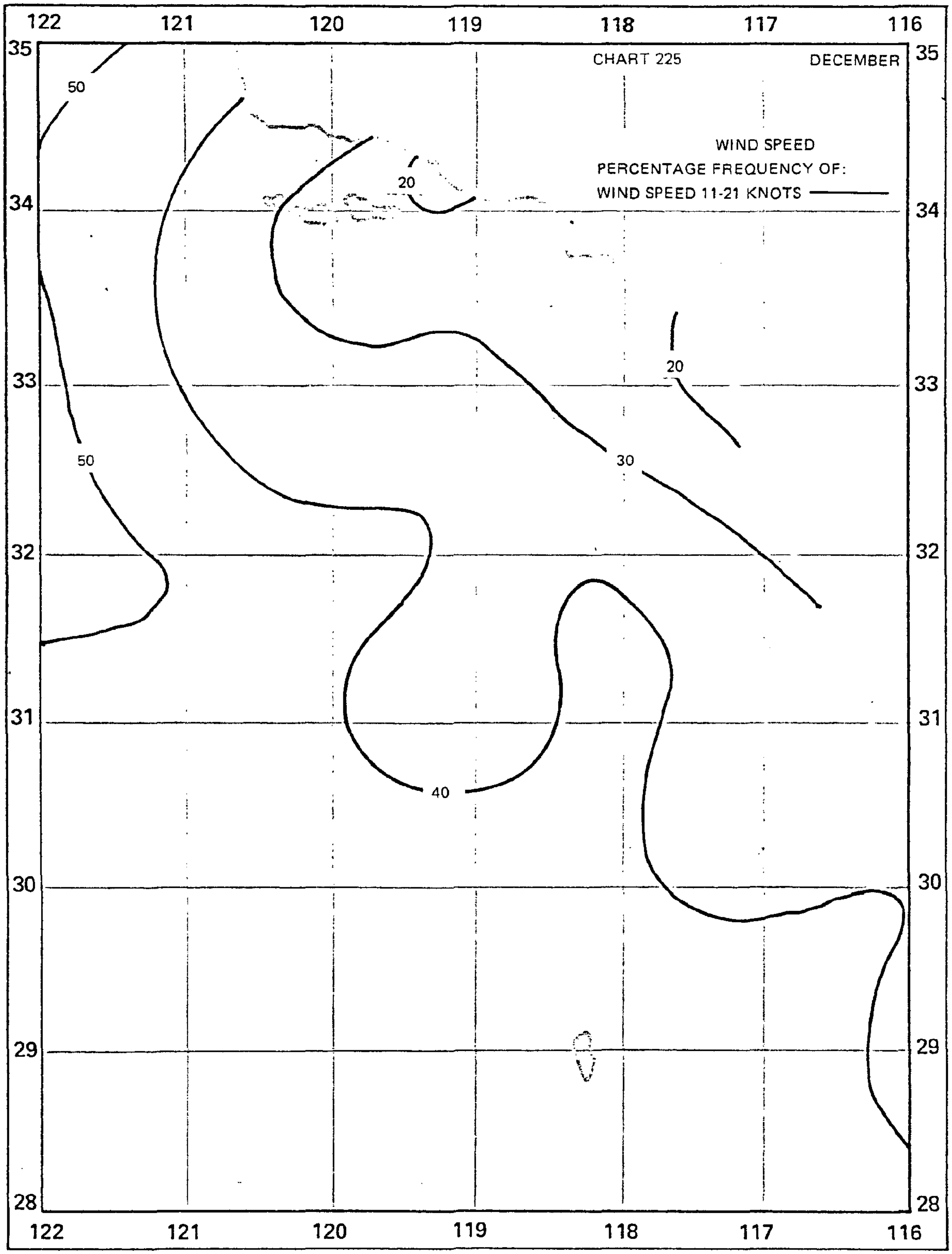


CHART 205
NOVEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
20
30
40
50



122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 225
DECEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED 11-21 KNOTS
50
20
30
40

Percentage Frequency of Occurrence of Wind Speed ≤ 6 Knots and ≥ 34 Knots

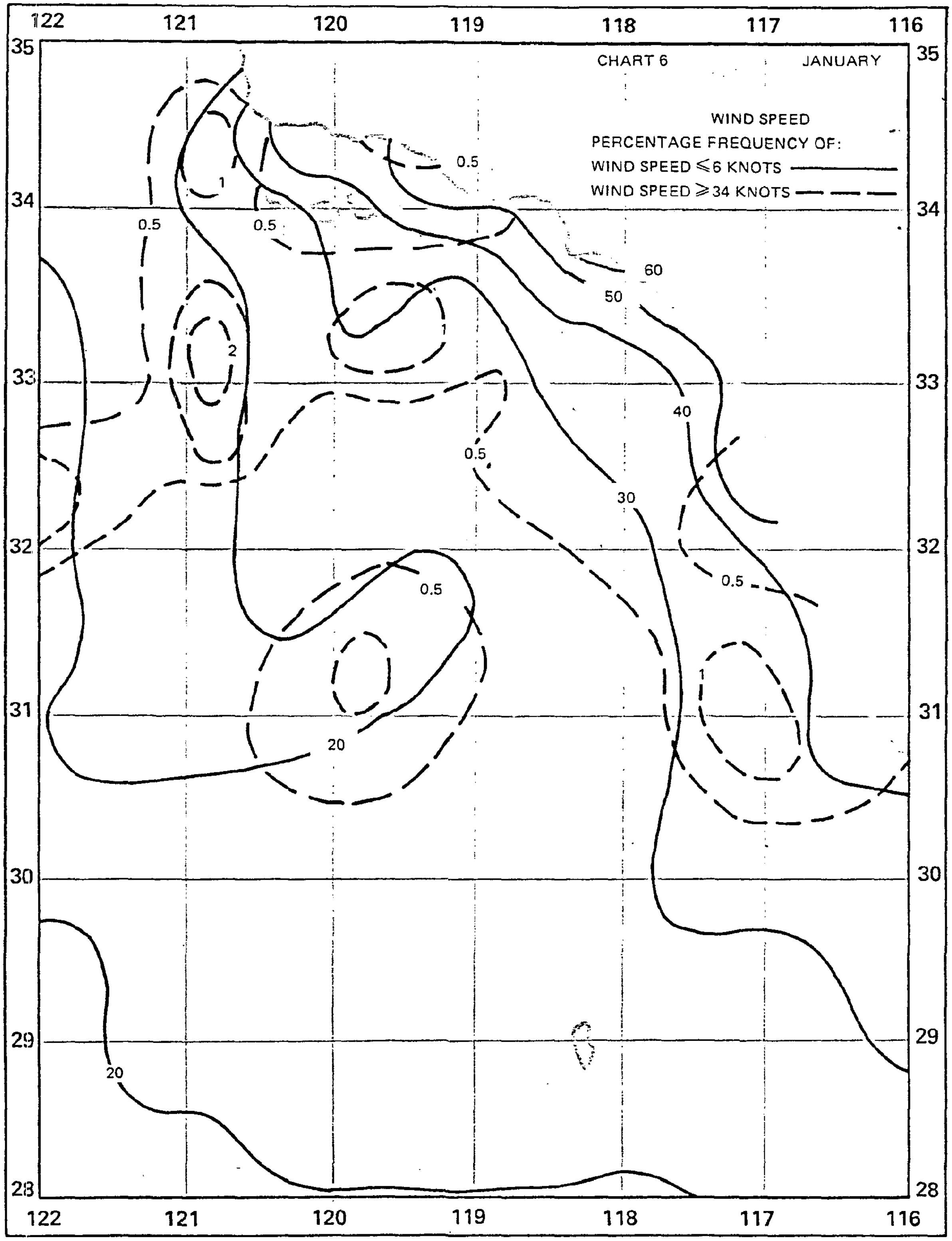


CHART 6
JANUARY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
0.5
1
2
20
30
40
50
60

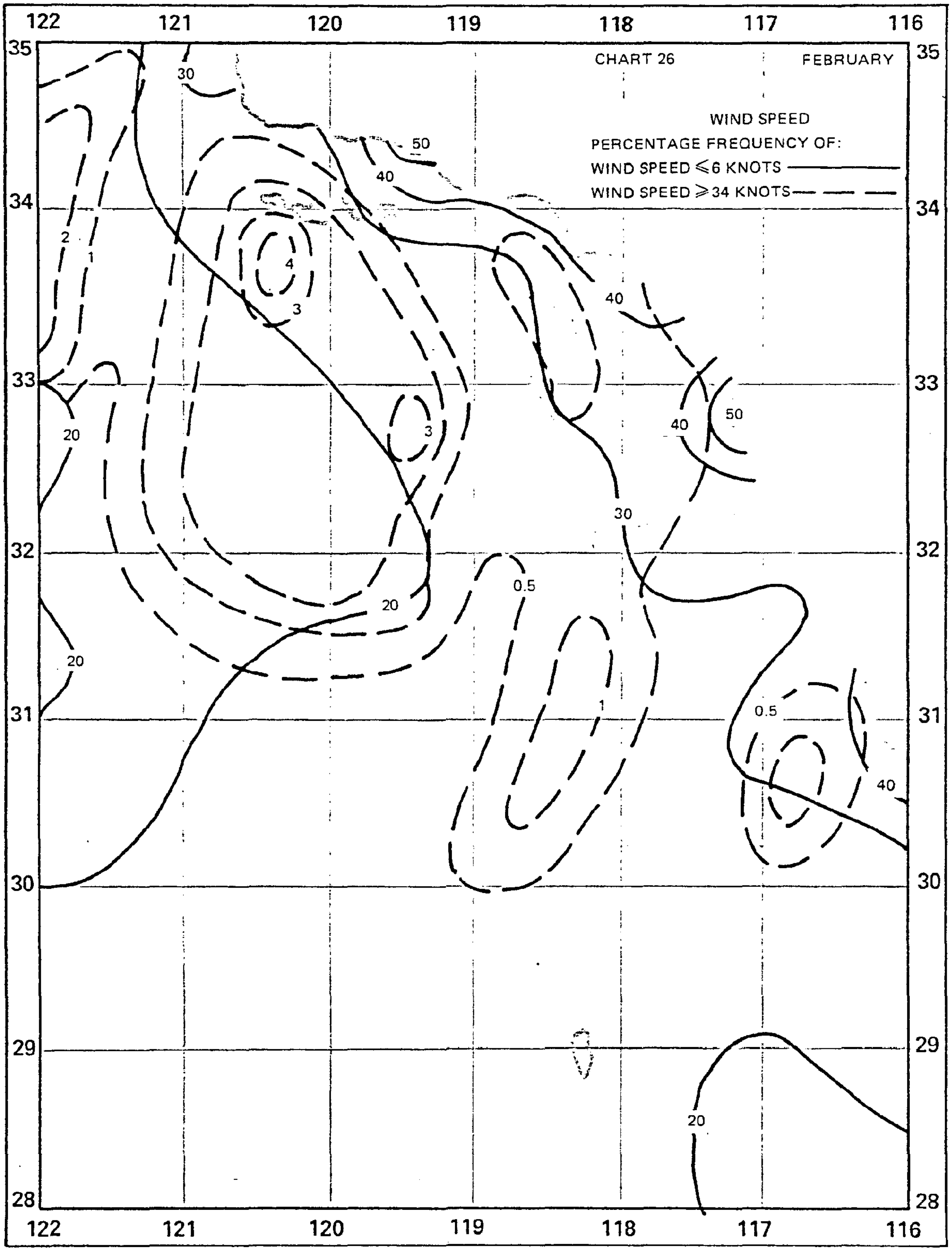


CHART 26
FEBRUARY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
50
40
30
20
4
3
2
1
0.5

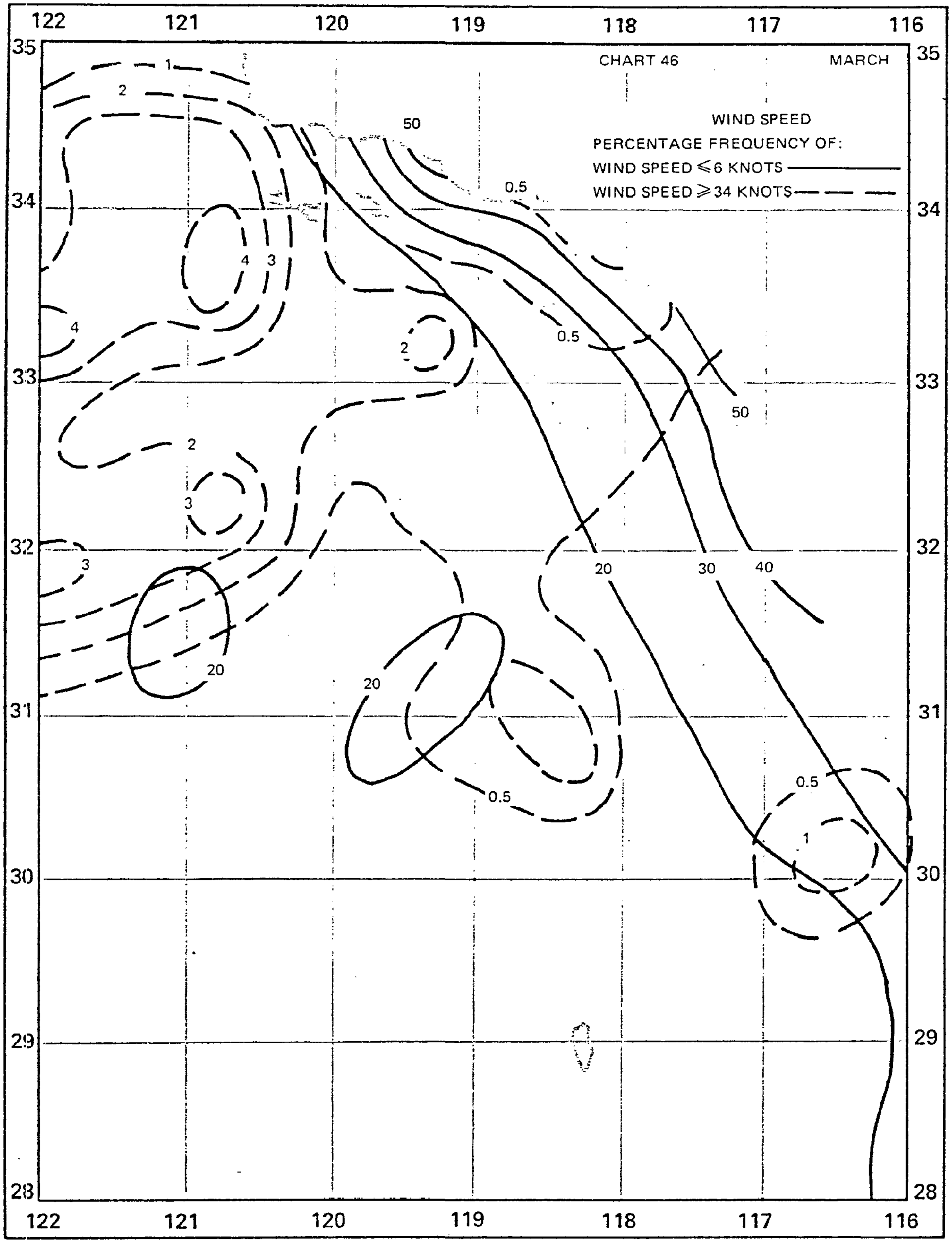


CHART 46
MARCH
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28

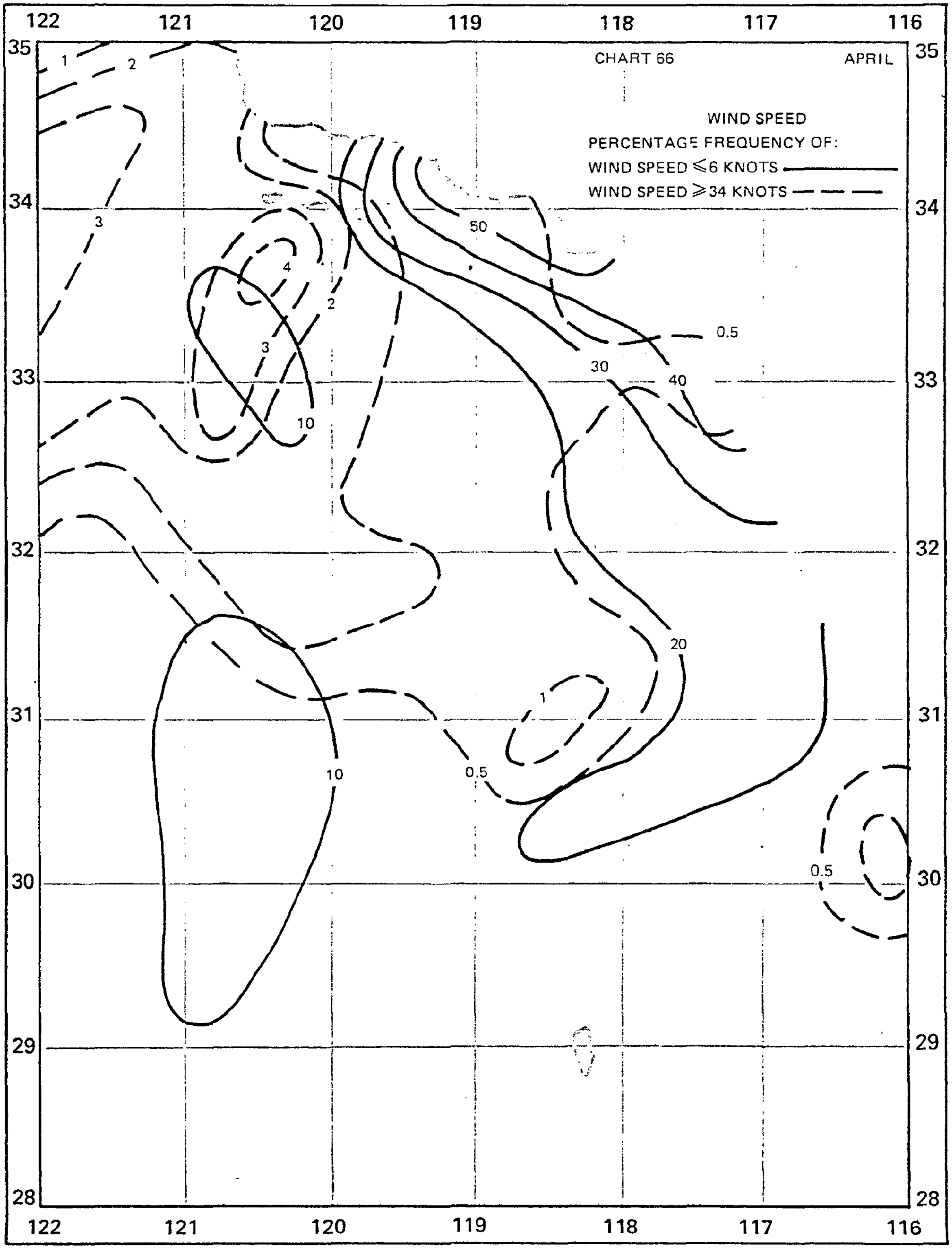


CHART 66
APRIL
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
1
2
3
4
10
50
30
40
0.5
20

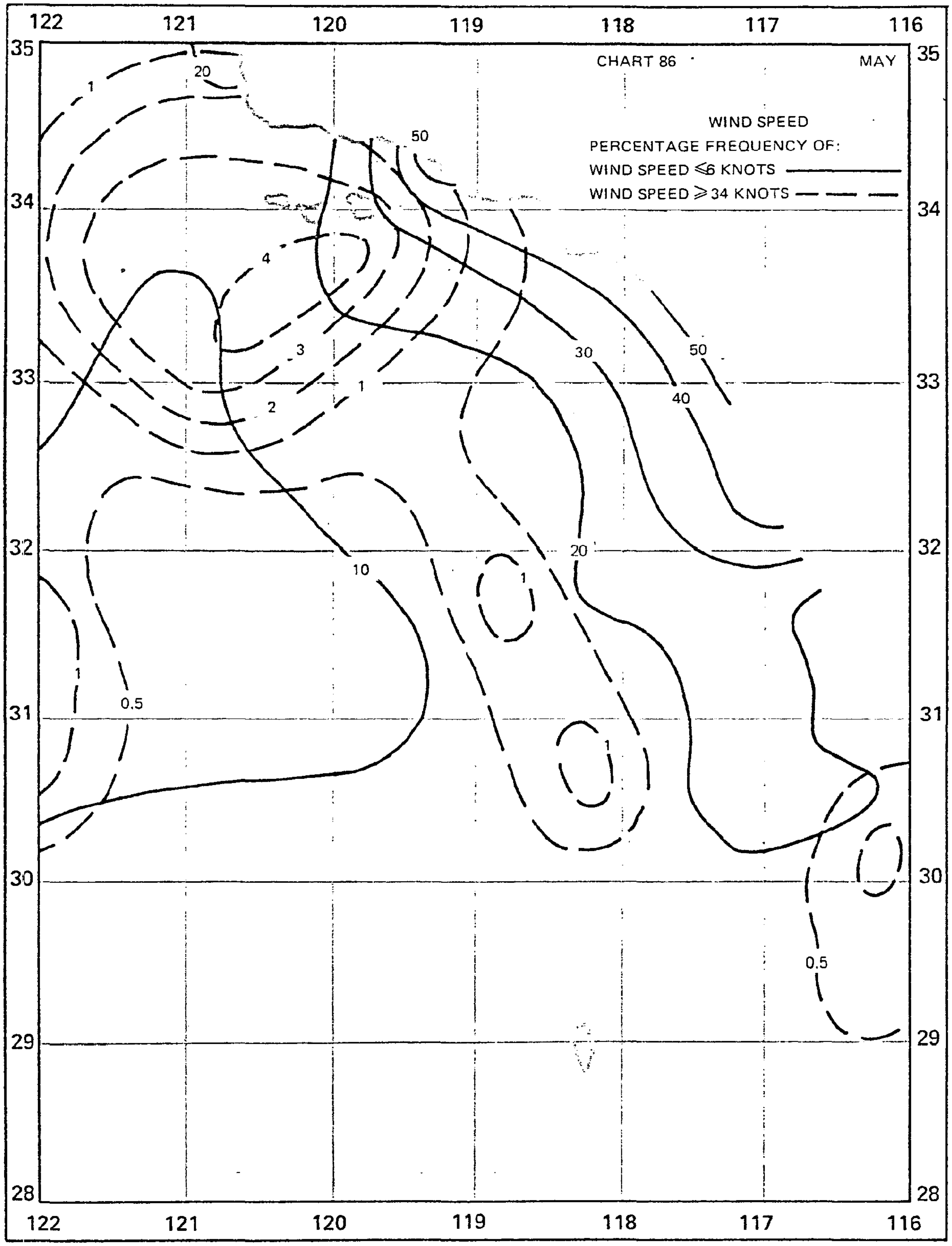
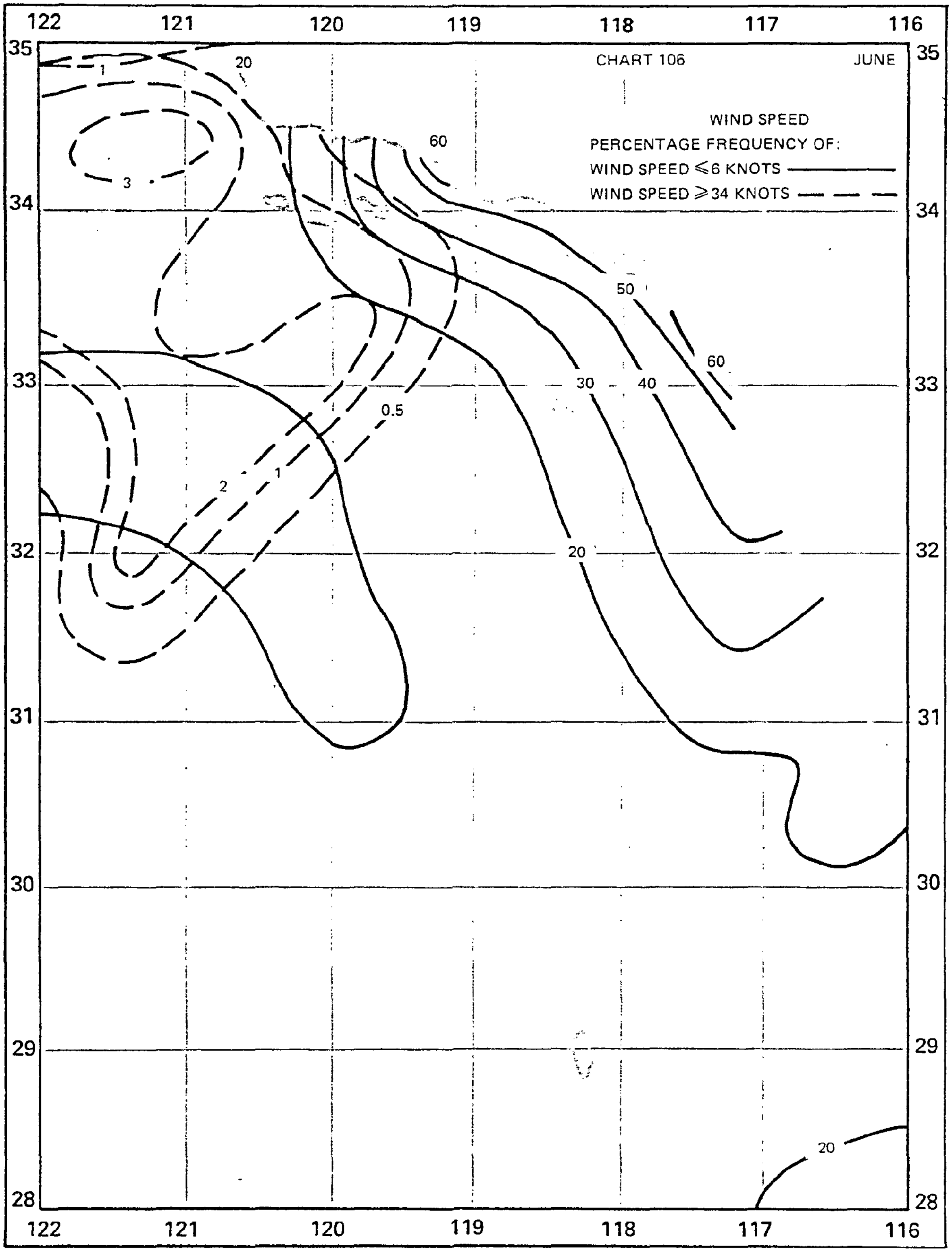


CHART 86
MAY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
1
50
4
3
2
1
30
50
40
10
20
1
1
0.5
1
0.5


122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 106
JUNE
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
20
1
3
60
50
60
30
40
0.5
2
1
20
20

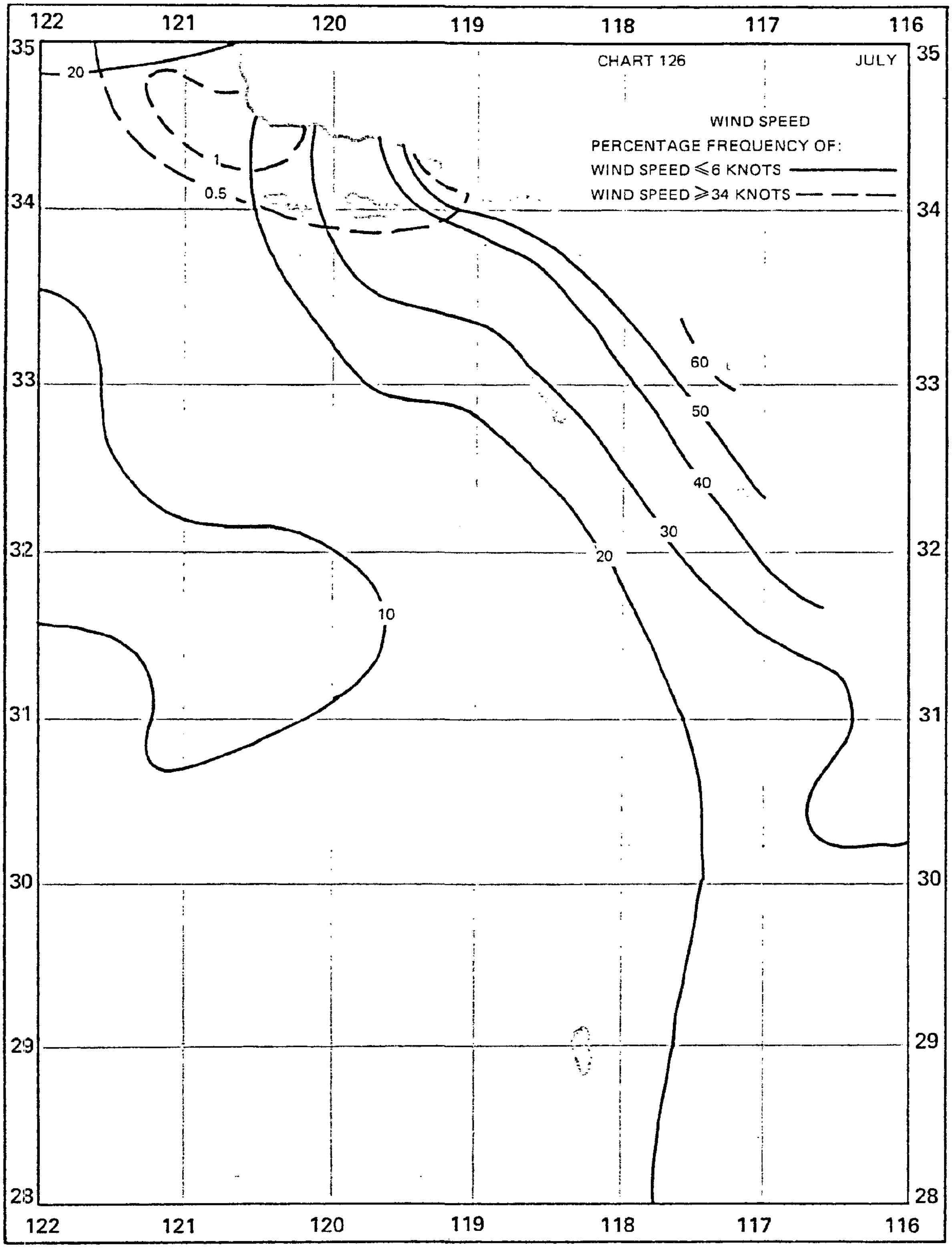


CHART 126
JULY
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
1
0.5
60
50
40
30
20
10

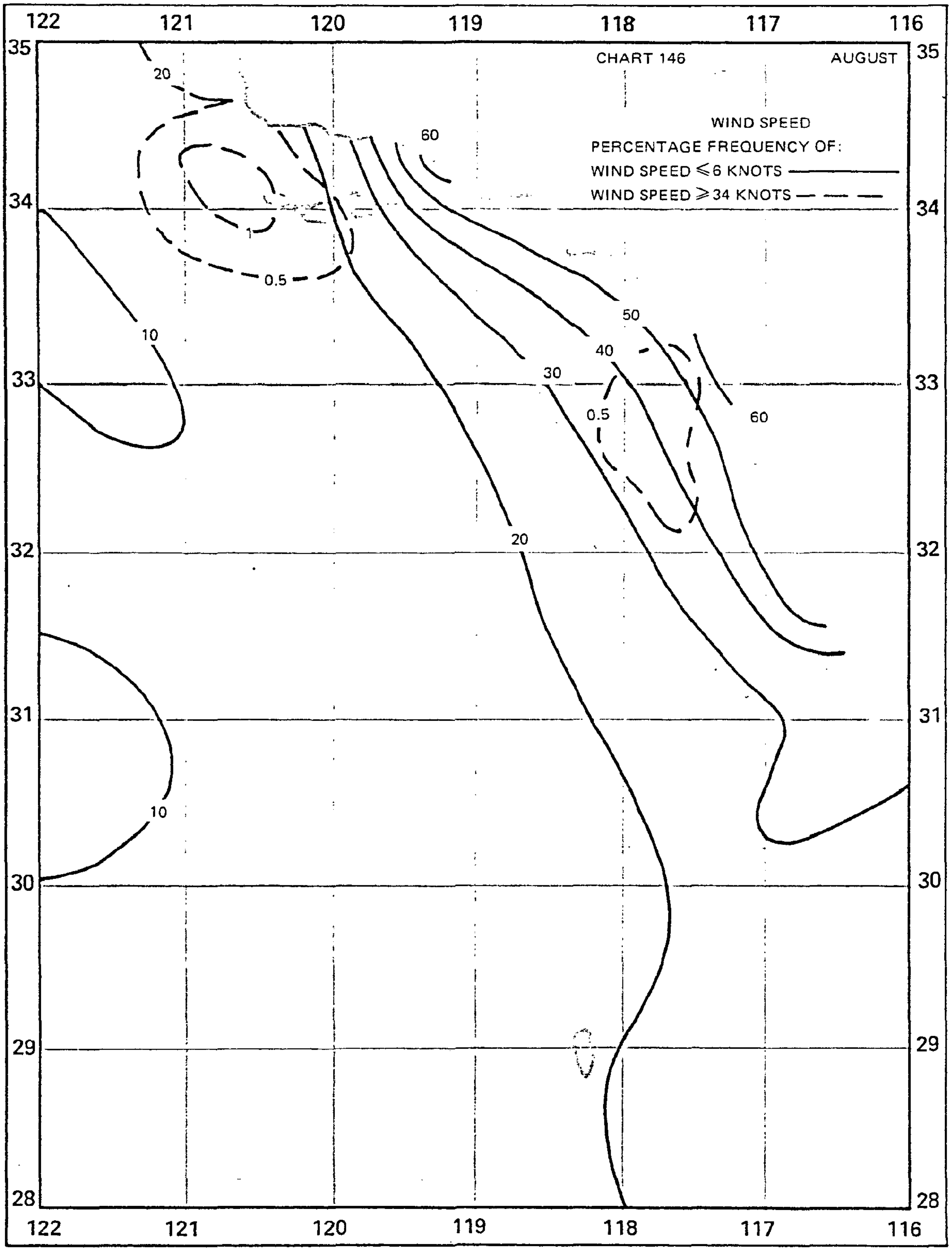


CHART 146
AUGUST
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
60
1
0.5
10
50
40
30
0.5
60
20
10

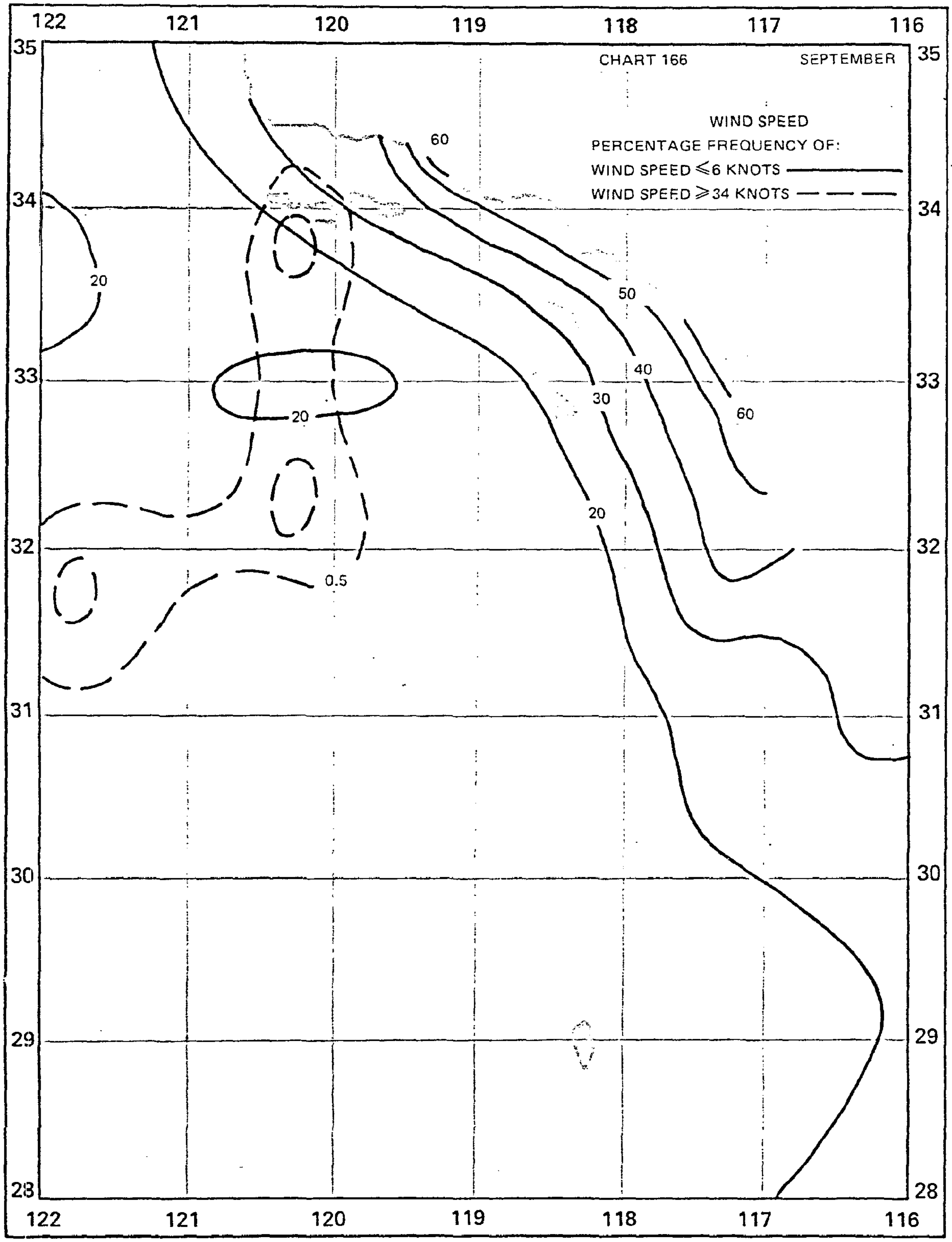


CHART 166
SEPTEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
60
50
40
30
20
0.5

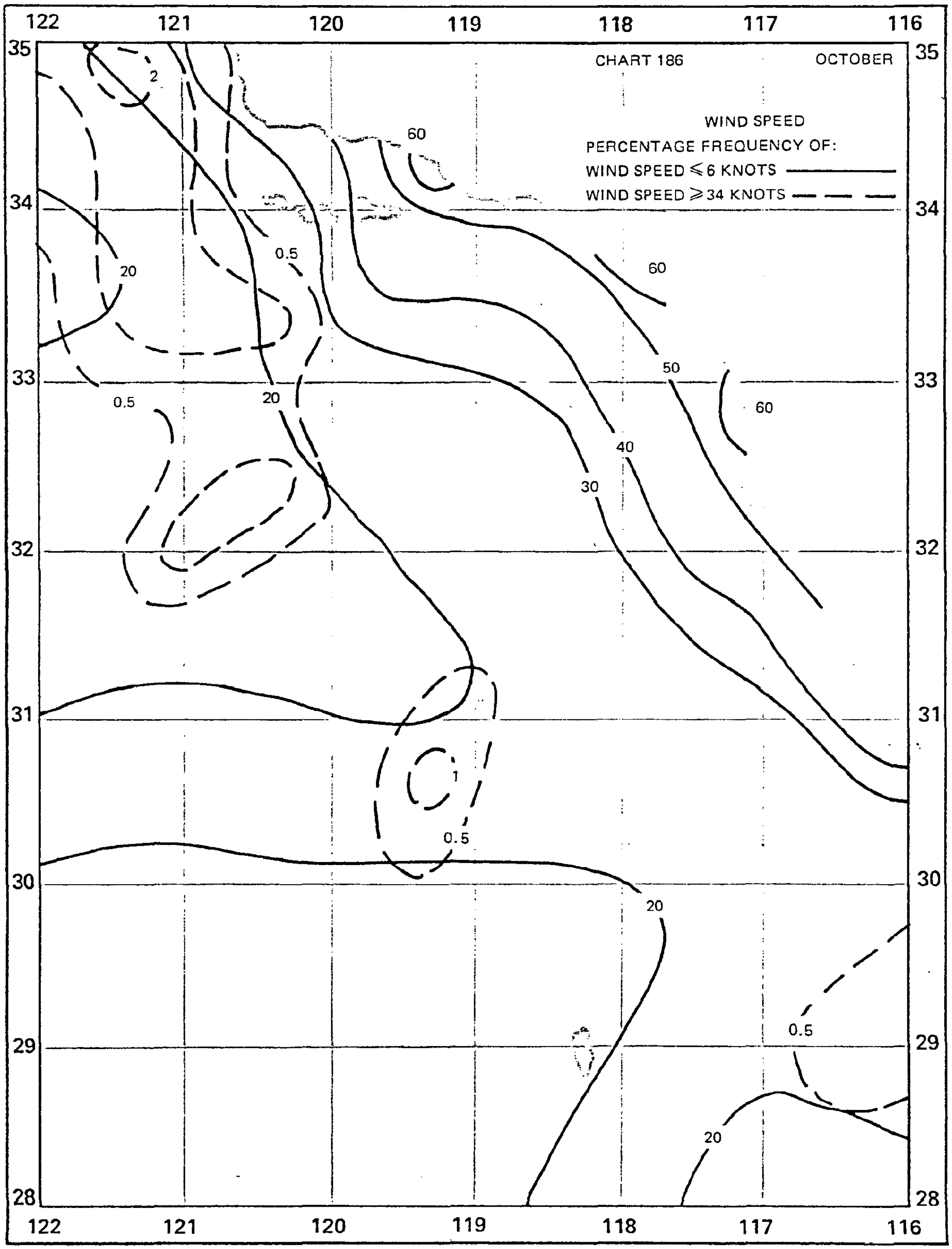


CHART 186
OCTOBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤ 6 KNOTS
WIND SPEED ≥ 34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
60
50
40
30
20
2
1
0.5

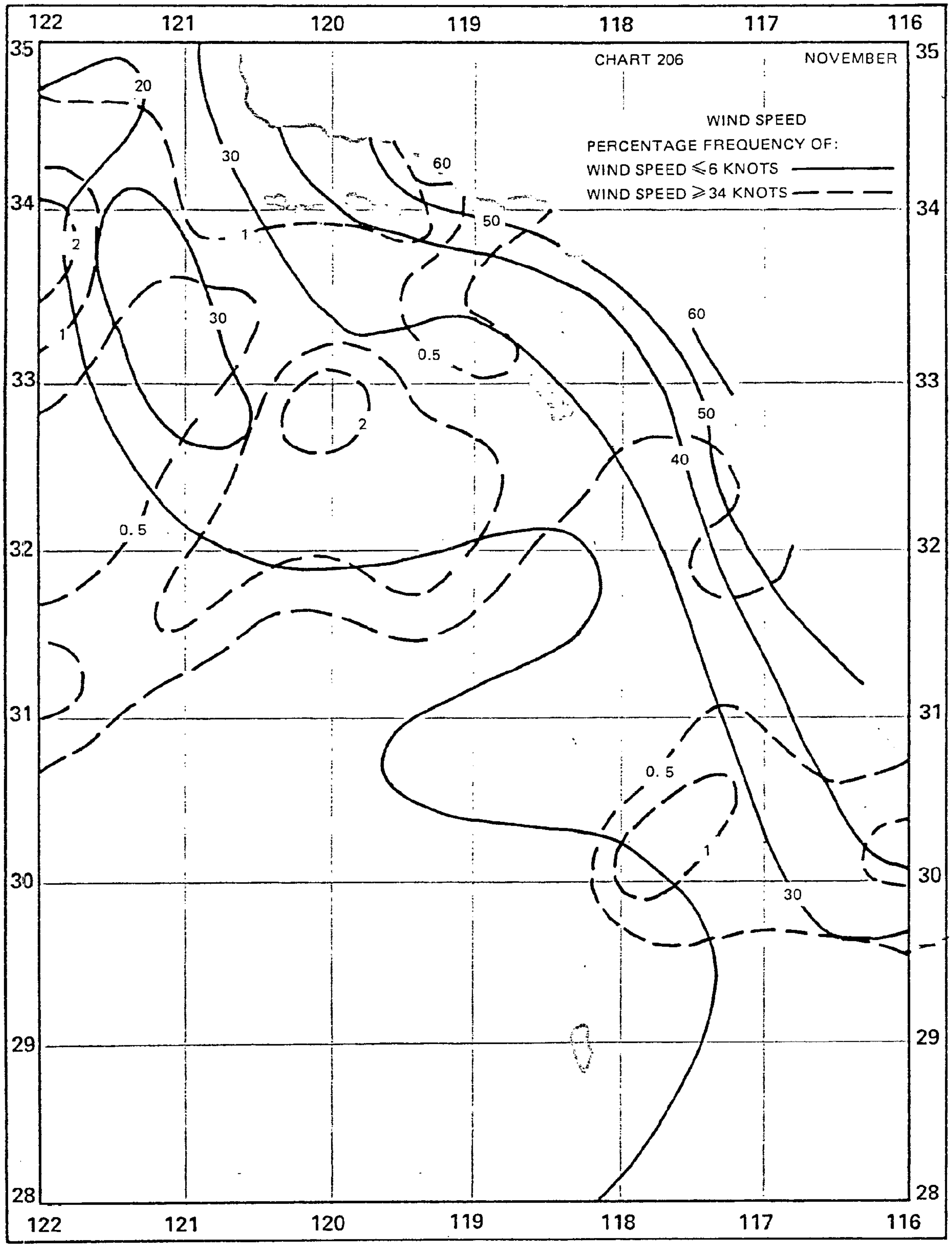


CHART 206
NOVEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
30
60
50
1
2
0.5
40
0. 5

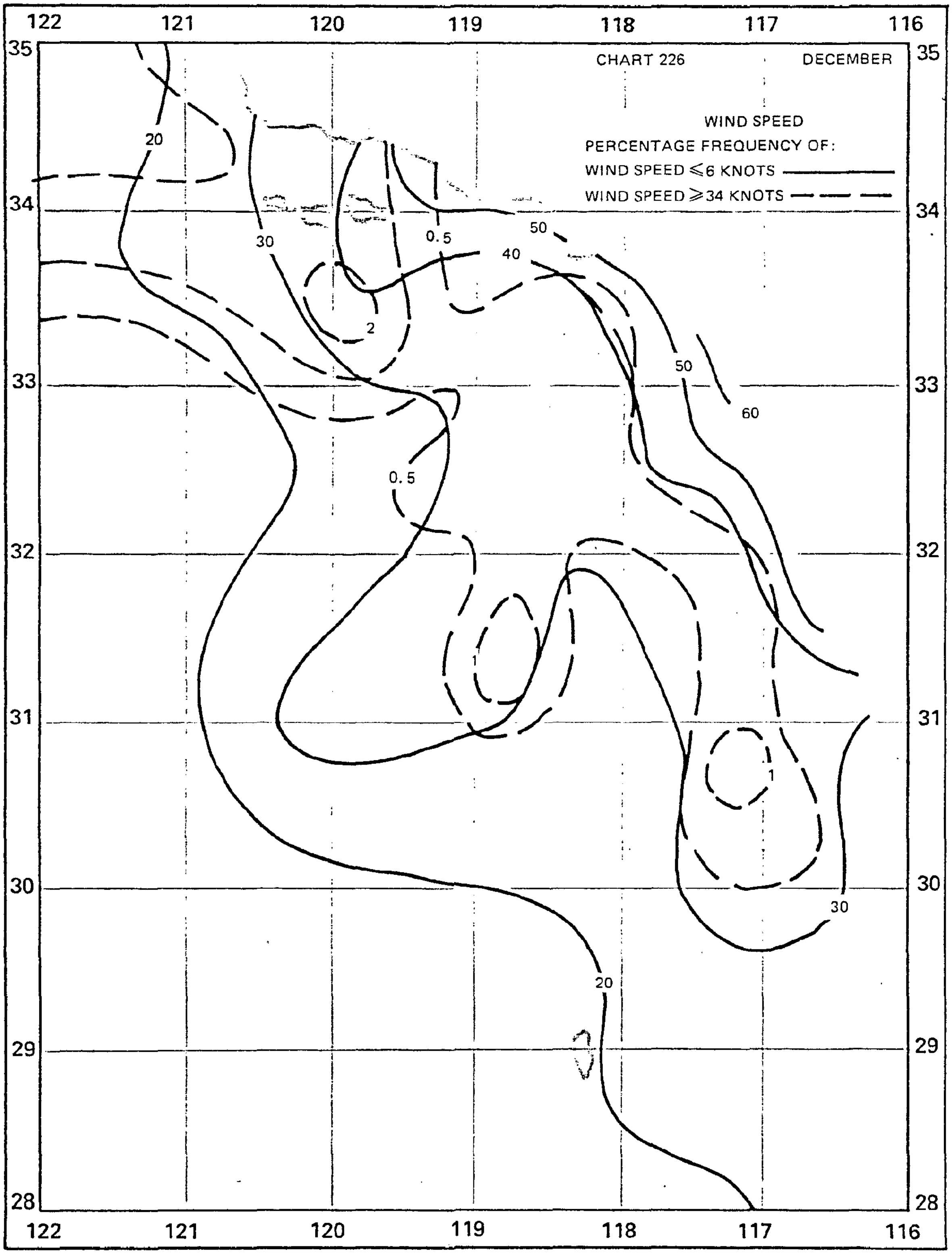


CHART 226
DECEMBER
WIND SPEED
PERCENTAGE FREQUENCY OF:
WIND SPEED ≤6 KNOTS
WIND SPEED ≥34 KNOTS
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
20
30
0.5
50
40
2
50
60
0.5
1
1
30
20

Mean Air Temperature

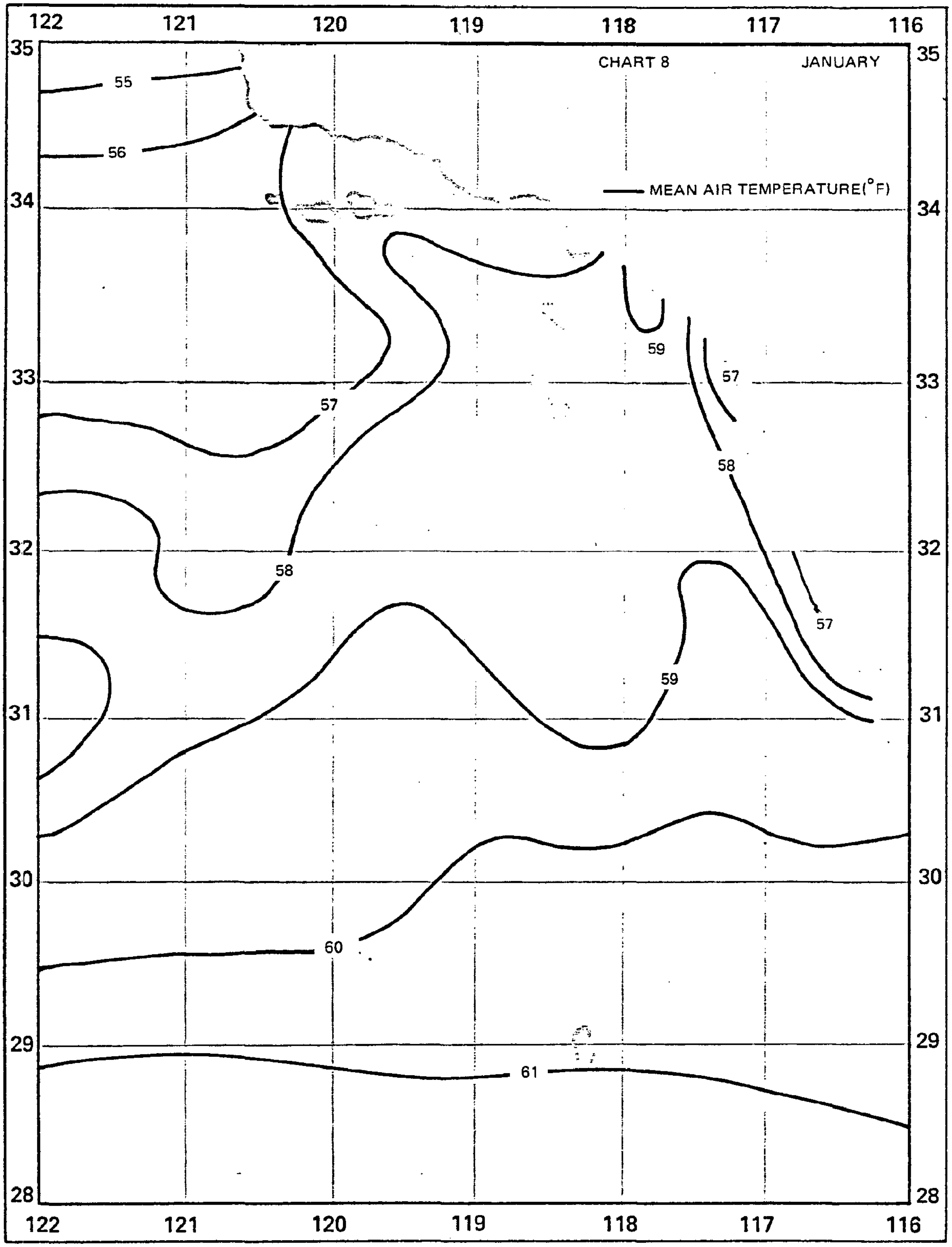


CHART 8
JANUARY
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
55
56
57
58
59
60
61

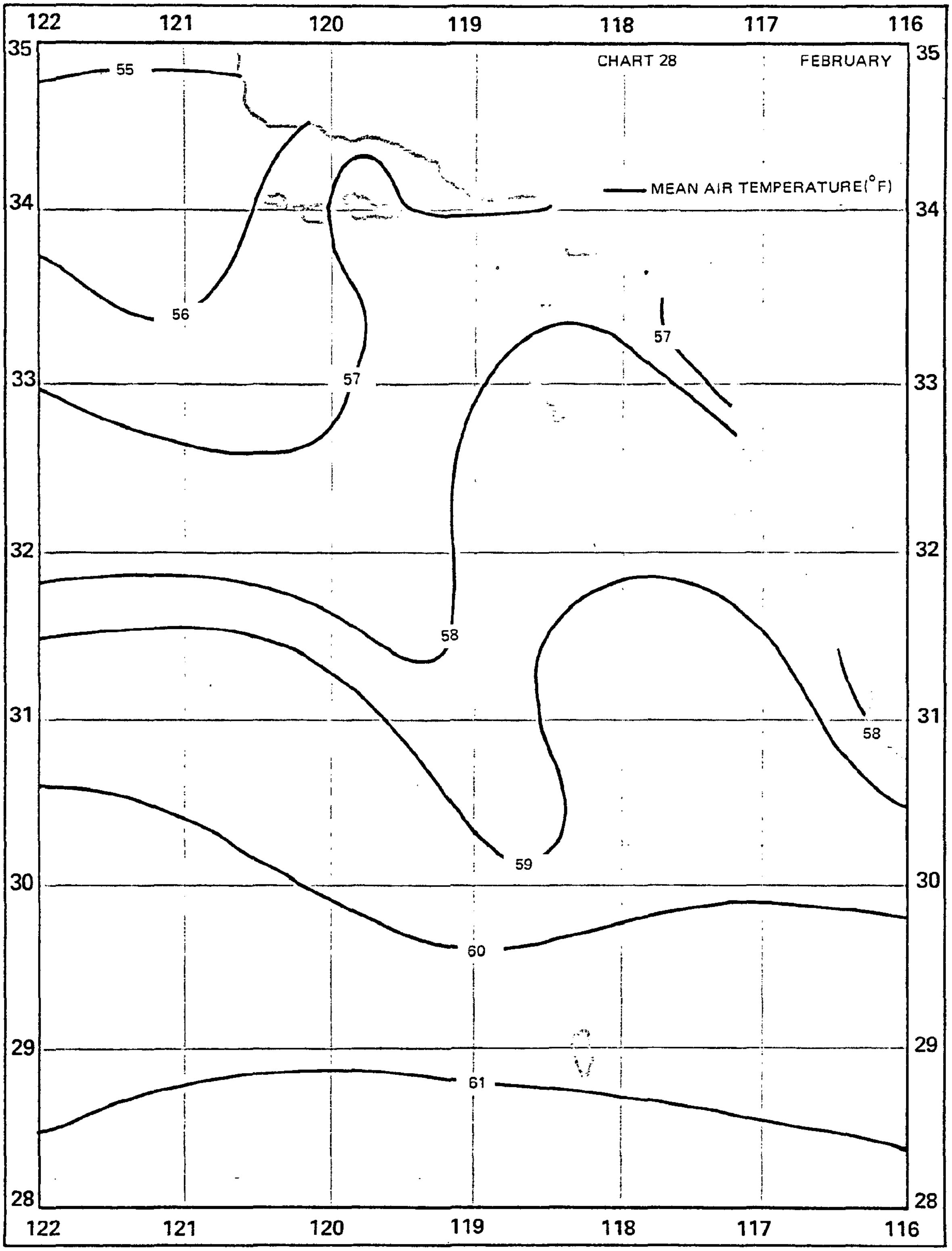


CHART 28
FEBRUARY
MEAN AIR TEMPERATURE(°F)
55
56
57
57
57
58
58
59
60
61
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28

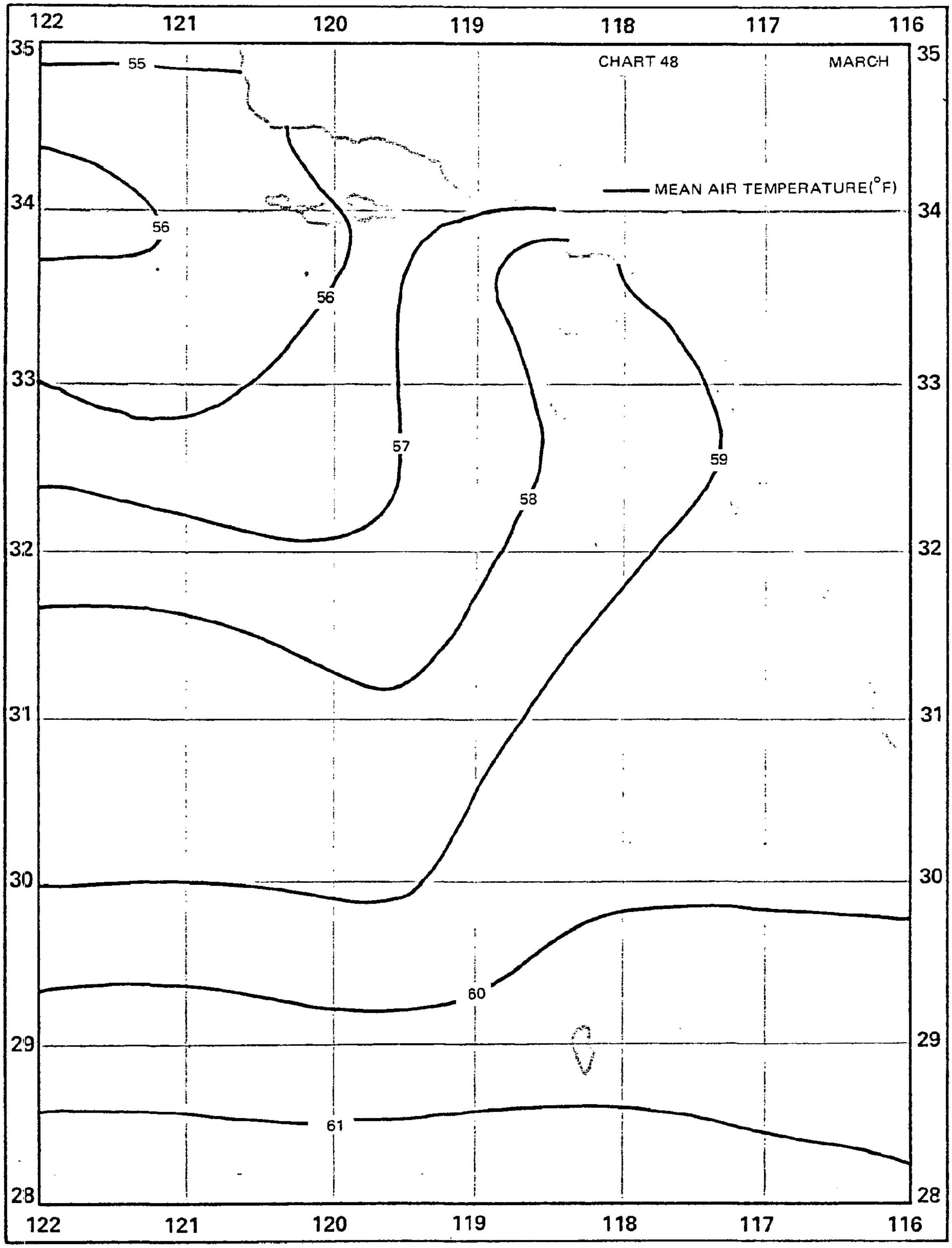


CHART 48
MARCH
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
55
56
56
57
58
59
60
61

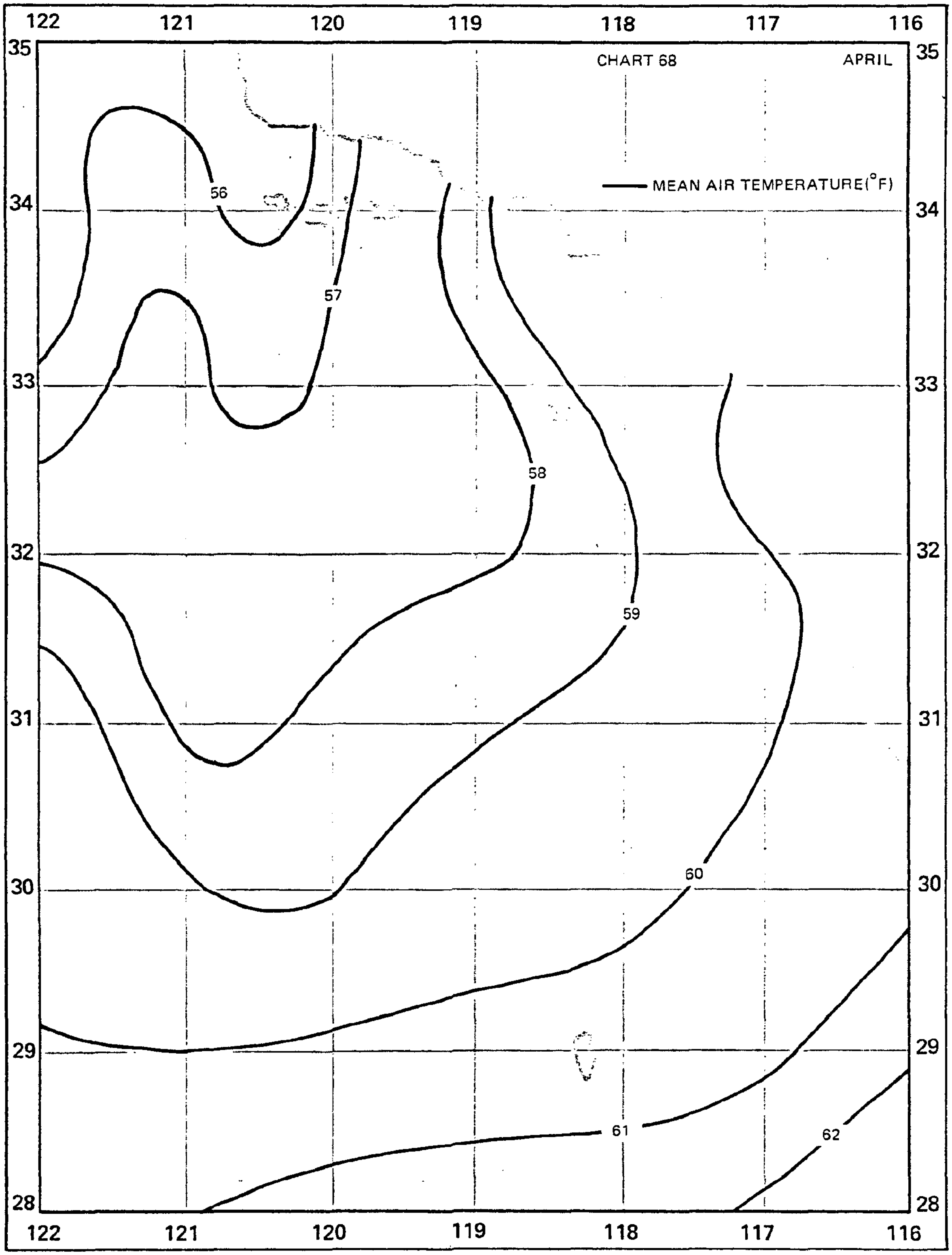
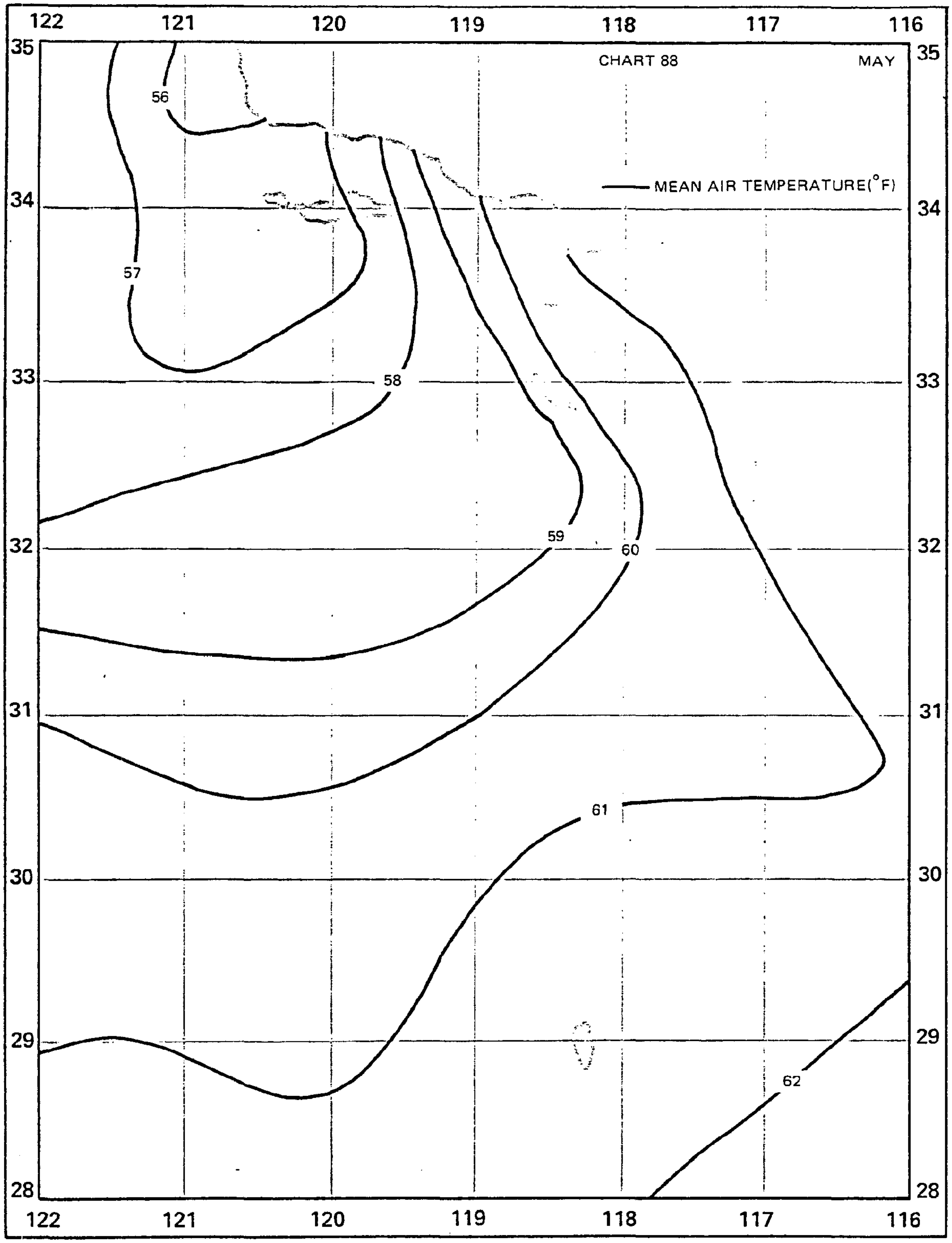
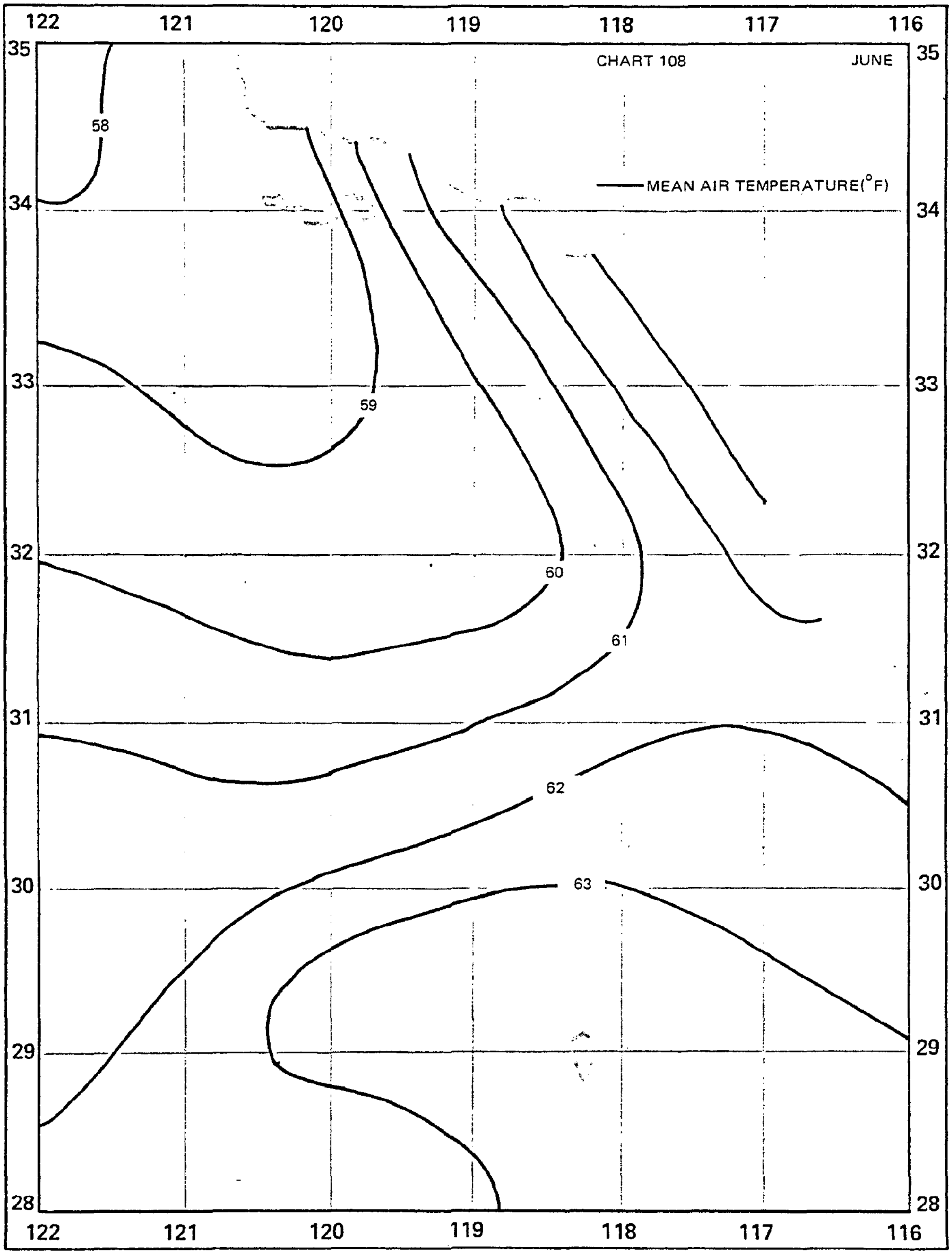


CHART 68
APRIL
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
56
57
58
59
60
61
62


122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 88
MAY
MEAN AIR TEMPERATURE(°F)
56
57
58
59
60
61
62



122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
CHART 108
JUNE
MEAN AIR TEMPERATURE(°F)
58
59
60
61
62
63

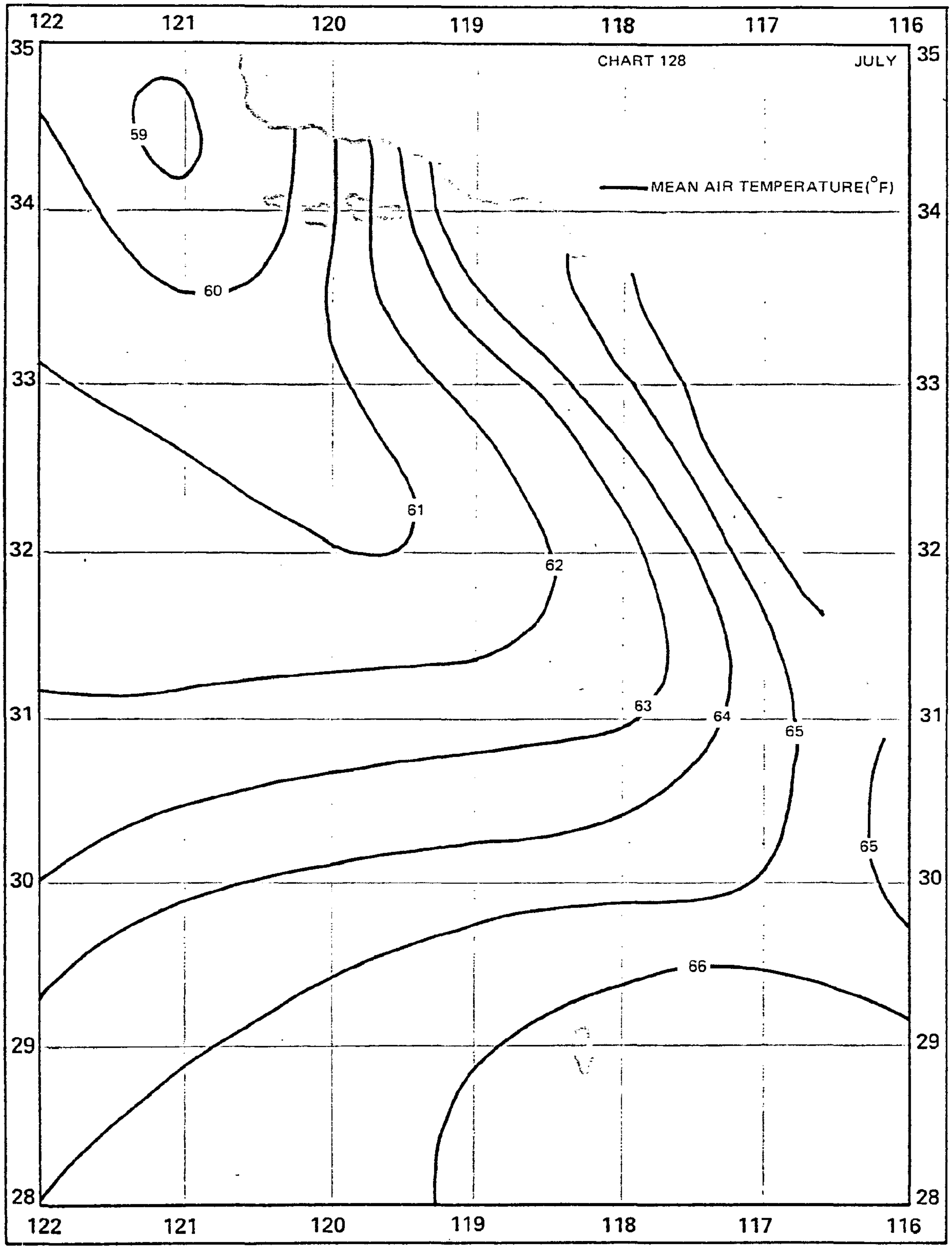


CHART 128
JULY
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
59
60
61
62
63
64
65
65
66

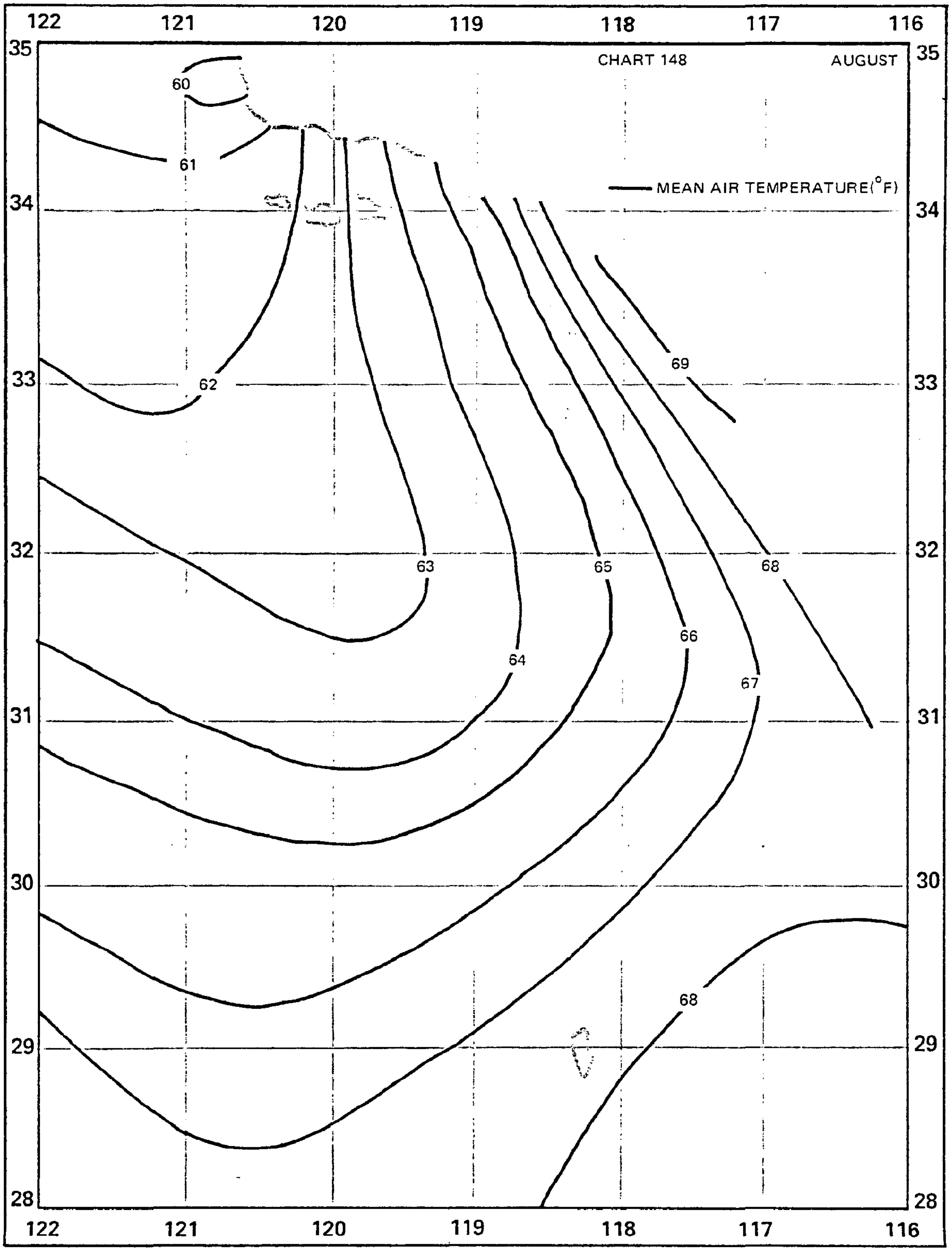


CHART 148
AUGUST
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
60
61
62
63
64
65
66
67
68
69
68

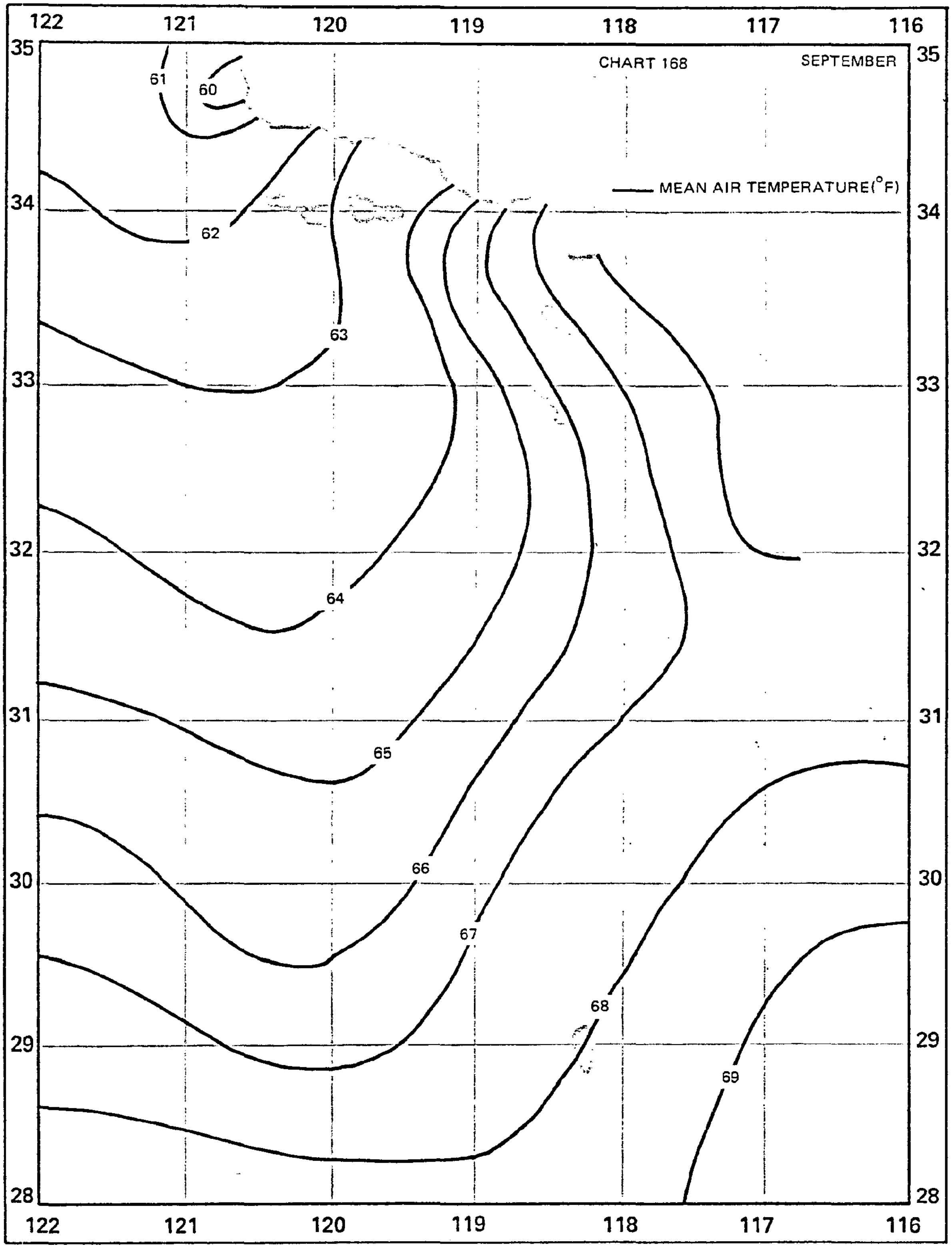


CHART 168
SEPTEMBER
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
60
61
62
63
64
65
66
67
68
69

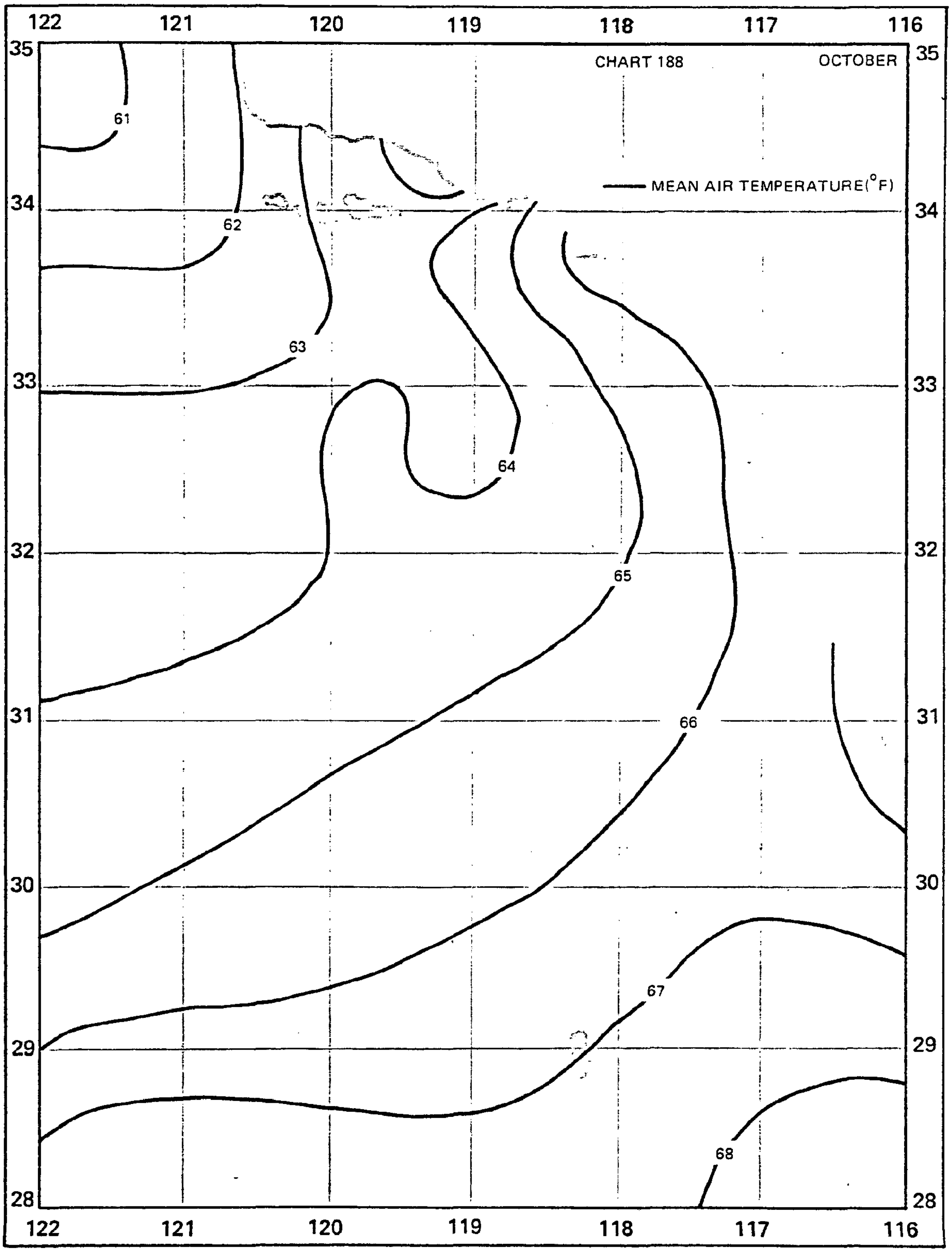


CHART 188
OCTOBER
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
61
62
63
64
65
66
67
68

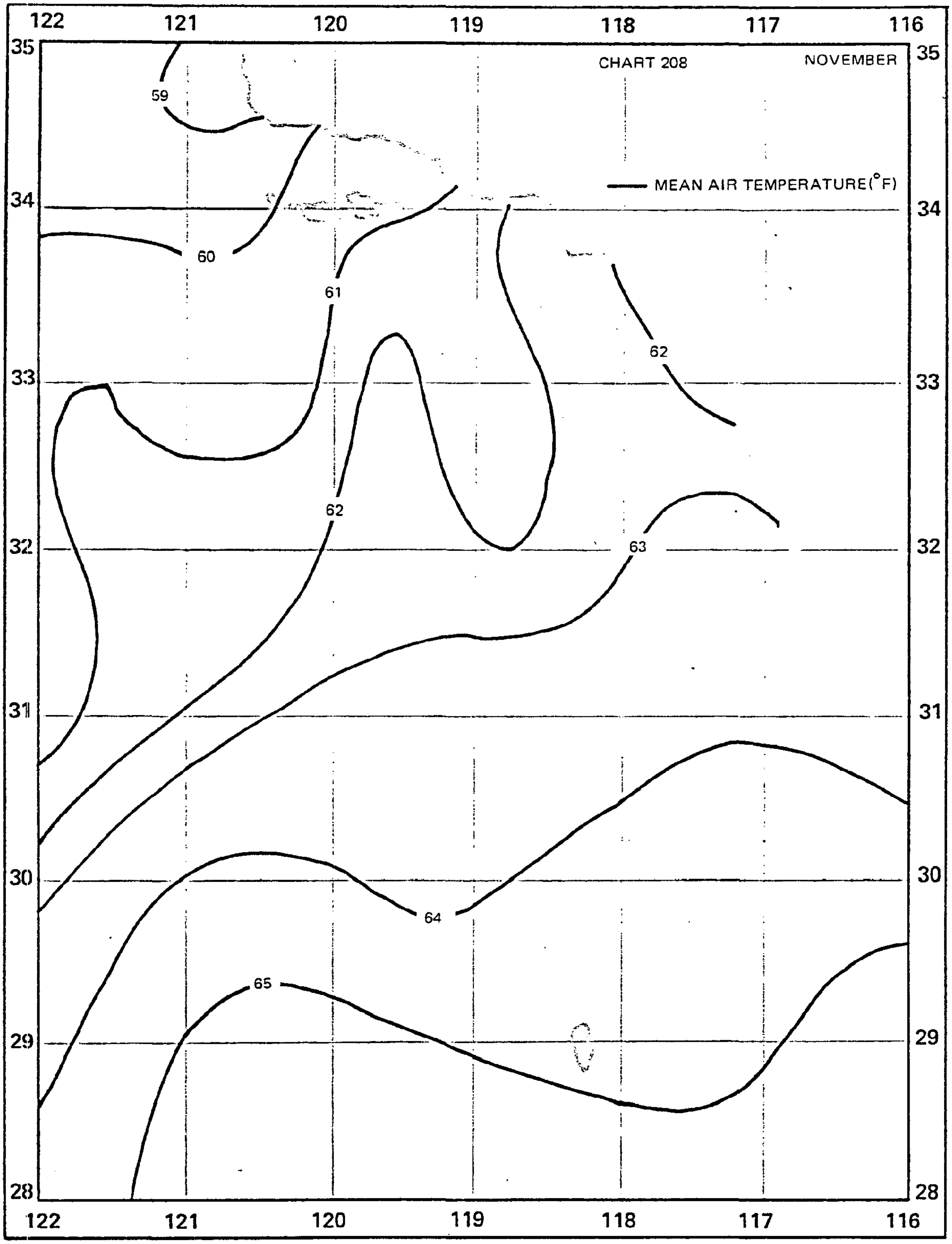


CHART 208
NOVEMBER
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
59
60
61
62
62
63
64
65

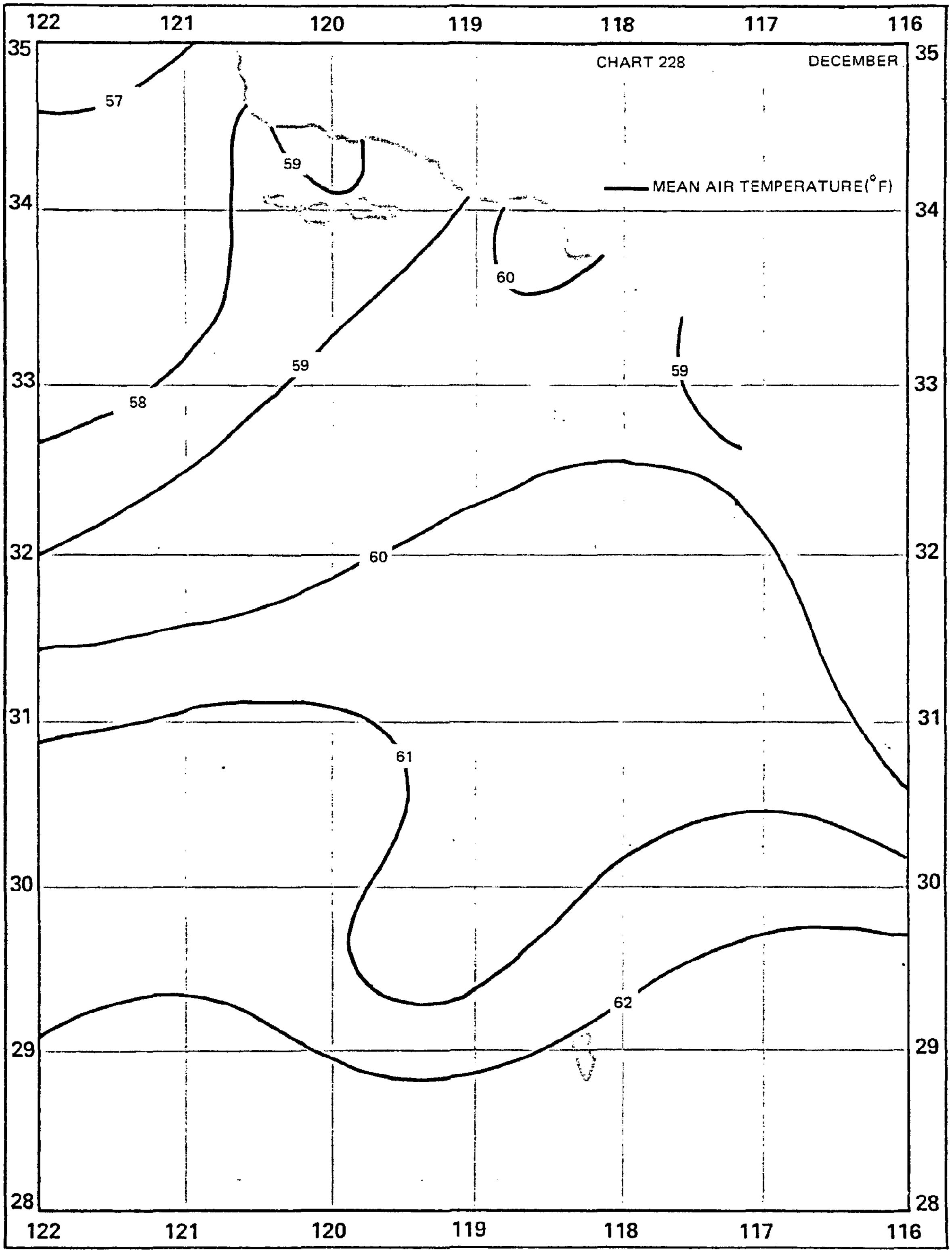


CHART 228
DECEMBER
MEAN AIR TEMPERATURE(°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
57
59
60
58
59
59
60
61
62

Mean Sea Surface Temperature

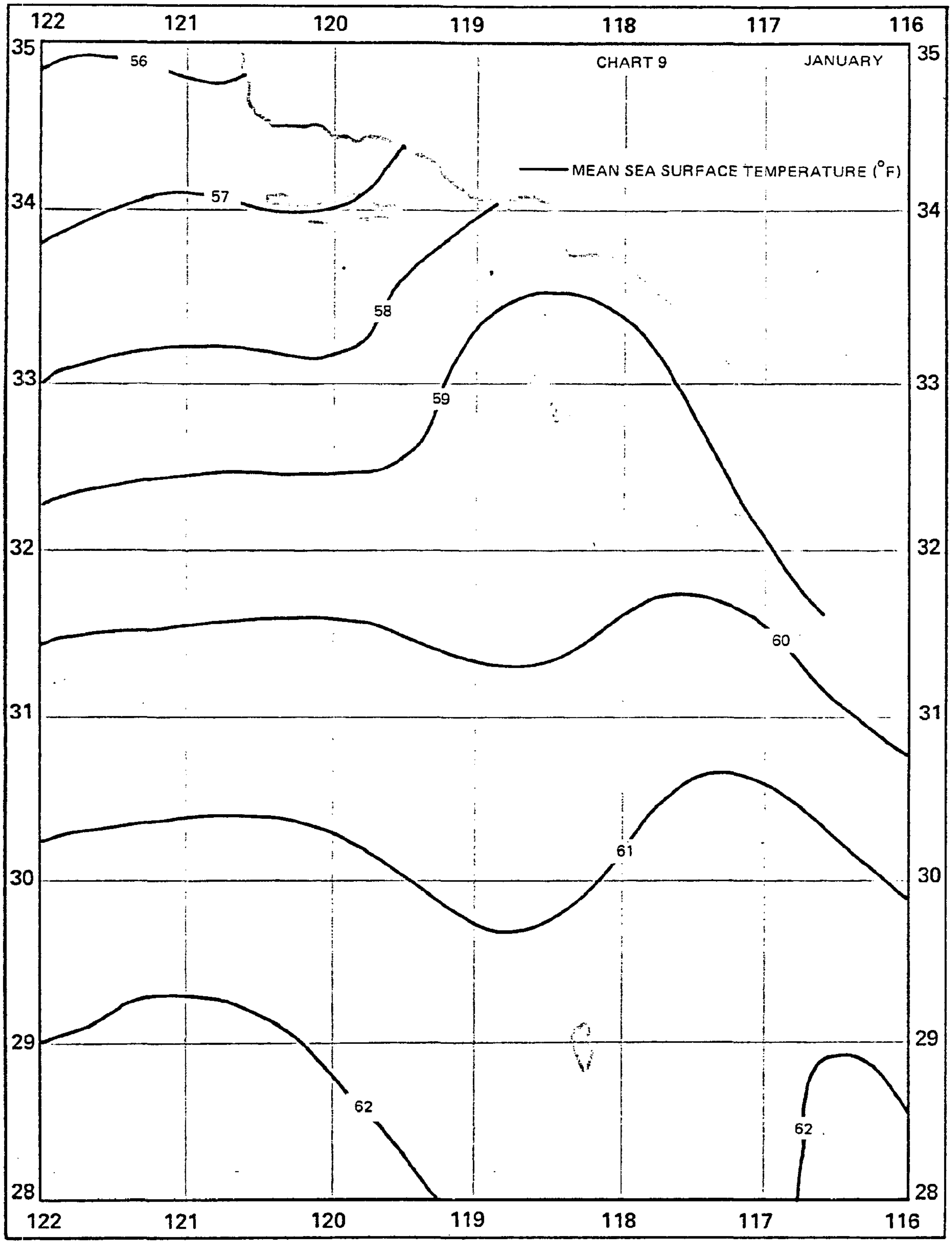


CHART 9
JANUARY
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
118
117
116
35
34
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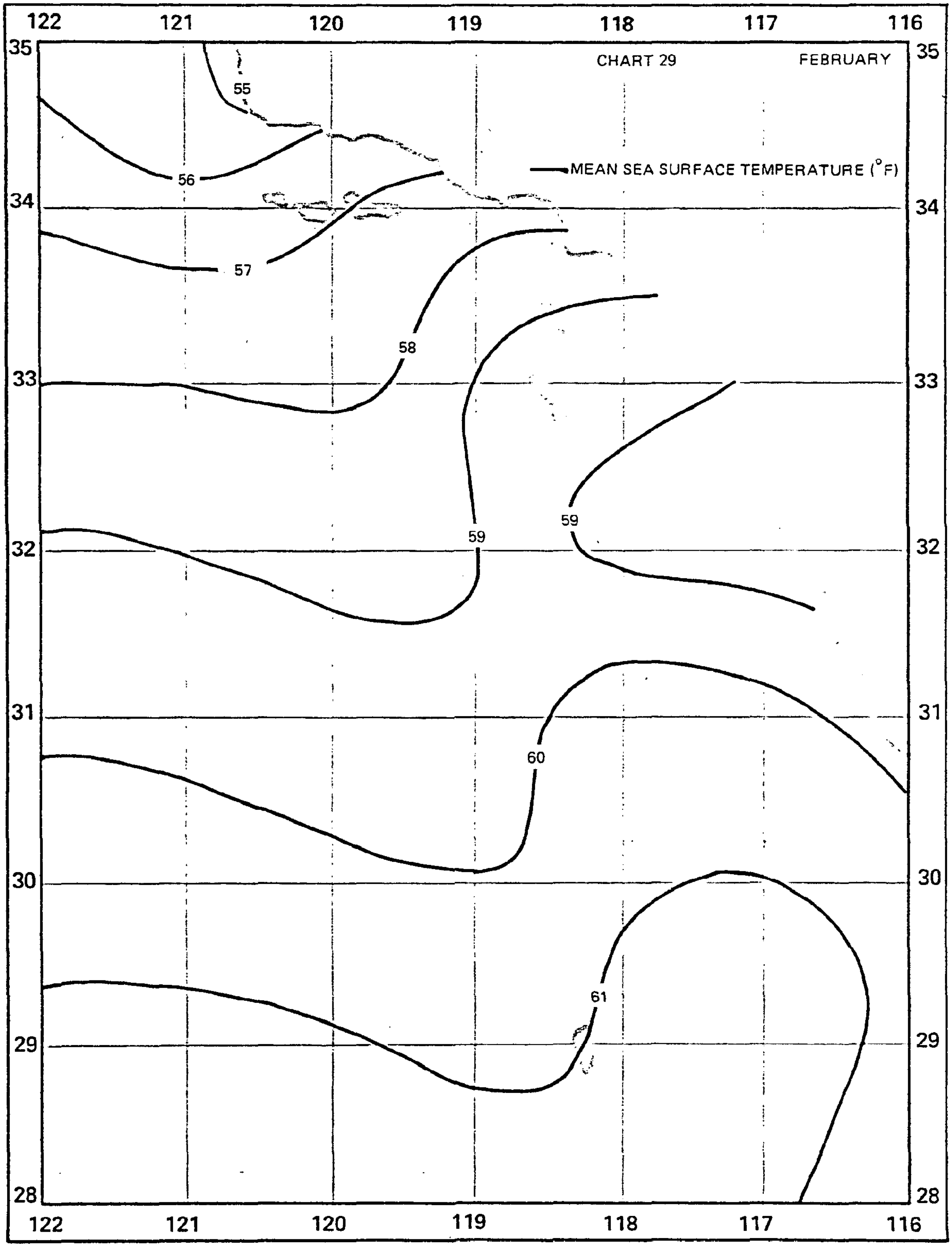
CHART 29
FEBRUARY
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
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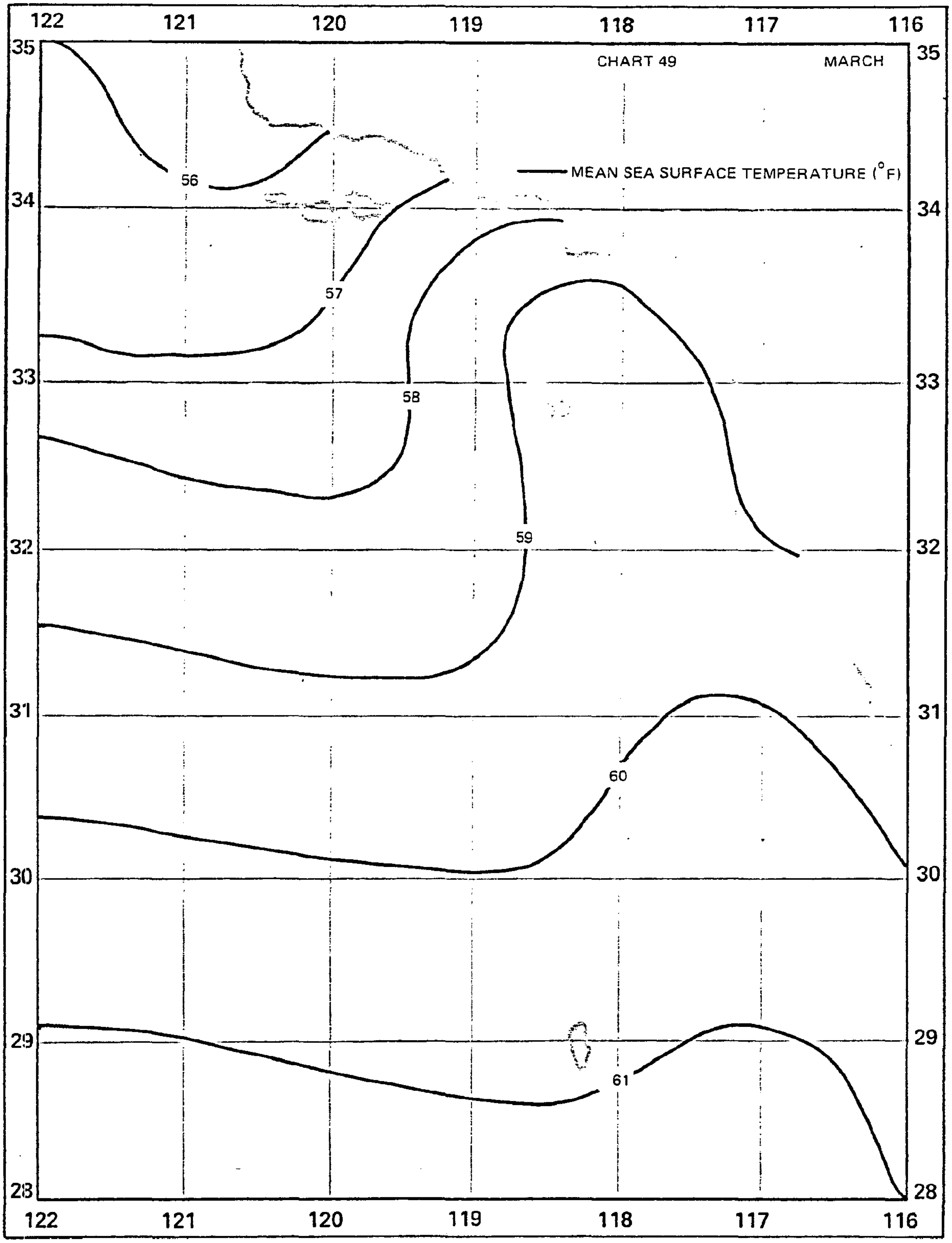

122
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31
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29
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CHART 49
MARCH
MEAN SEA SURFACE TEMPERATURE (°F)
56
57
58
59
60
61

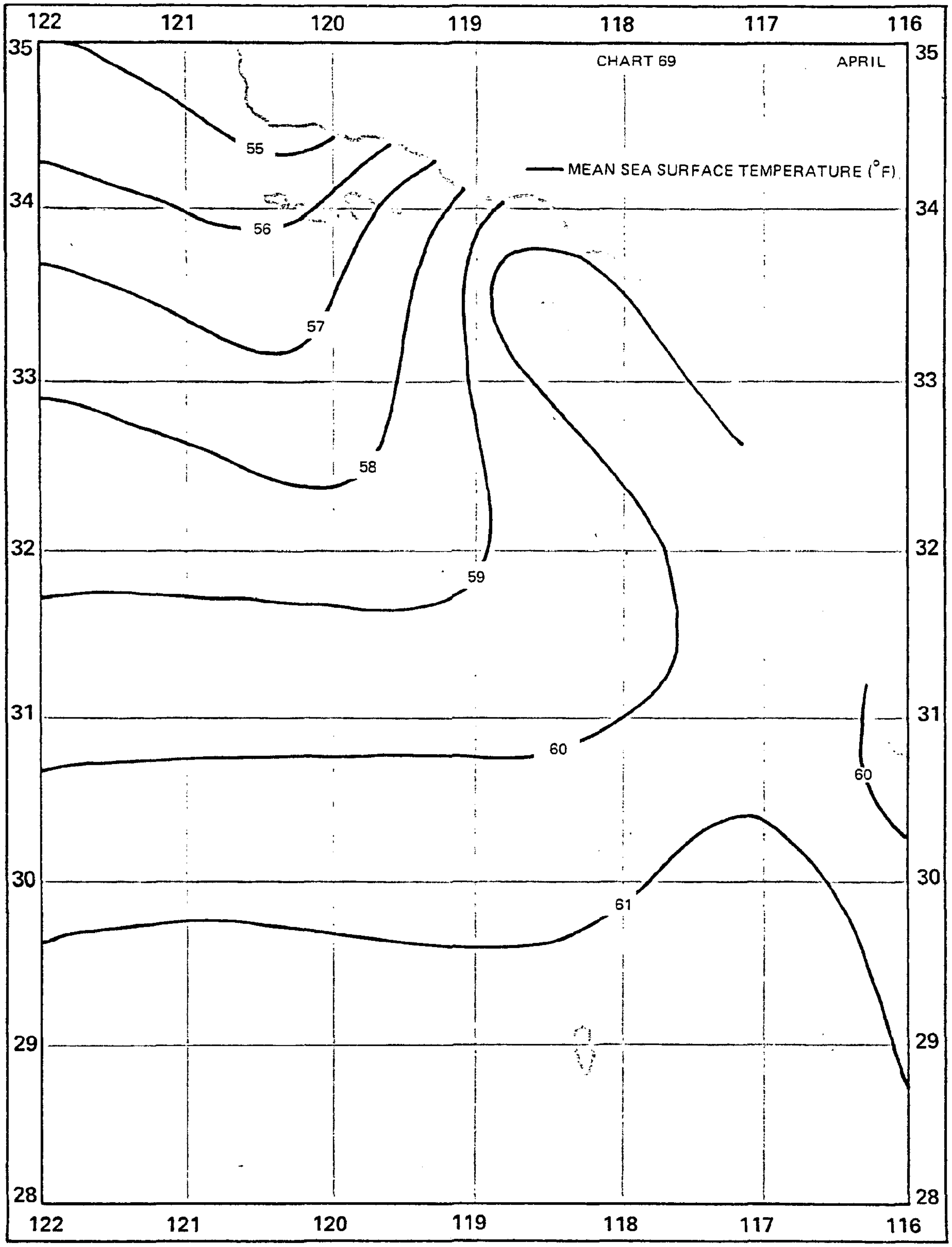

CHART 69
APRIL
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
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116
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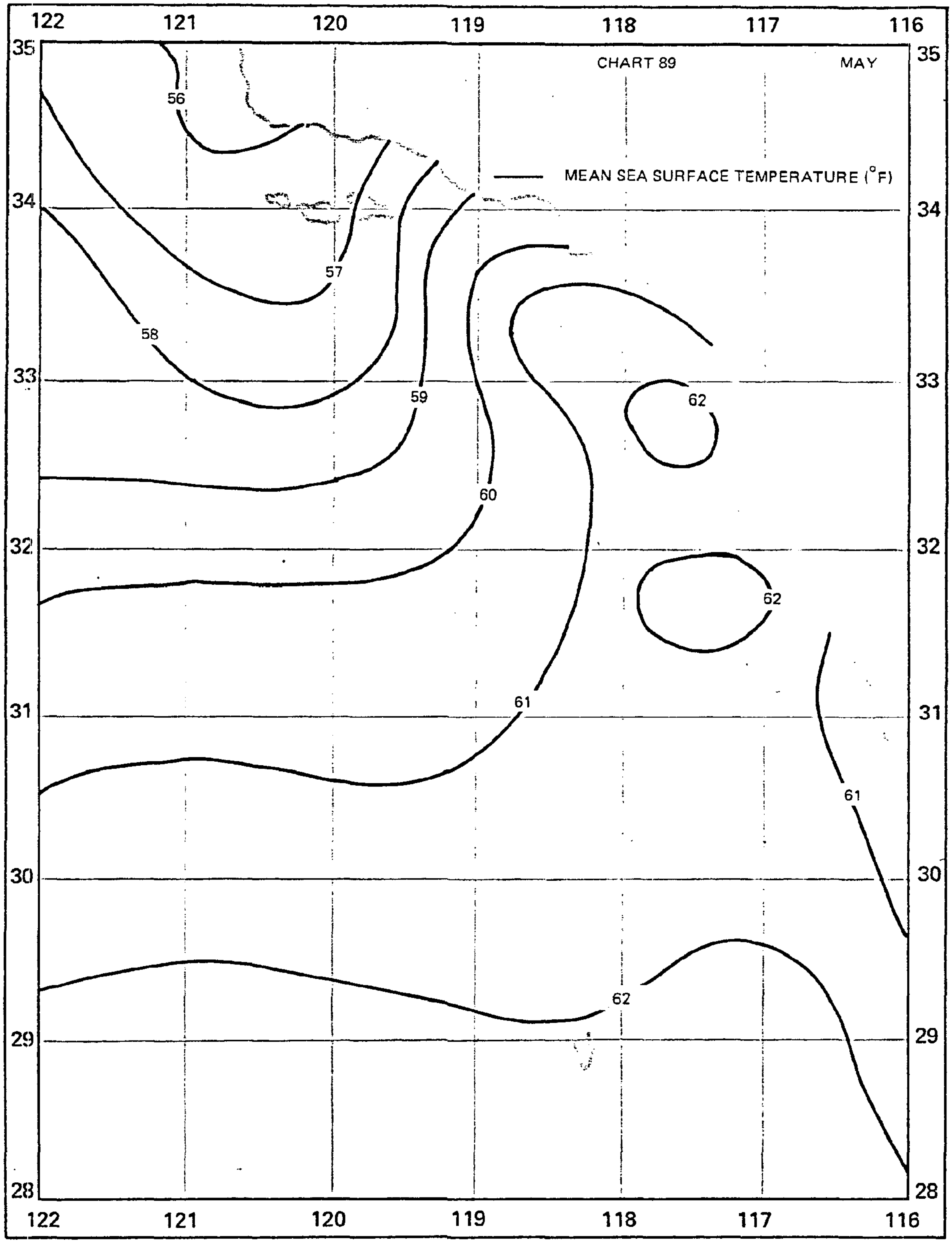
CHART 89
MAY
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
118
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116
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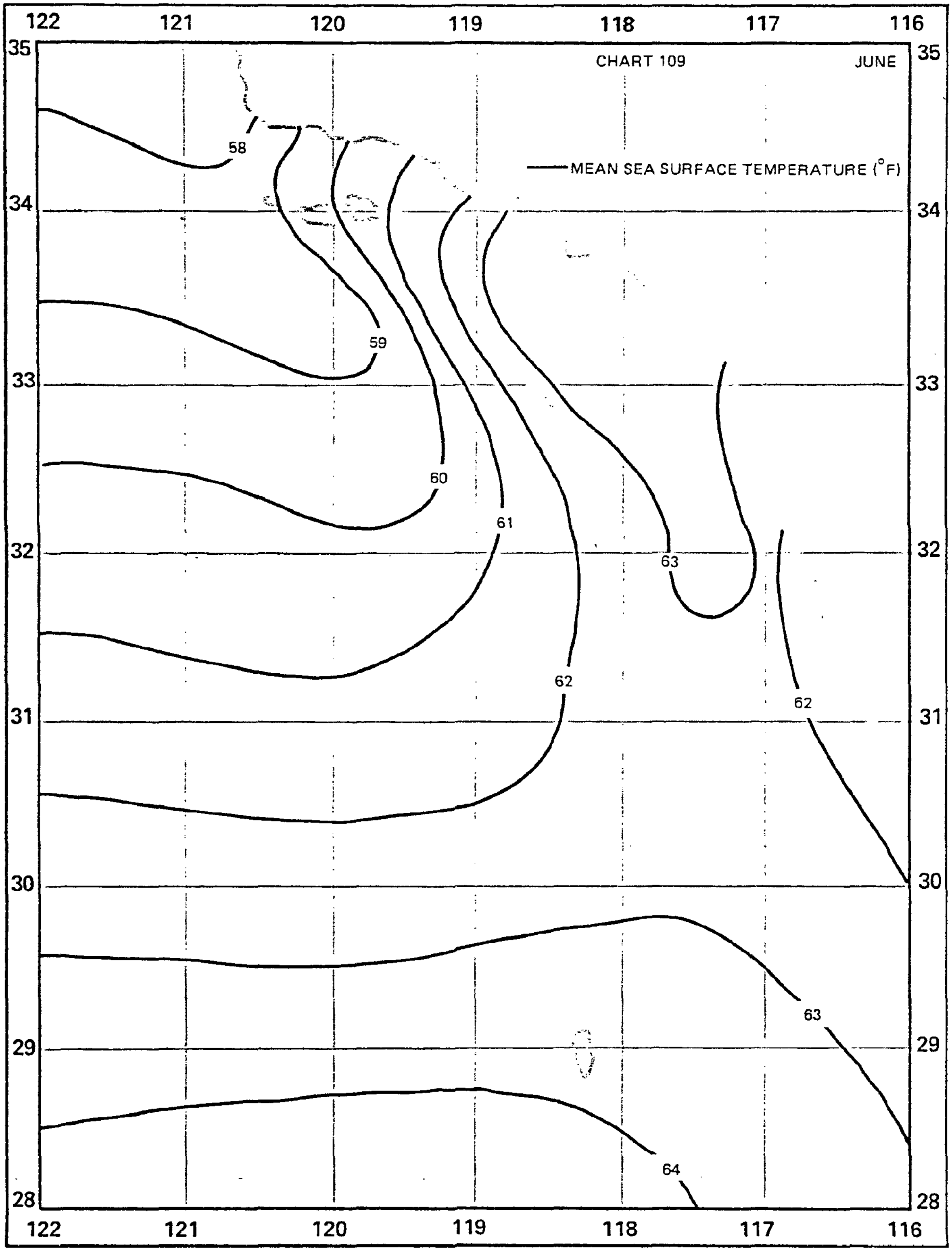
122
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119
118
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116
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32
31
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CHART 109
JUNE
MEAN SEA SURFACE TEMPERATURE (°F)
58
59
60
61
62
63
62
63
64

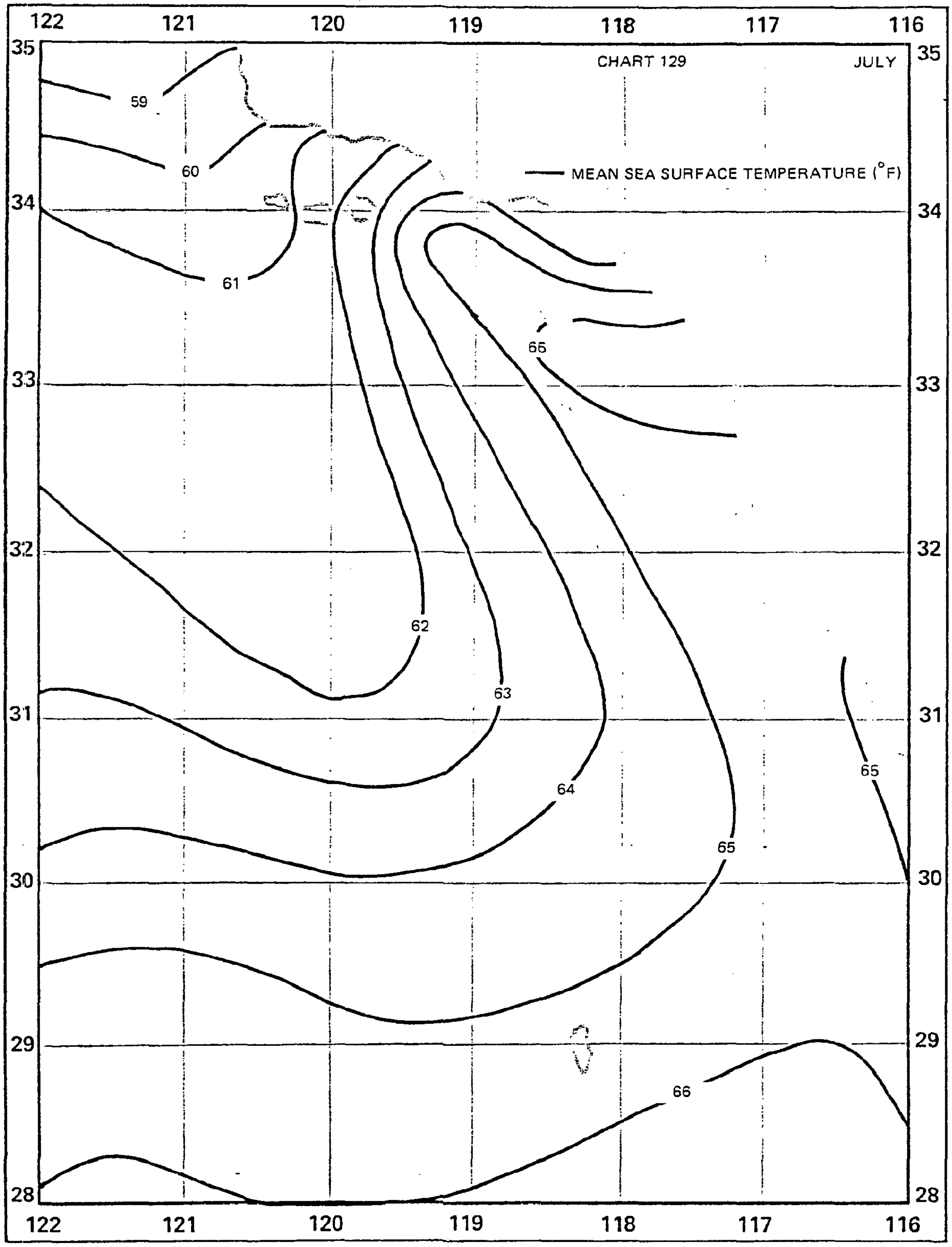

CHART 129
JULY
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
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116
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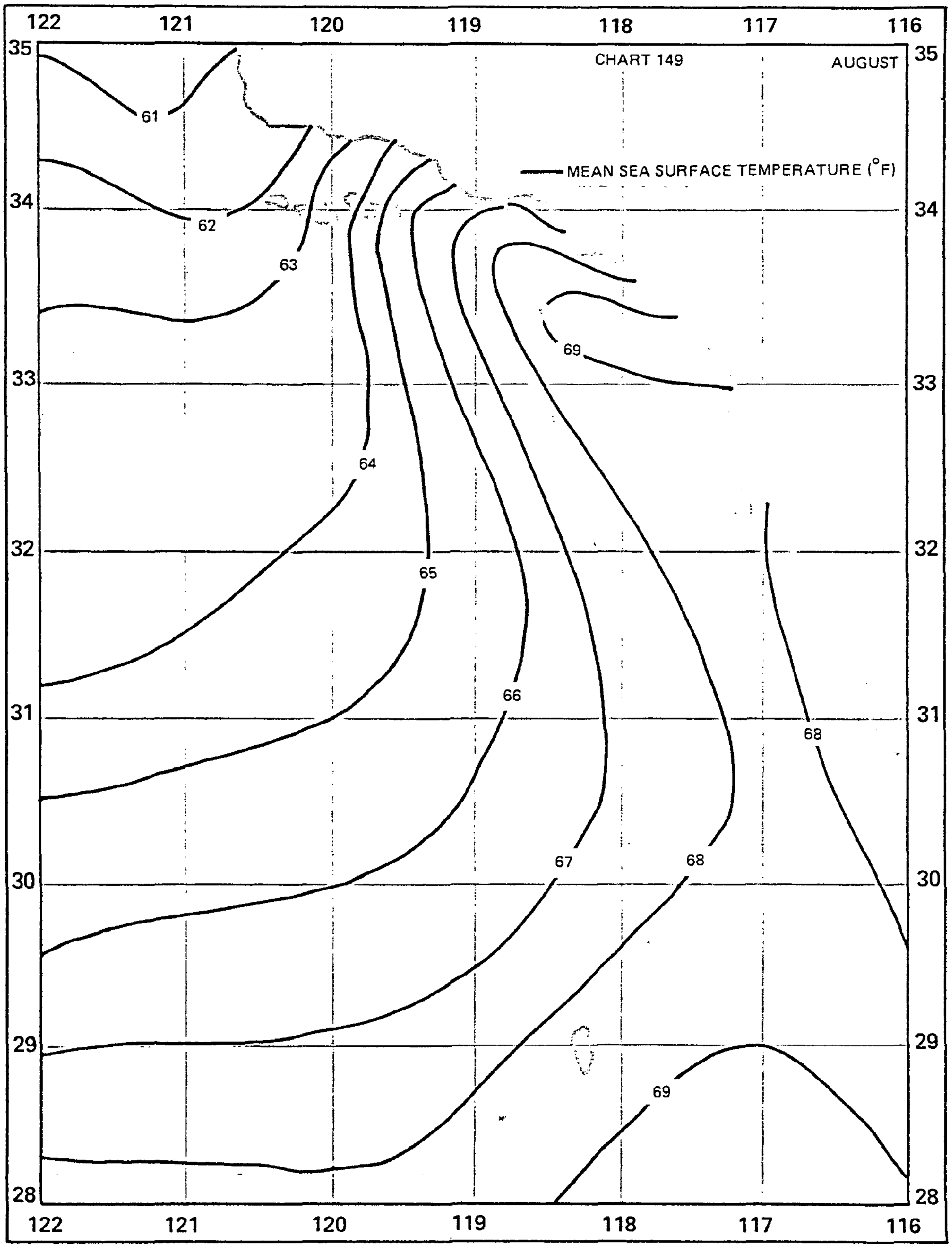

CHART 149
AUGUST
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
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116
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31
30
29
28
61
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63
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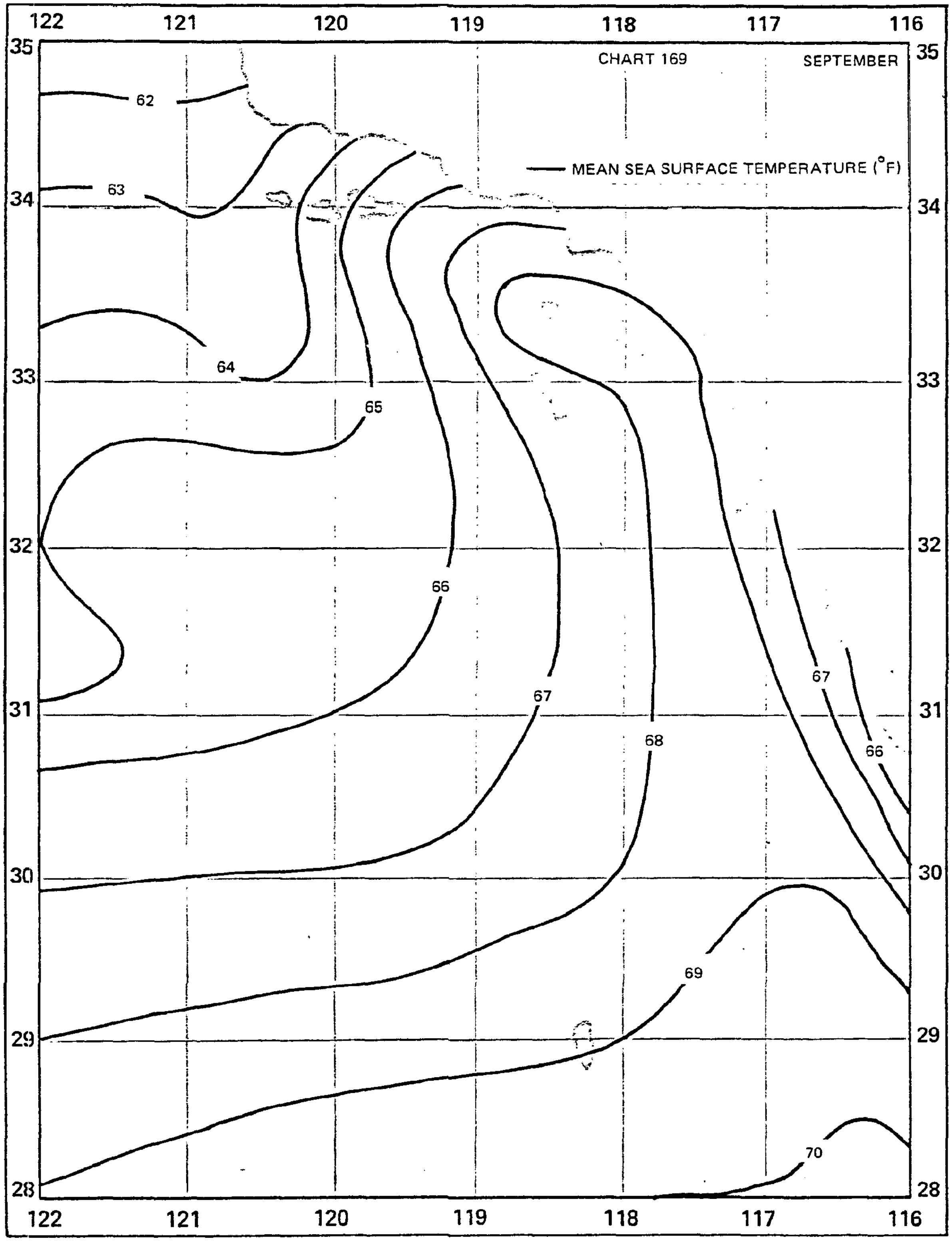
CHART 169
SEPTEMBER
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
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116
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62
63
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68
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70
67
66

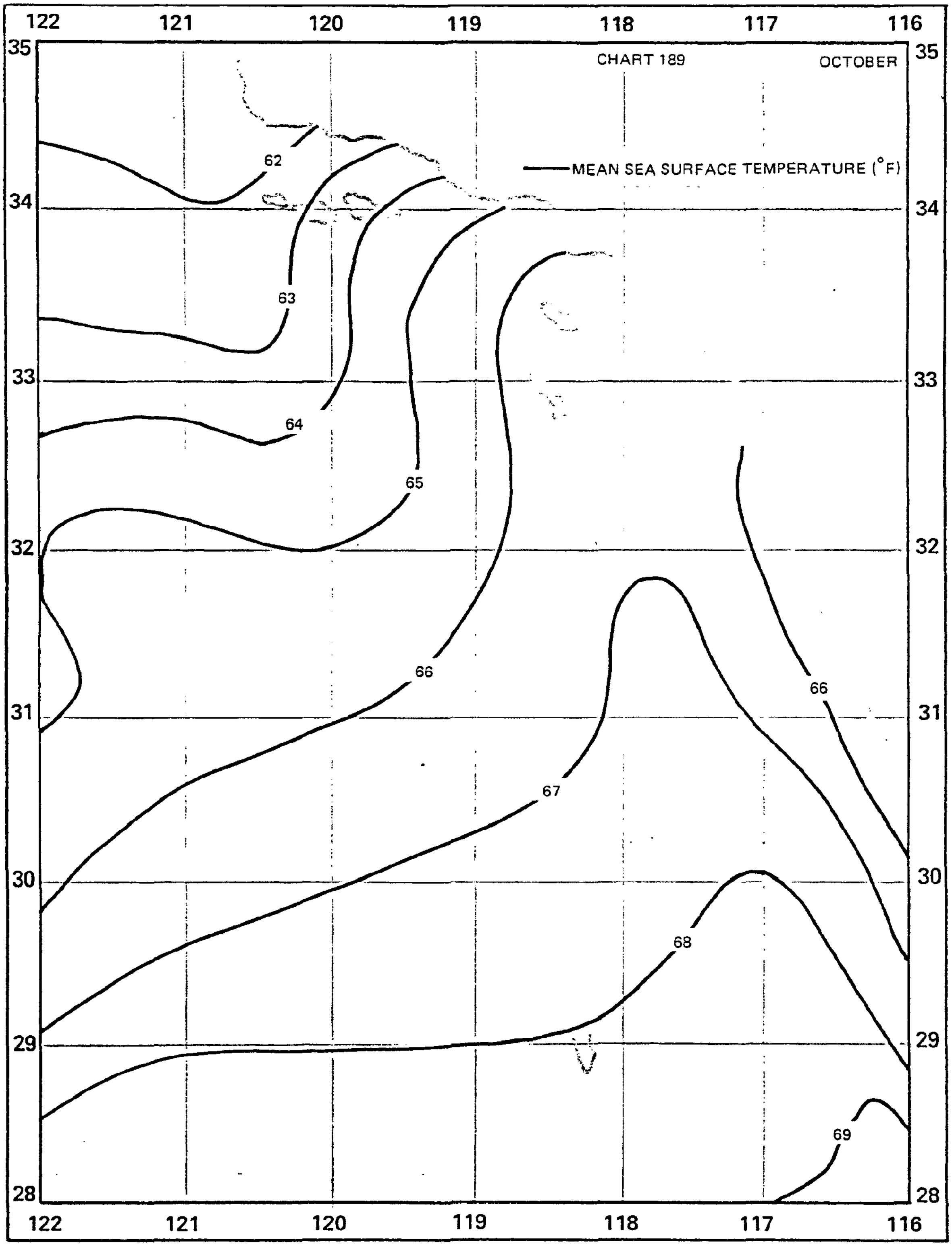

CHART 189
OCTOBER
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
62
63
64
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66
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67
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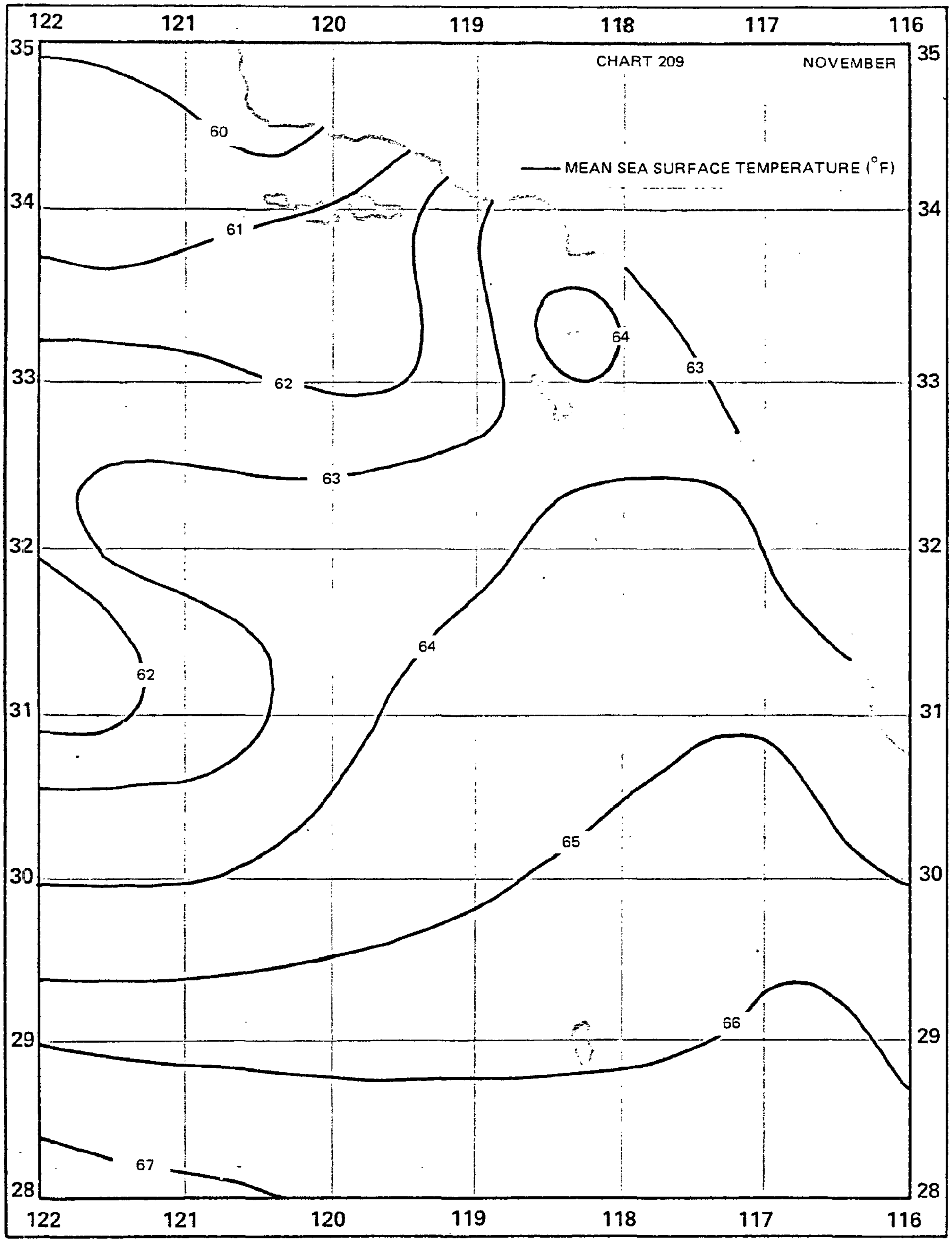
CHART 209
NOVEMBER
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
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117
116
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32
31
30
29
28
60
61
62
63
64
63
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66
67

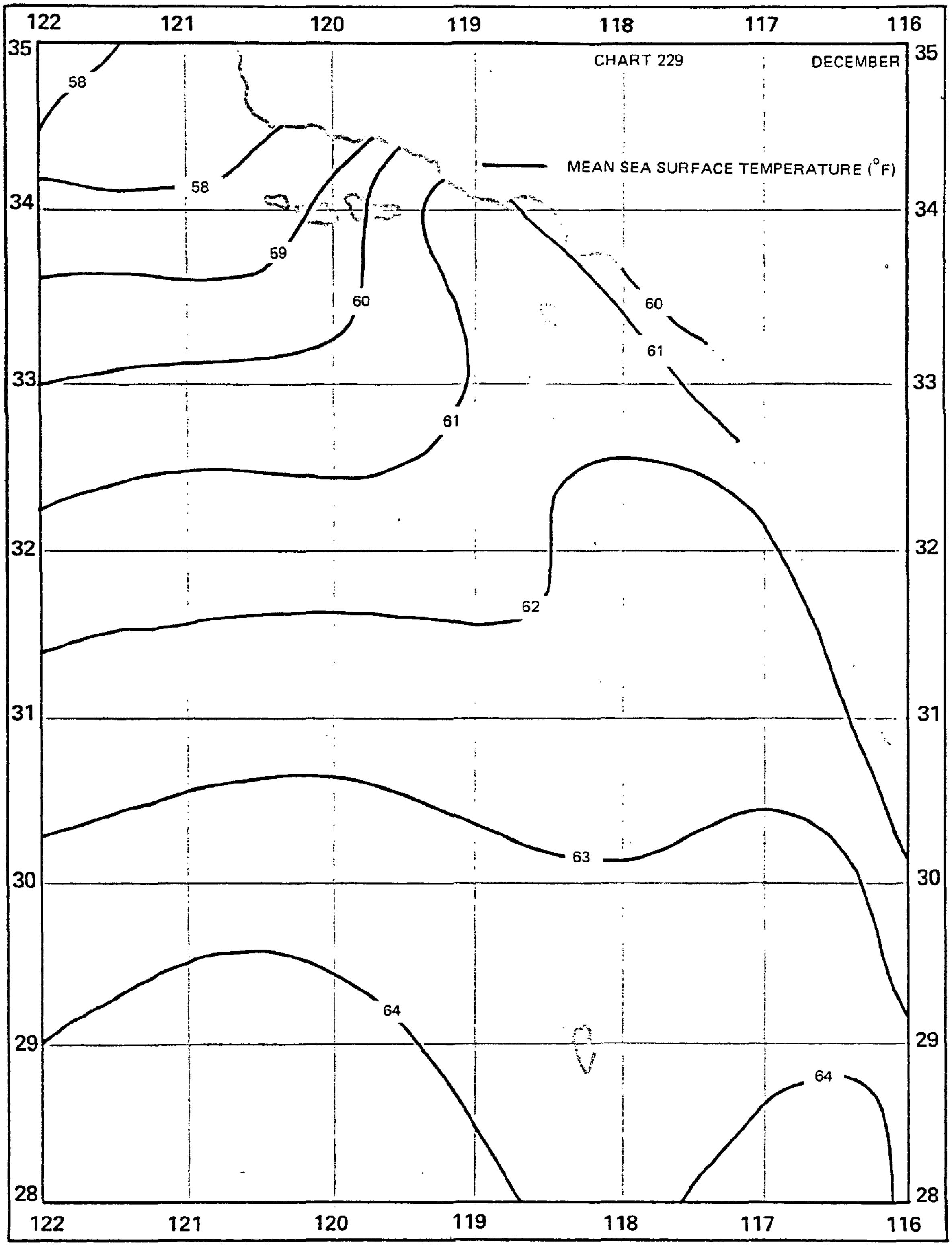

CHART 229
DECEMBER
MEAN SEA SURFACE TEMPERATURE (°F)
122
121
120
119
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116
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34
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31
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28
58
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61
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63
64

Prevailing Current Direction and Mean Current Speed (Knots)

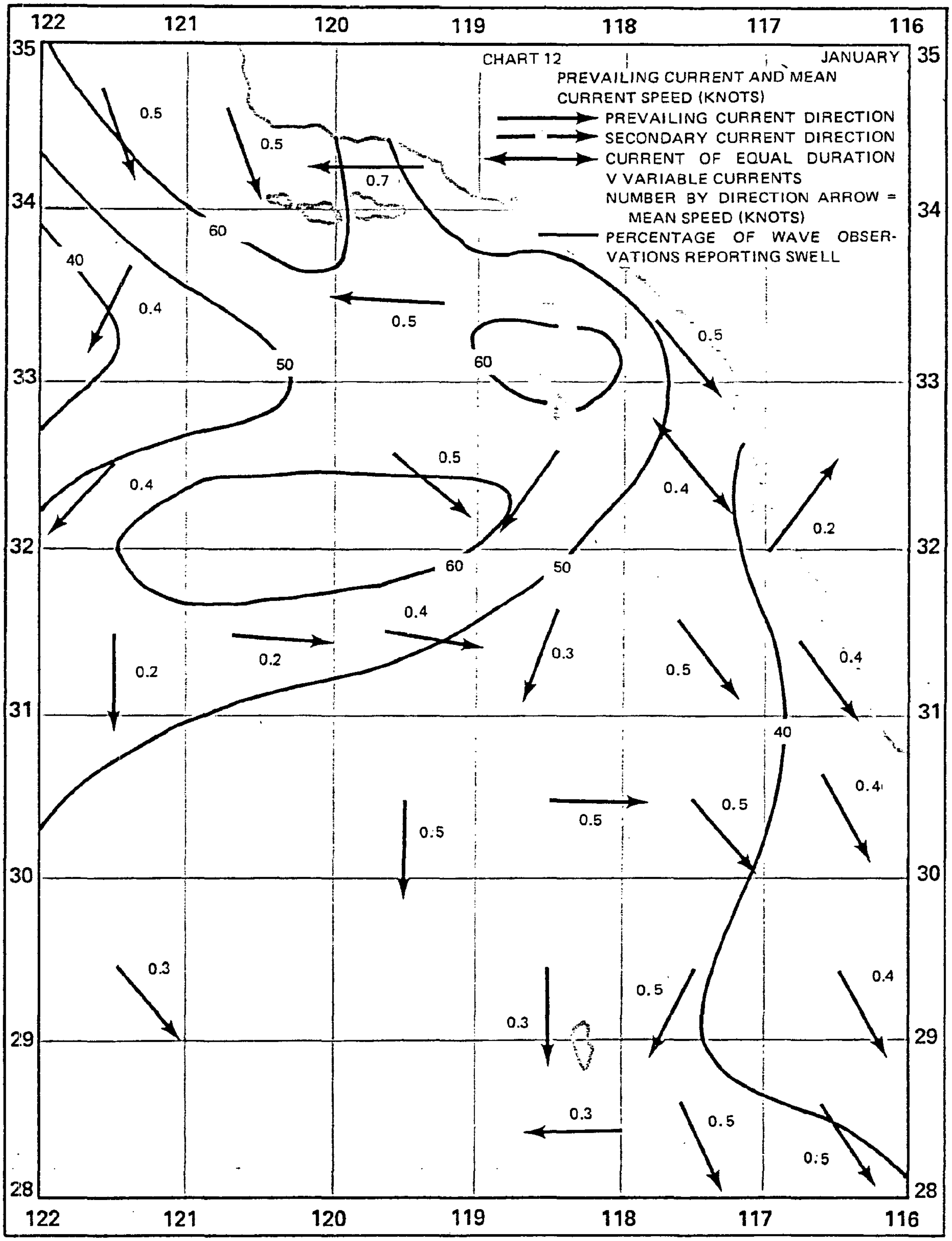
CHART 12
JANUARY
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
0.5
0.7
0.4
0.2
0.3
40
50
60

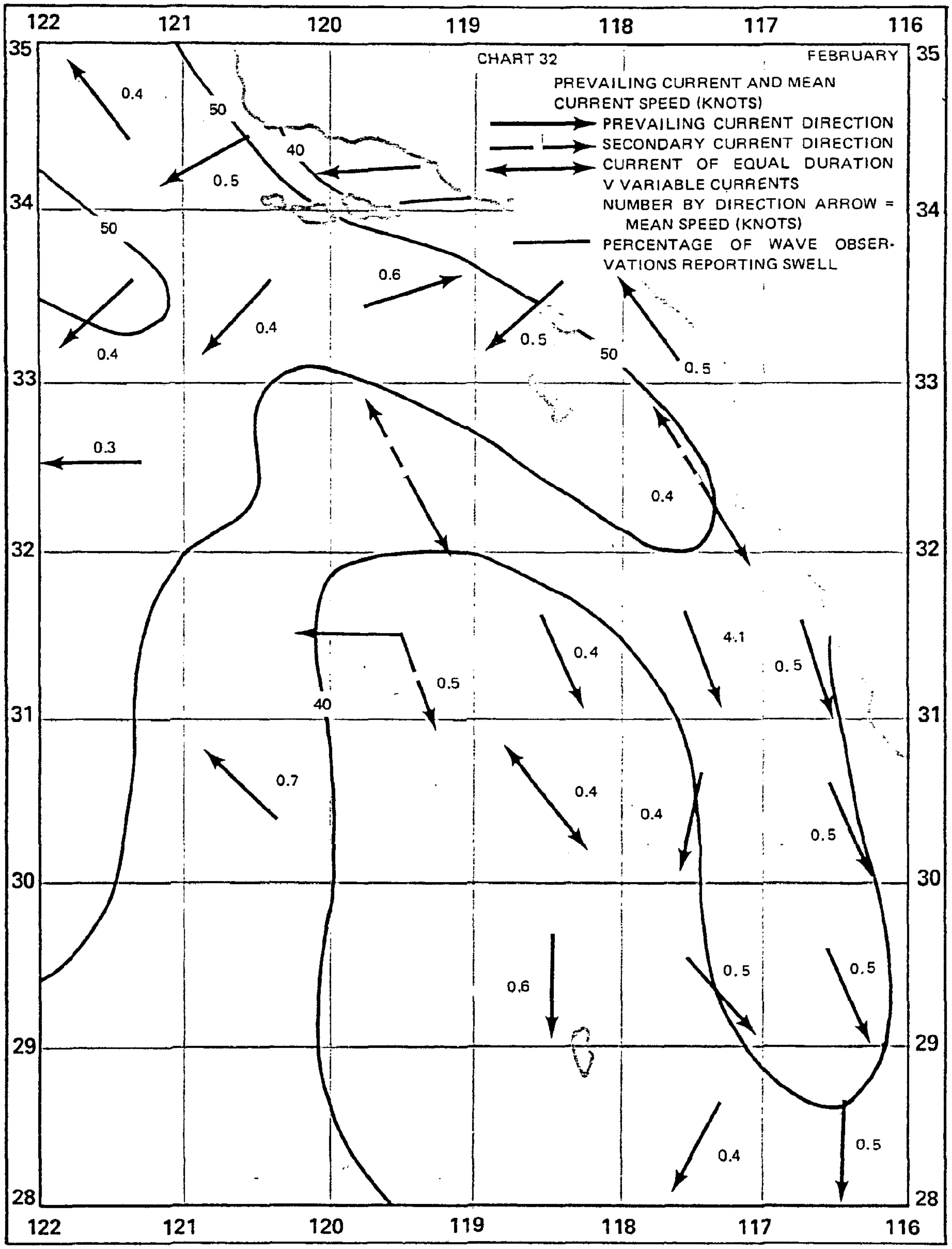
CHART 32
FEBRUARY
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
119
118
117
116
35
34
33
32
31
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29
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0.4
50
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0.5
0.6
0.3
0.7
4.1
0.5
40
0.4

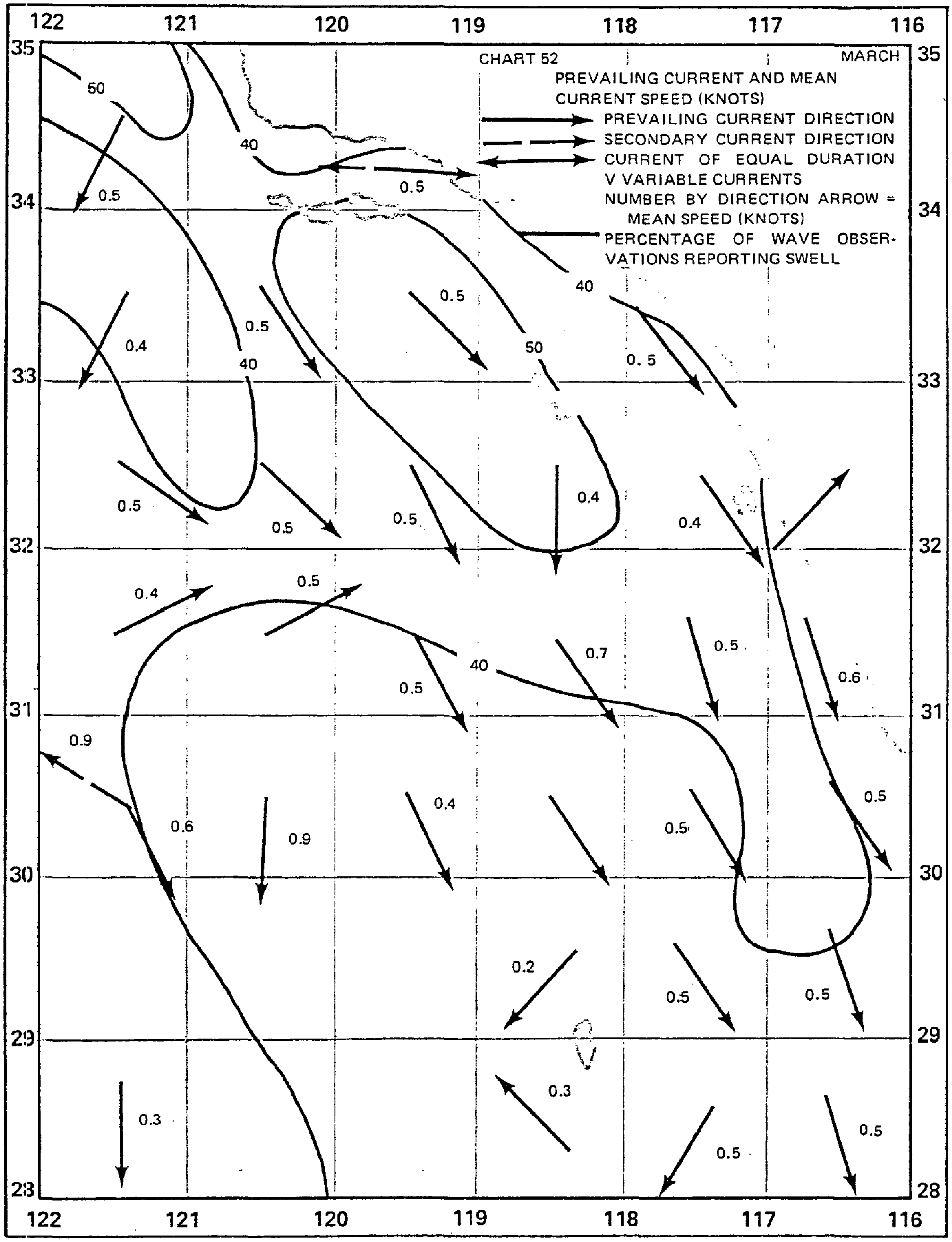
CHART 52
MARCH
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
119
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116
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0.6
0.9
0.2
0.3

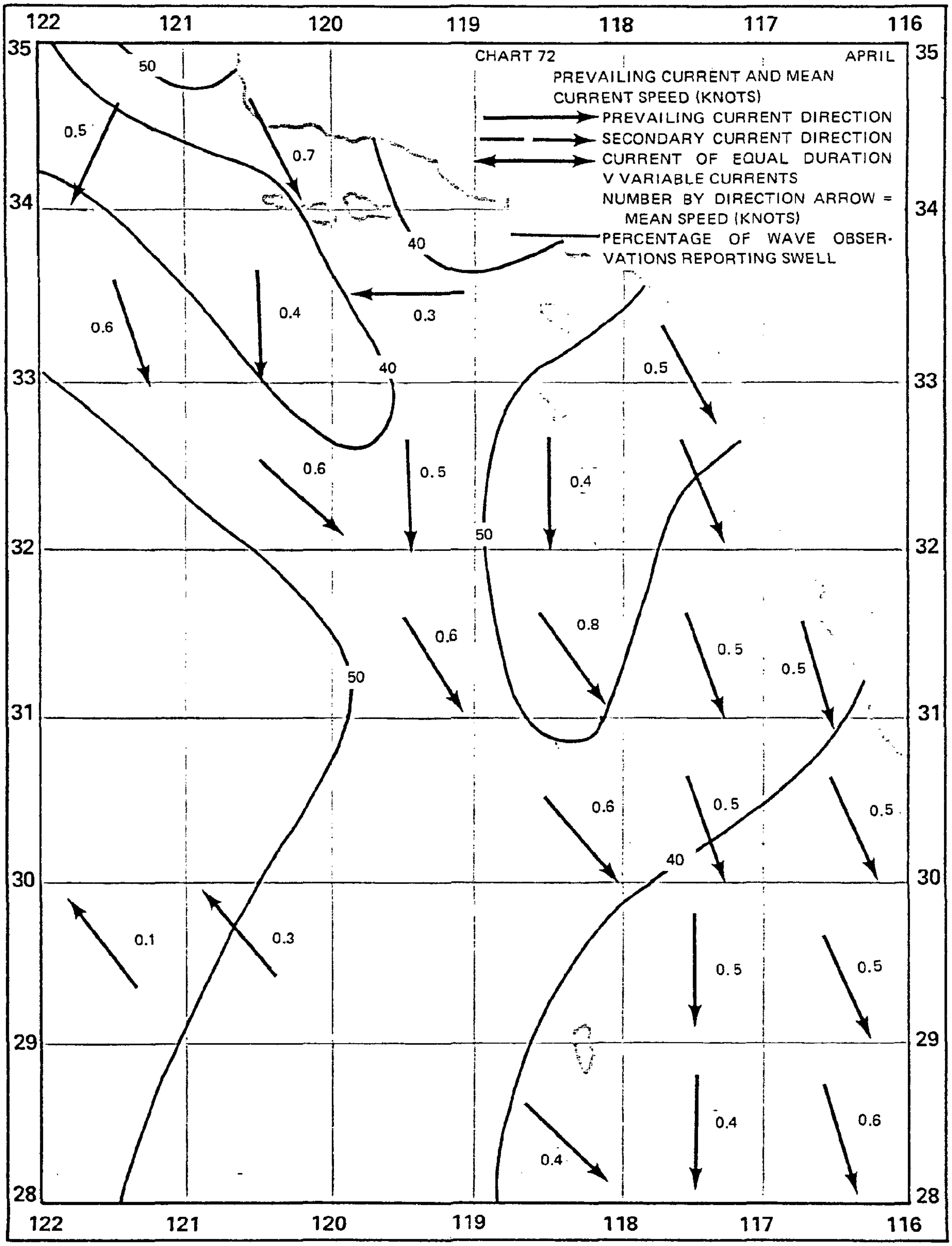

CHART 72
APRIL
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
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116
35
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29
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0.5
0.7
0.6
0.4
0.3
0.8
0.1

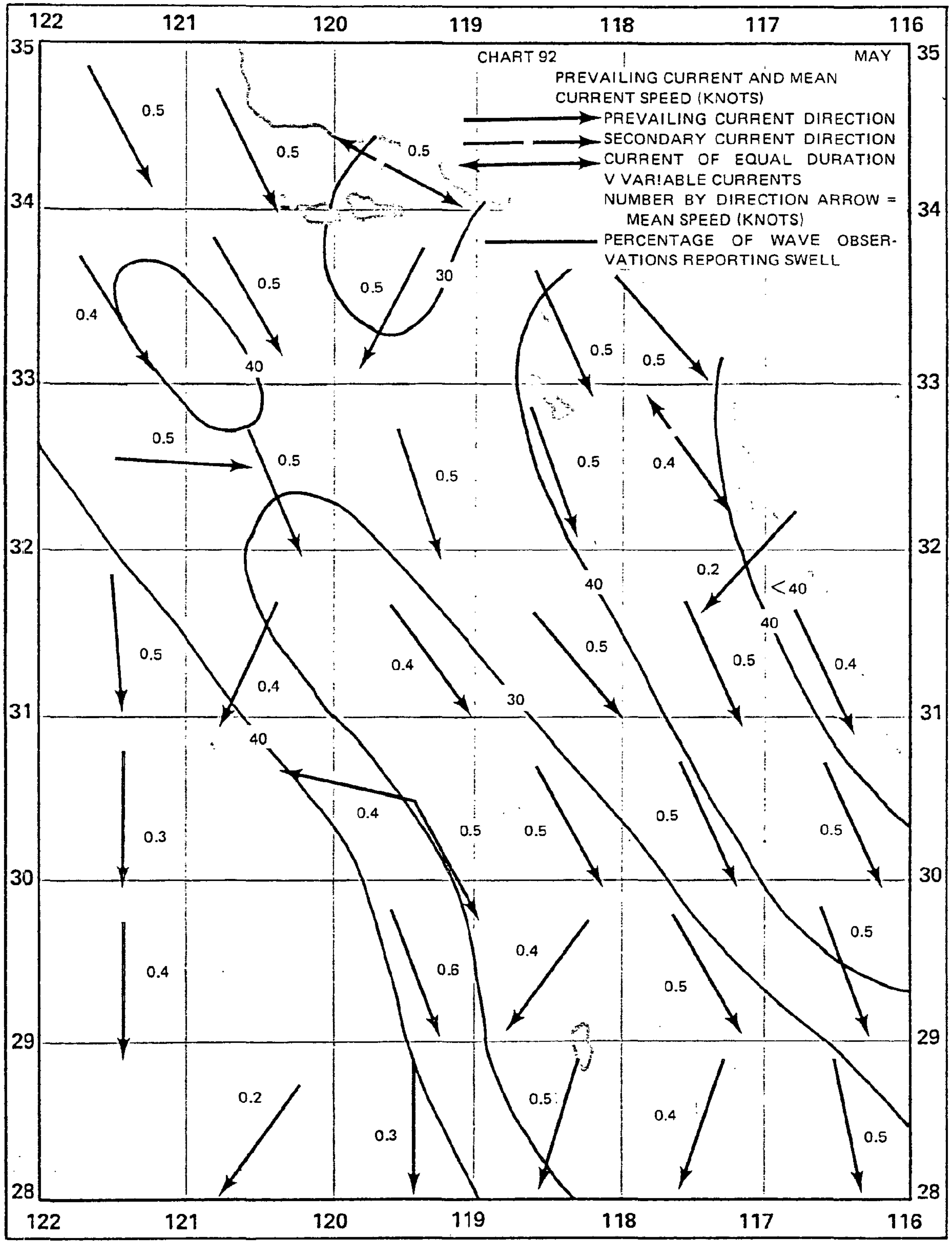
CHART 92
MAY
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
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32
31
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28
0.5
0.4
0.3
0.2
0.6
40
30
<40

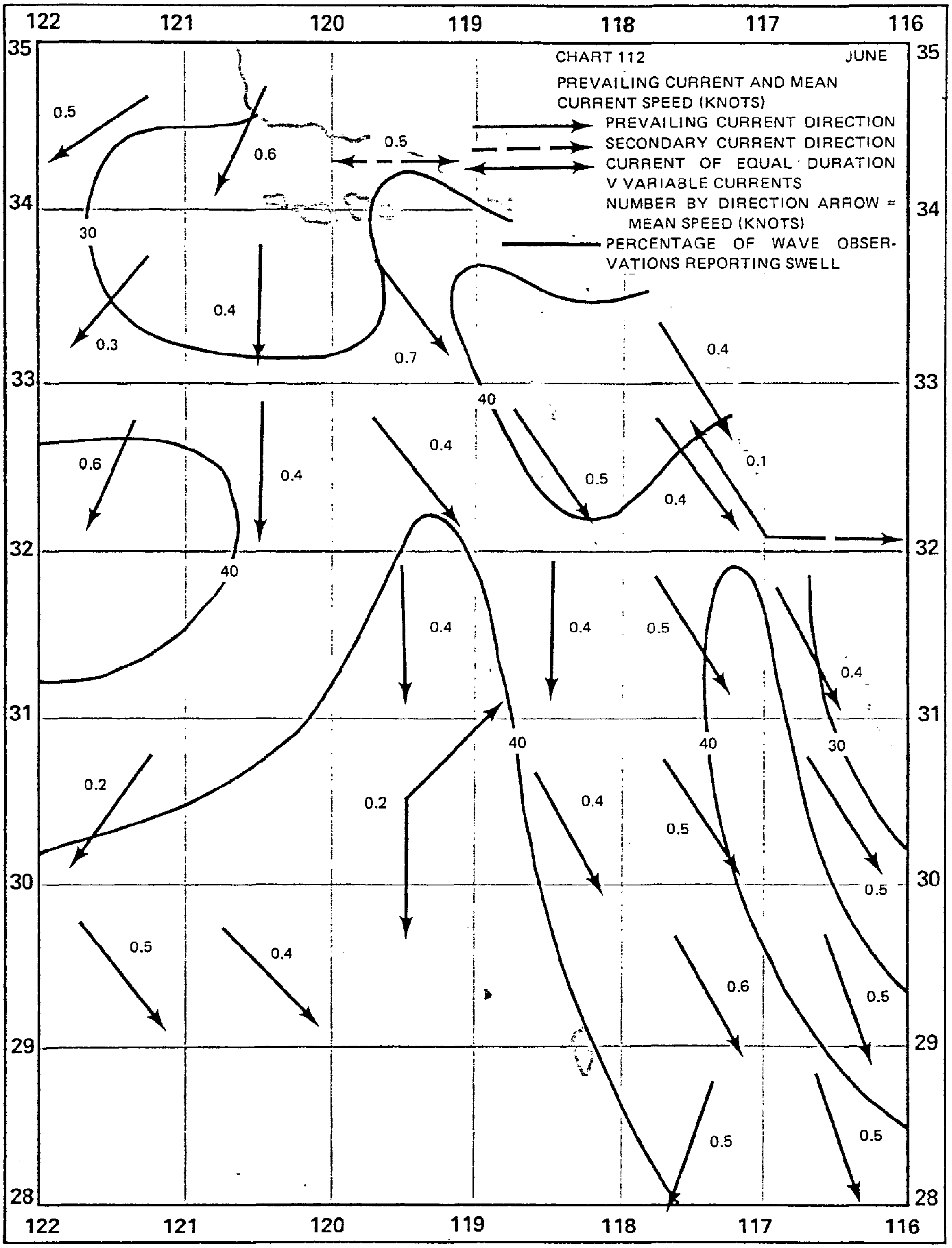
CHART 112
JUNE
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
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116
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29
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0.5
0.6
0.5
30
0.4
0.3
0.7
0.4
40
0.4
0.1
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0.4
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0.4
40
0.4
0.4
0.5
0.4
40
40
30
0.2
0.2
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0.4
0.6
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0.5
0.5

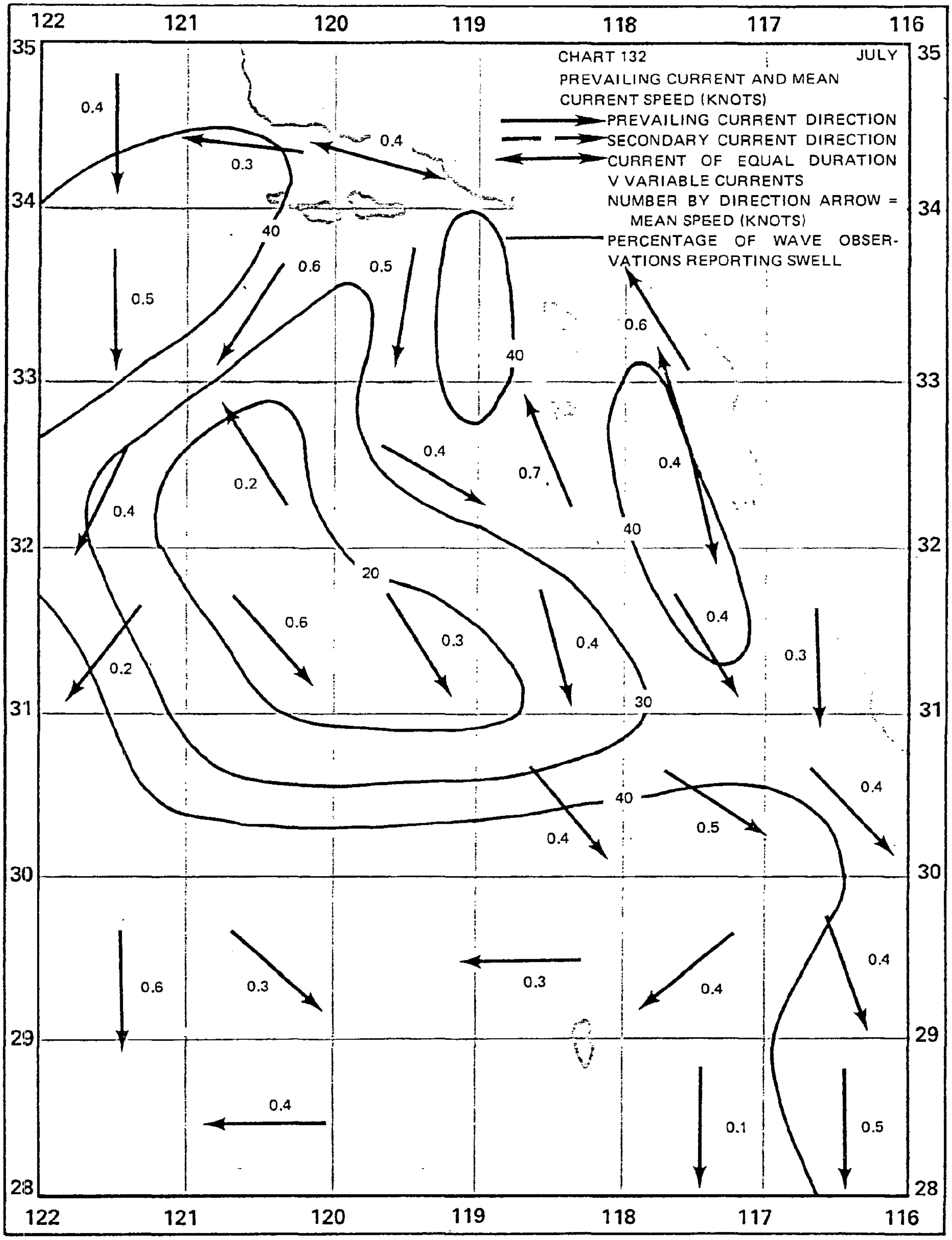
CHART 132
JULY
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
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118
117
116
35
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32
31
30
29
28
0.4
0.3
0.4
40
0.5
0.6
0.5
0.6
40
0.4
0.2
0.4
0.7
0.4
40
20
0.6
0.3
0.4
0.4
0.2
0.3
30
0.4
40
0.5
0.4
0.6
0.3
0.3
0.4
0.4
0.4
0.1
0.5

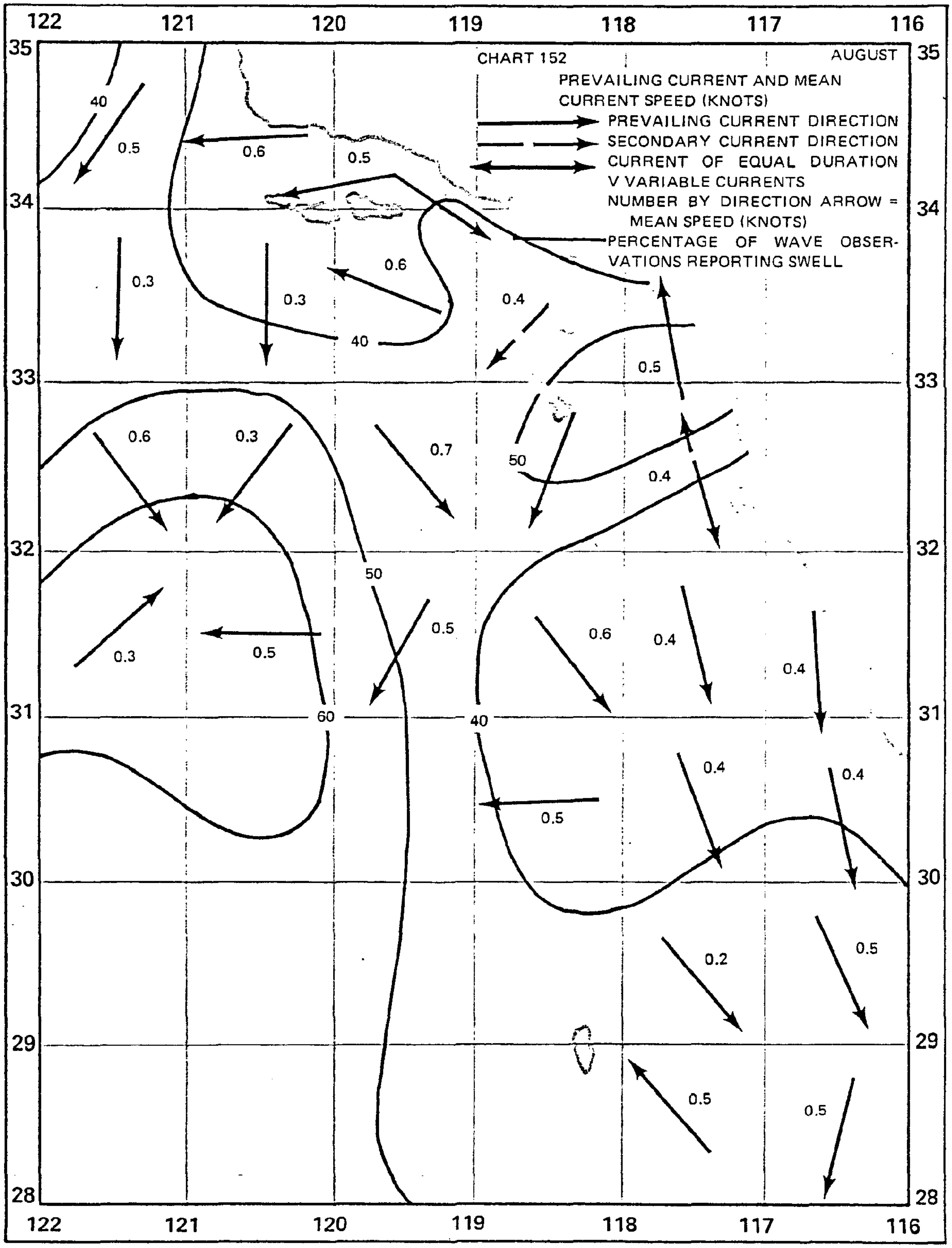

CHART 152
AUGUST
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
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0.5
0.6
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0.7
0.2
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50
60

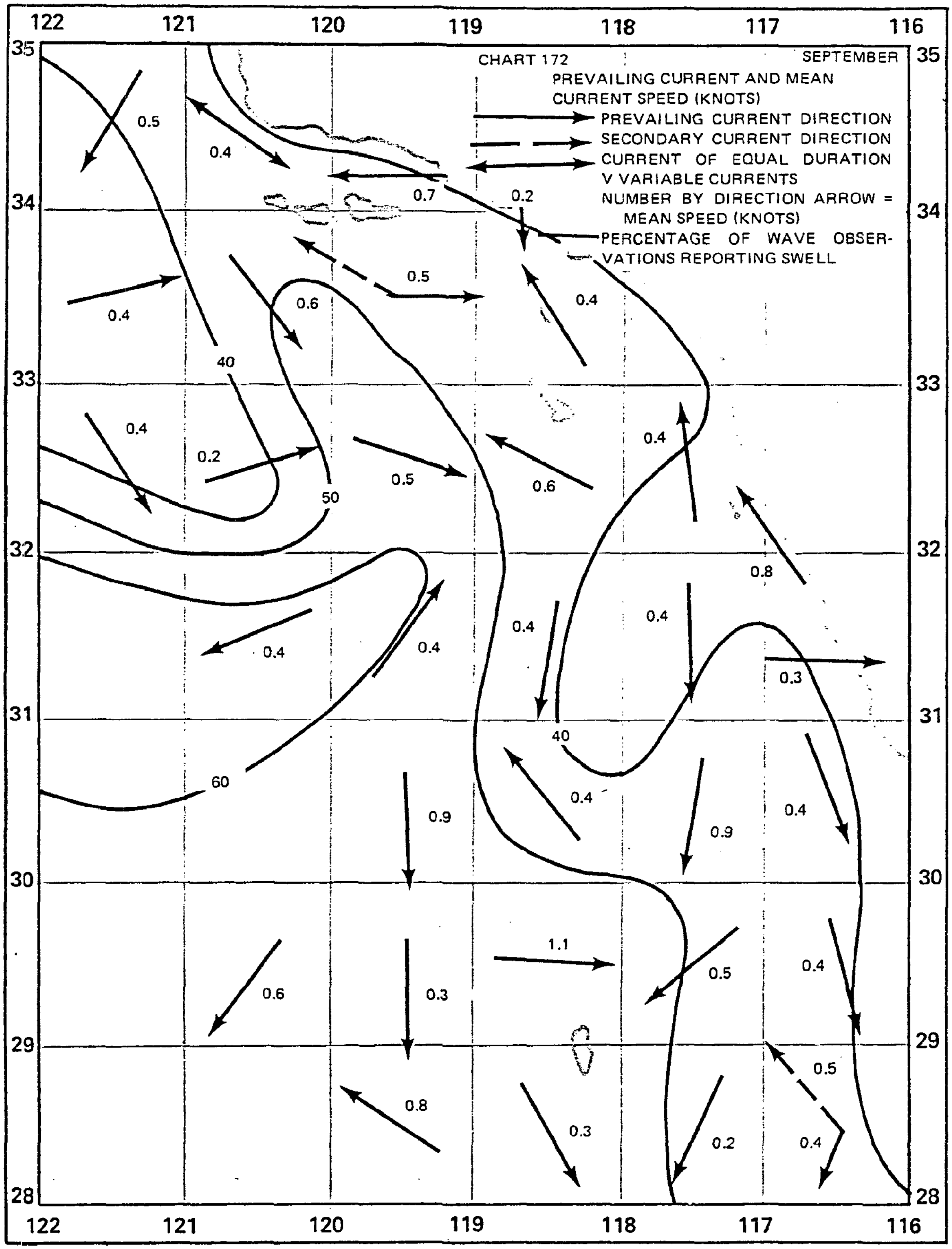

CHART 172
SEPTEMBER
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
119
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117
116
35
34
33
32
31
30
29
28
0.5
0.4
0.7
0.2
0.4
0.6
0.5
0.4
40
0.4
0.2
50
0.5
0.6
0.4
0.8
0.4
0.4
0.4
0.4
0.3
60
40
0.4
0.9
0.9
0.4
1.1
0.5
0.4
0.6
0.3
0.5
0.8
0.3
0.2
0.4

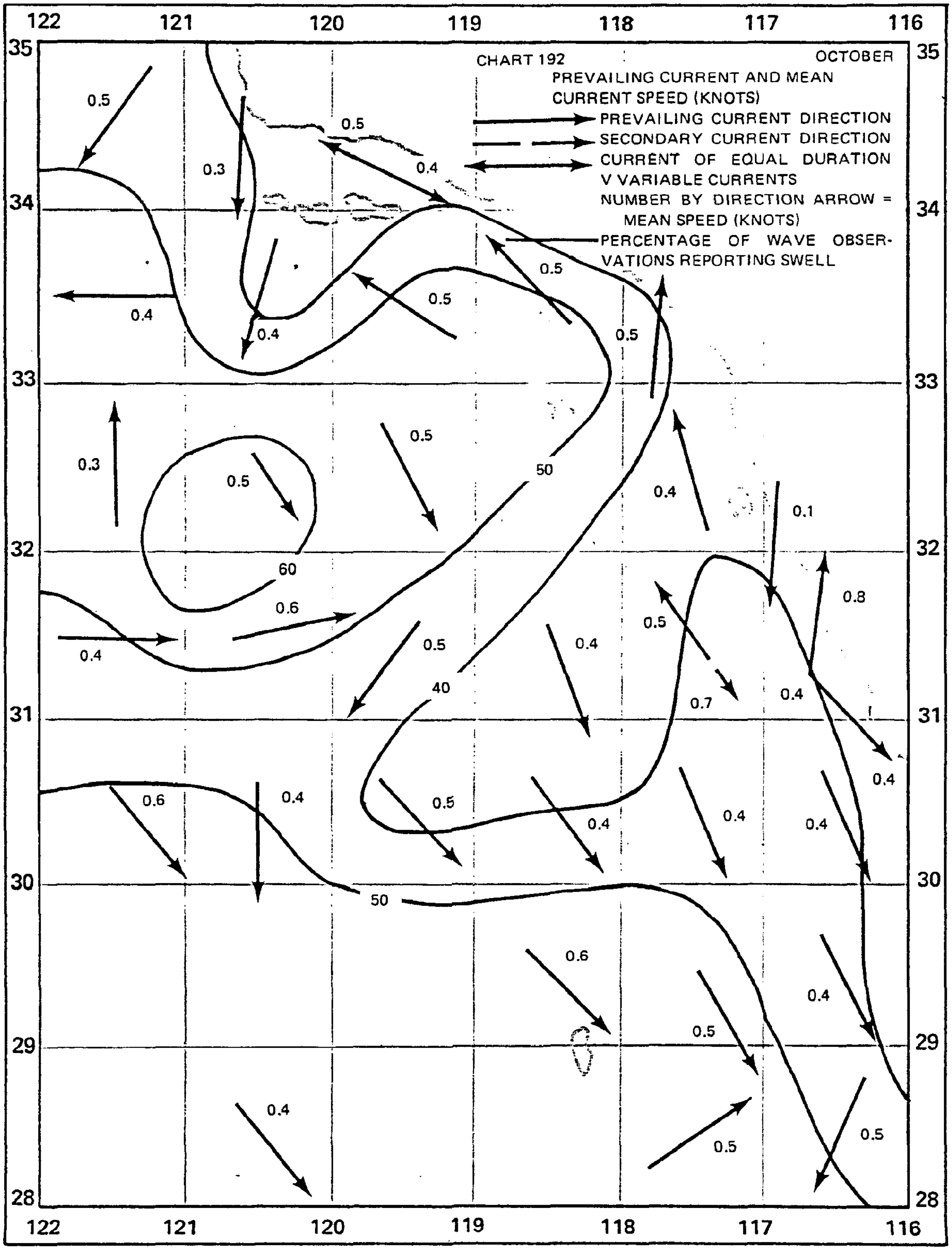

CHART 192
OCTOBER
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
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117
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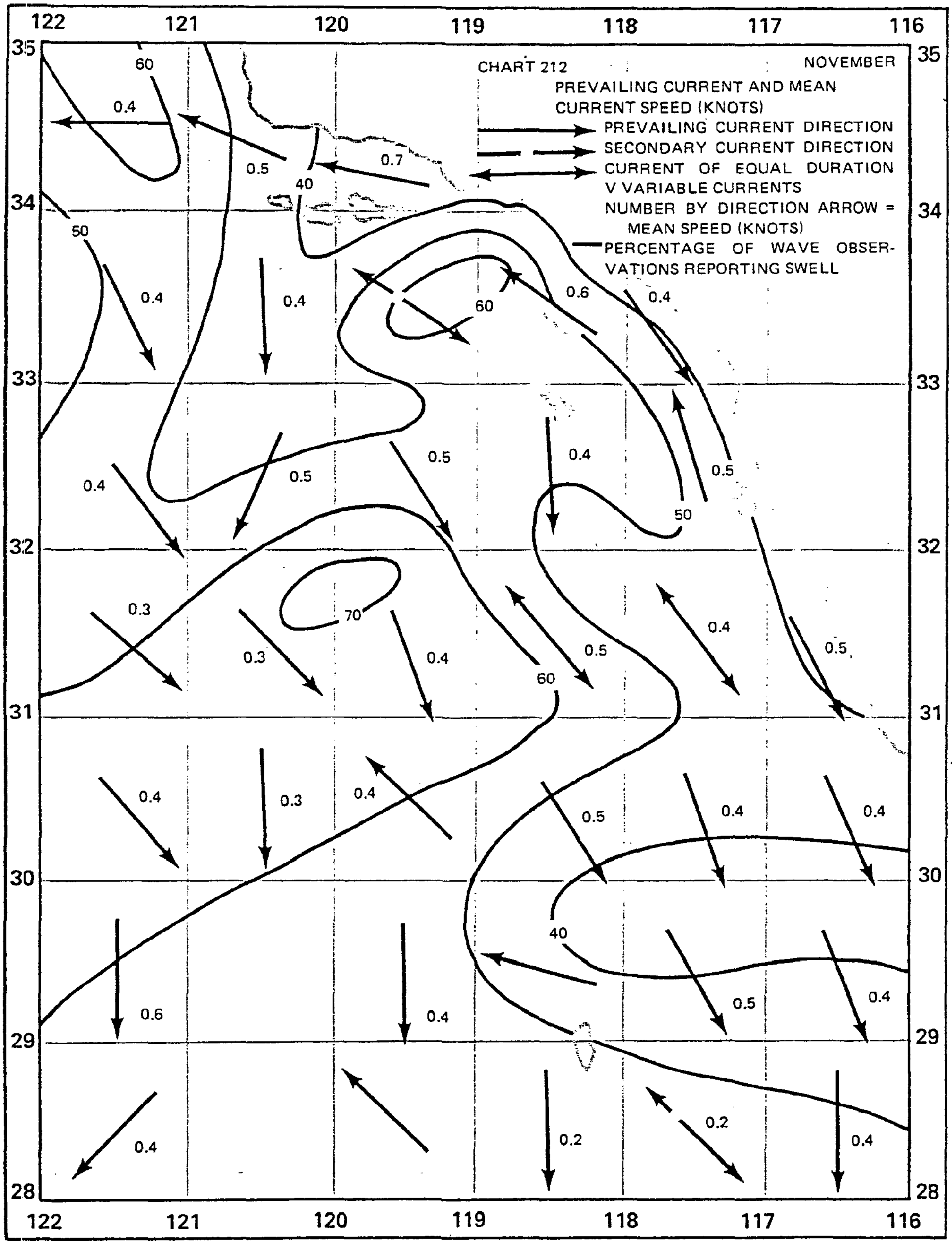

CHART 212
NOVEMBER
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
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116
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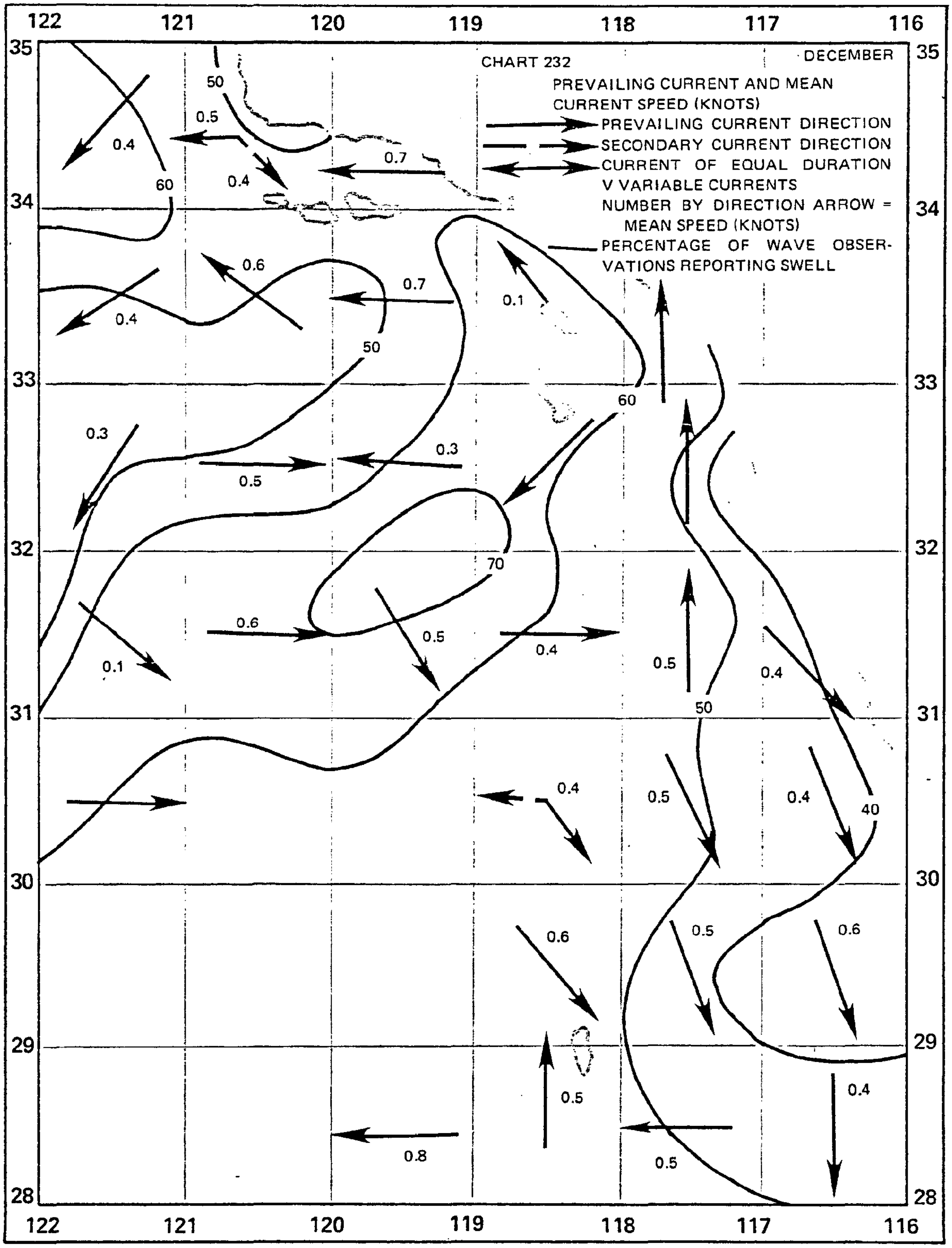
CHART 232
DECEMBER
PREVAILING CURRENT AND MEAN CURRENT SPEED (KNOTS)
PREVAILING CURRENT DIRECTION
SECONDARY CURRENT DIRECTION
CURRENT OF EQUAL DURATION
V VARIABLE CURRENTS
NUMBER BY DIRECTION ARROW = MEAN SPEED (KNOTS)
PERCENTAGE OF WAVE OBSERVATIONS REPORTING SWELL
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
50
0.5
0.4
0.7
60
0.6
0.1
0.3
70
0.8
40

Percentage Frequency of Occurrence of Wave Heights > 2 Feet and > 6 Feet

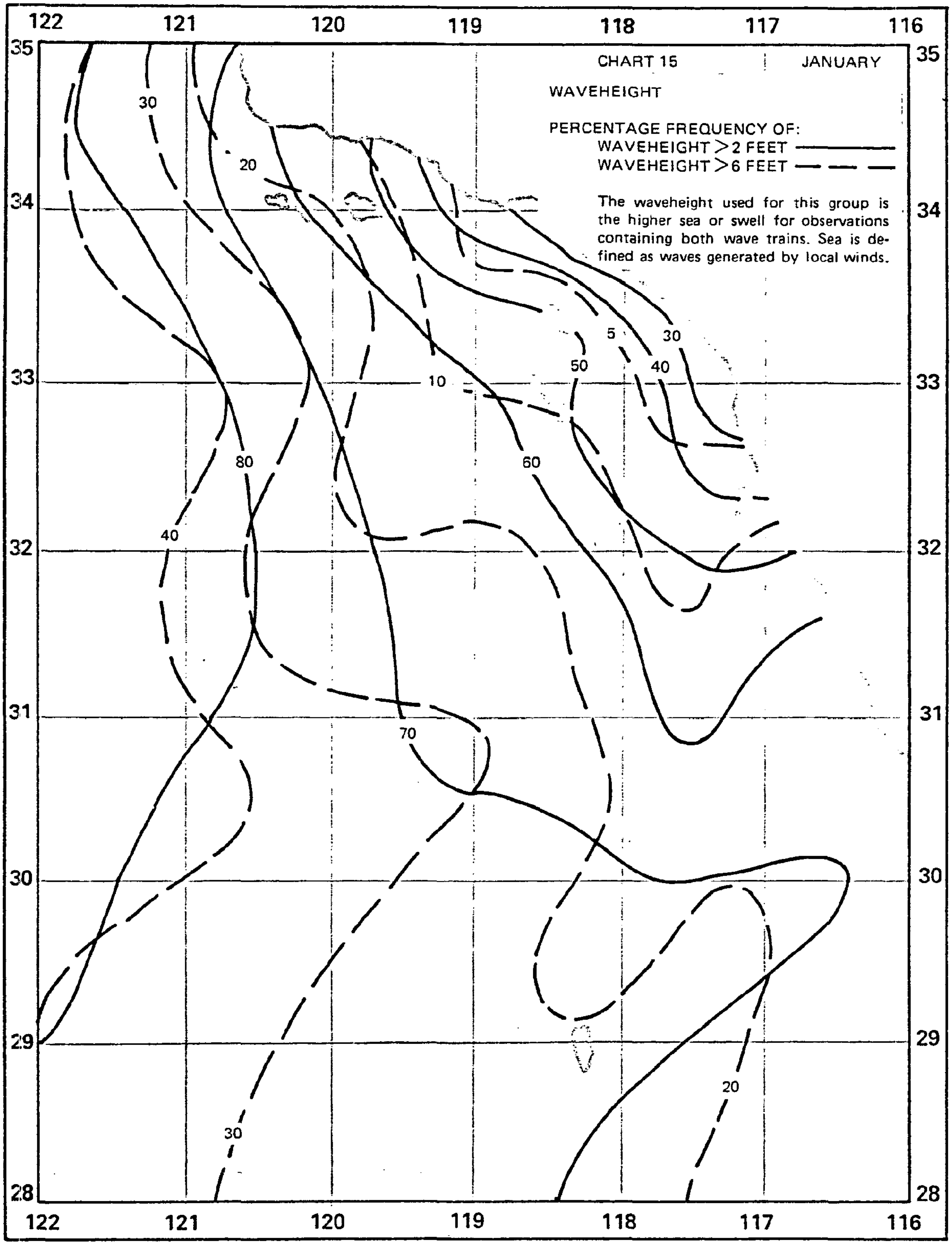

CHART 15
JANUARY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
121
120
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116
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70
80
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30
20

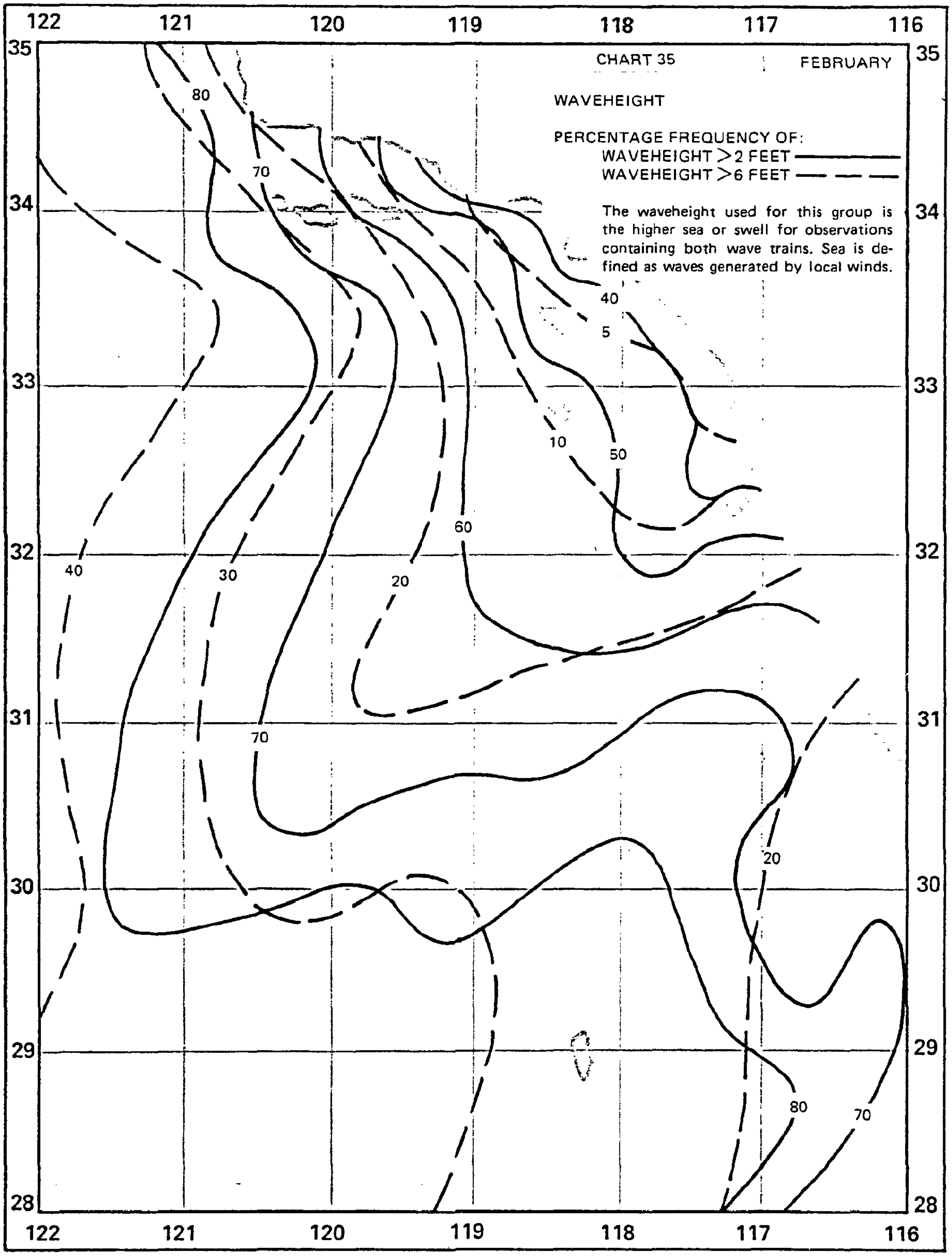

CHART 35
FEBRUARY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
121
120
119
118
117
116
35
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31
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28
80
70
40
5
10
50
60
40
30
20
70
20
80
70

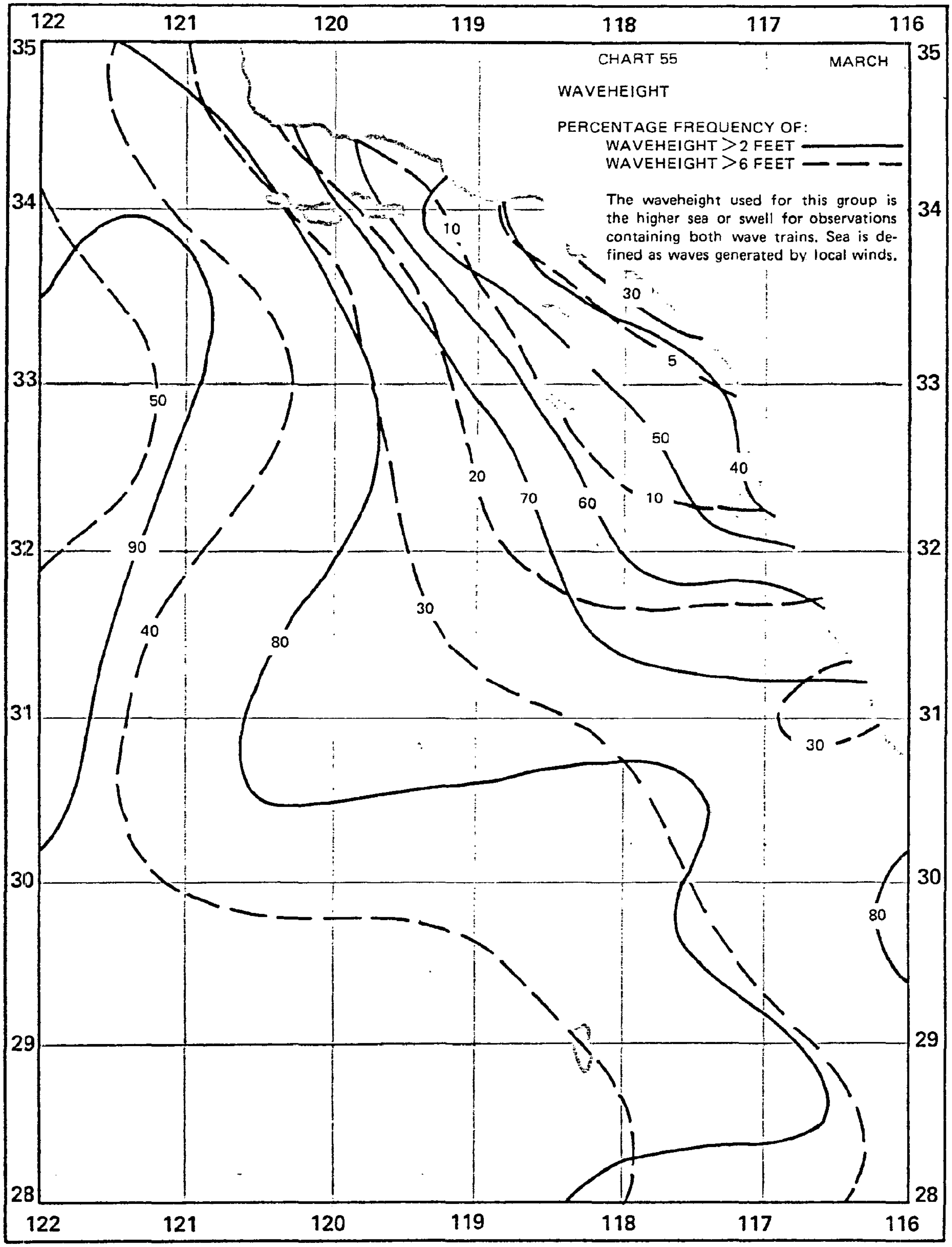

CHART 55
MARCH
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
121
120
119
118
117
116
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34
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32
31
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28
10
30
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40
20
70
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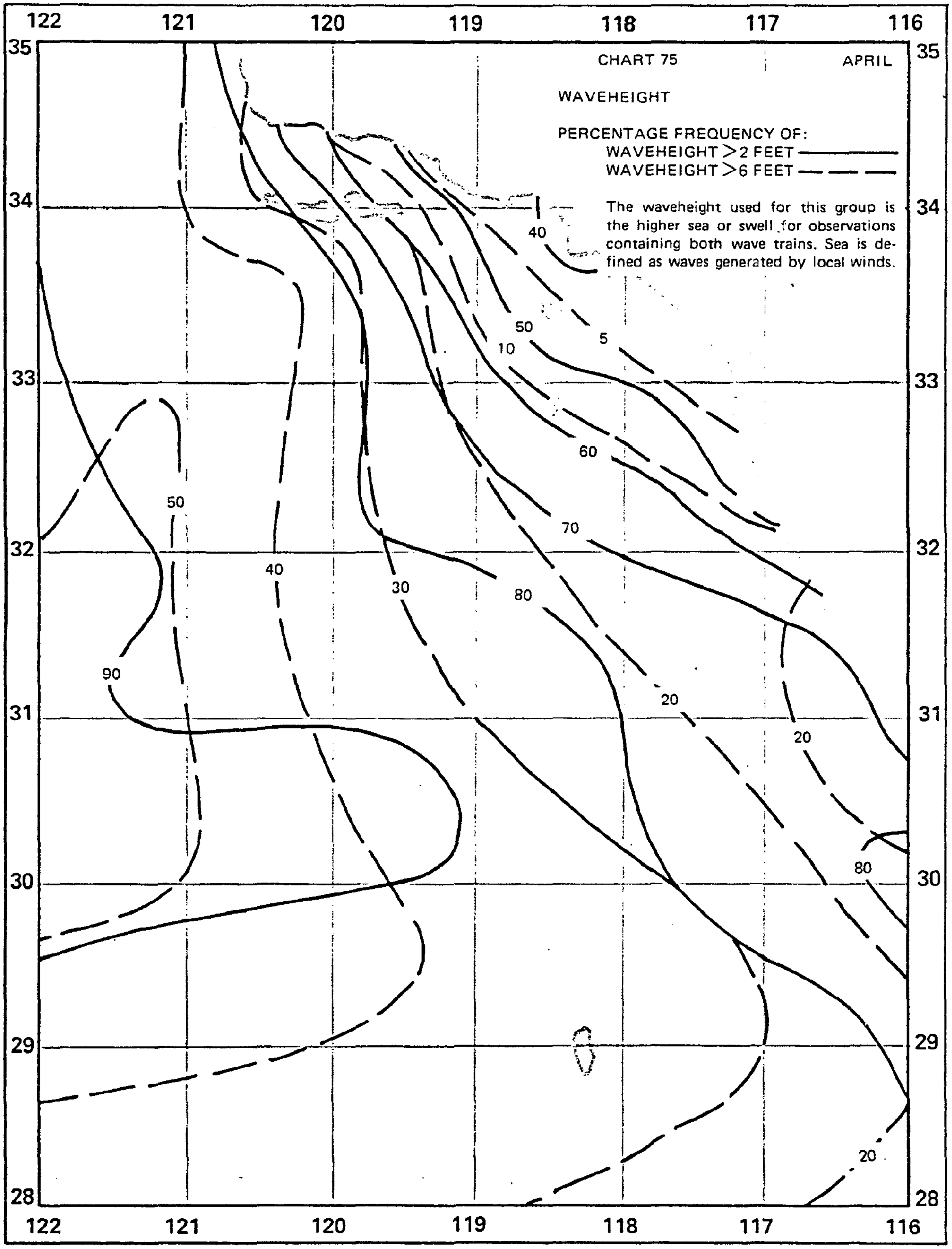
90
40
80
30
30
80


122
121
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116
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32
31
30
29
28
CHART 75
APRIL
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
40
50
5
10
60
70
50
40
30
80
90
20
20
80
20

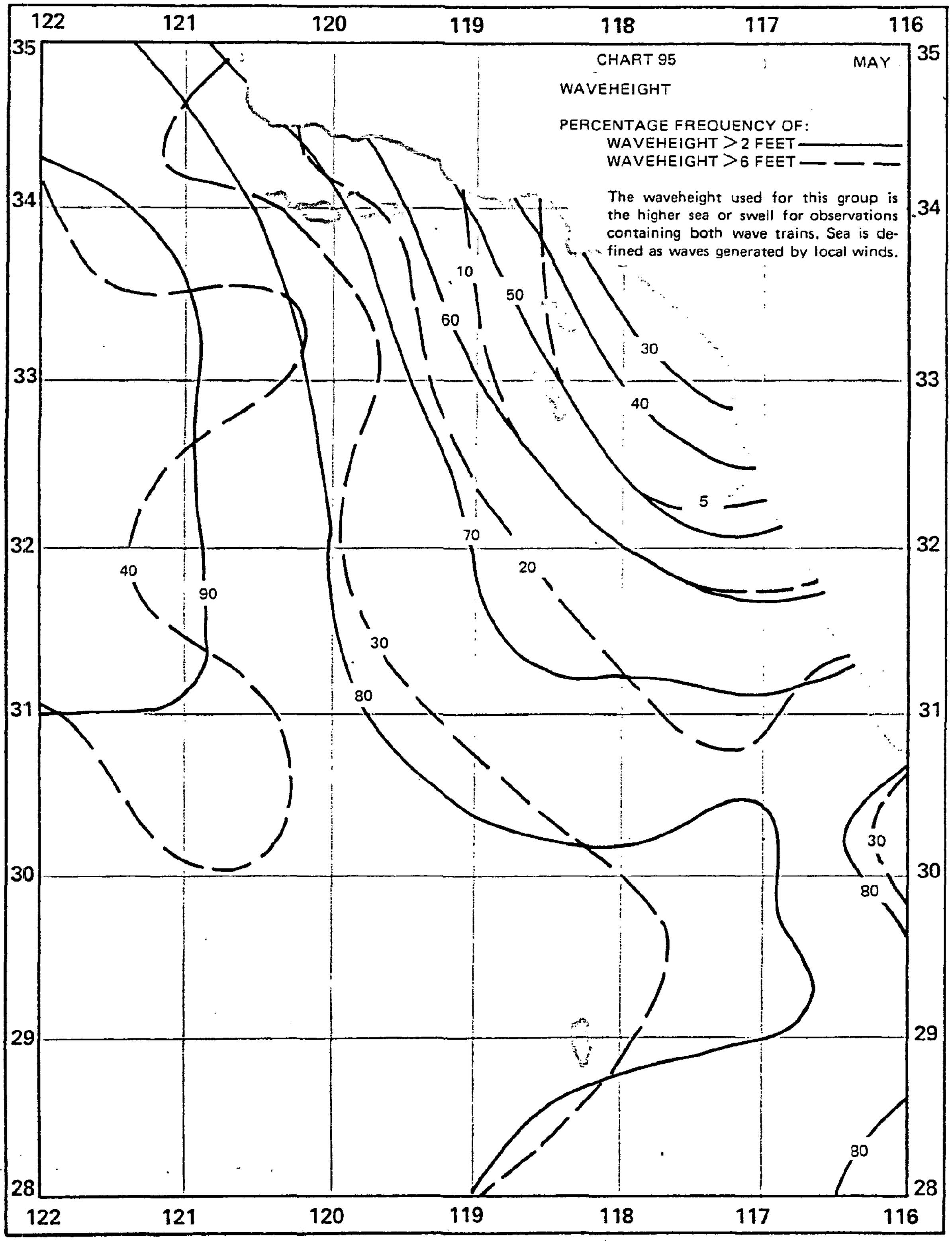

CHART 95
MAY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
121
120
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116
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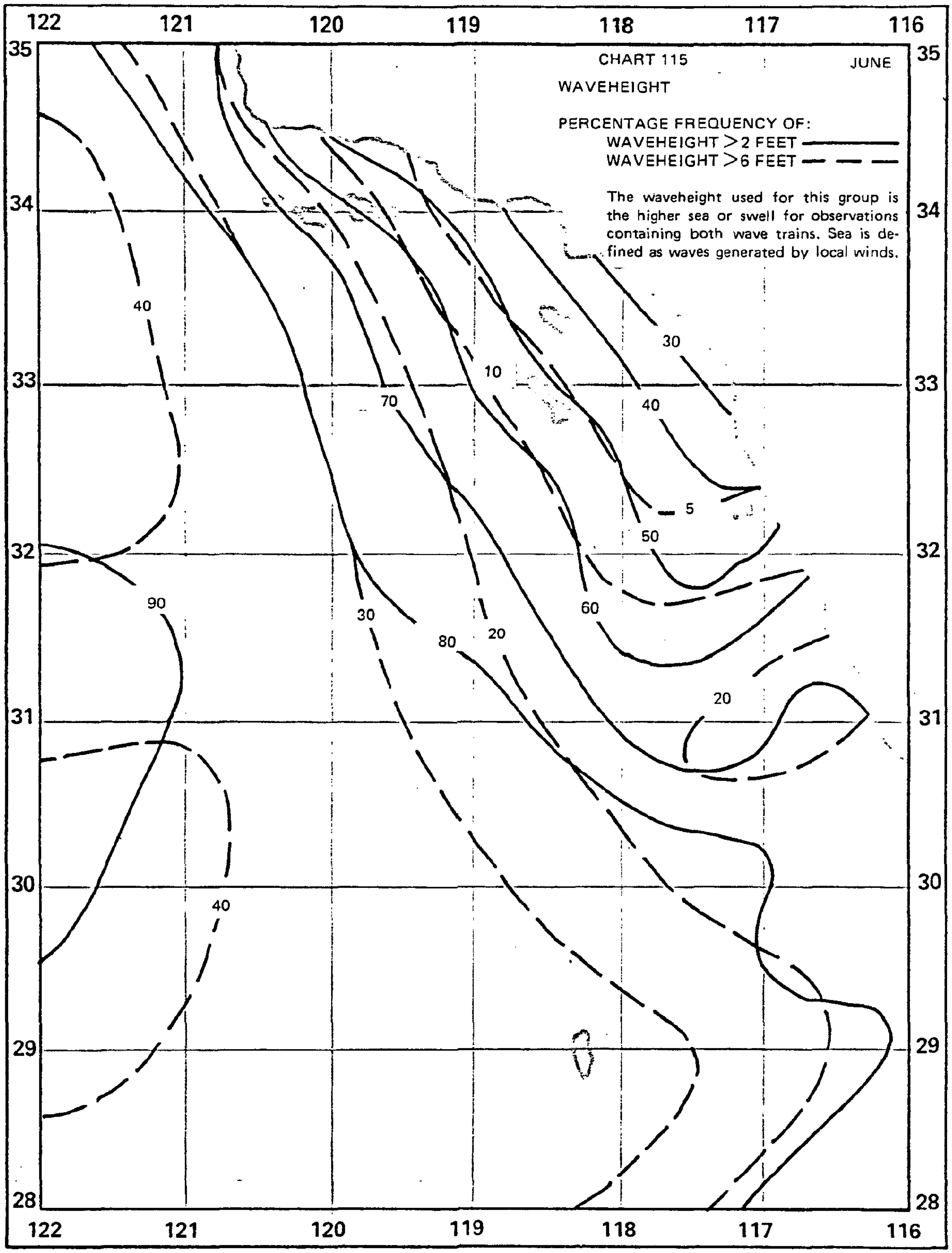
CHART 115
JUNE
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
121
120
119
118
117
116
35
34
33
32
31
30
29
28
40
30
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70
40
5
50
90
30
60
80
20
20
40

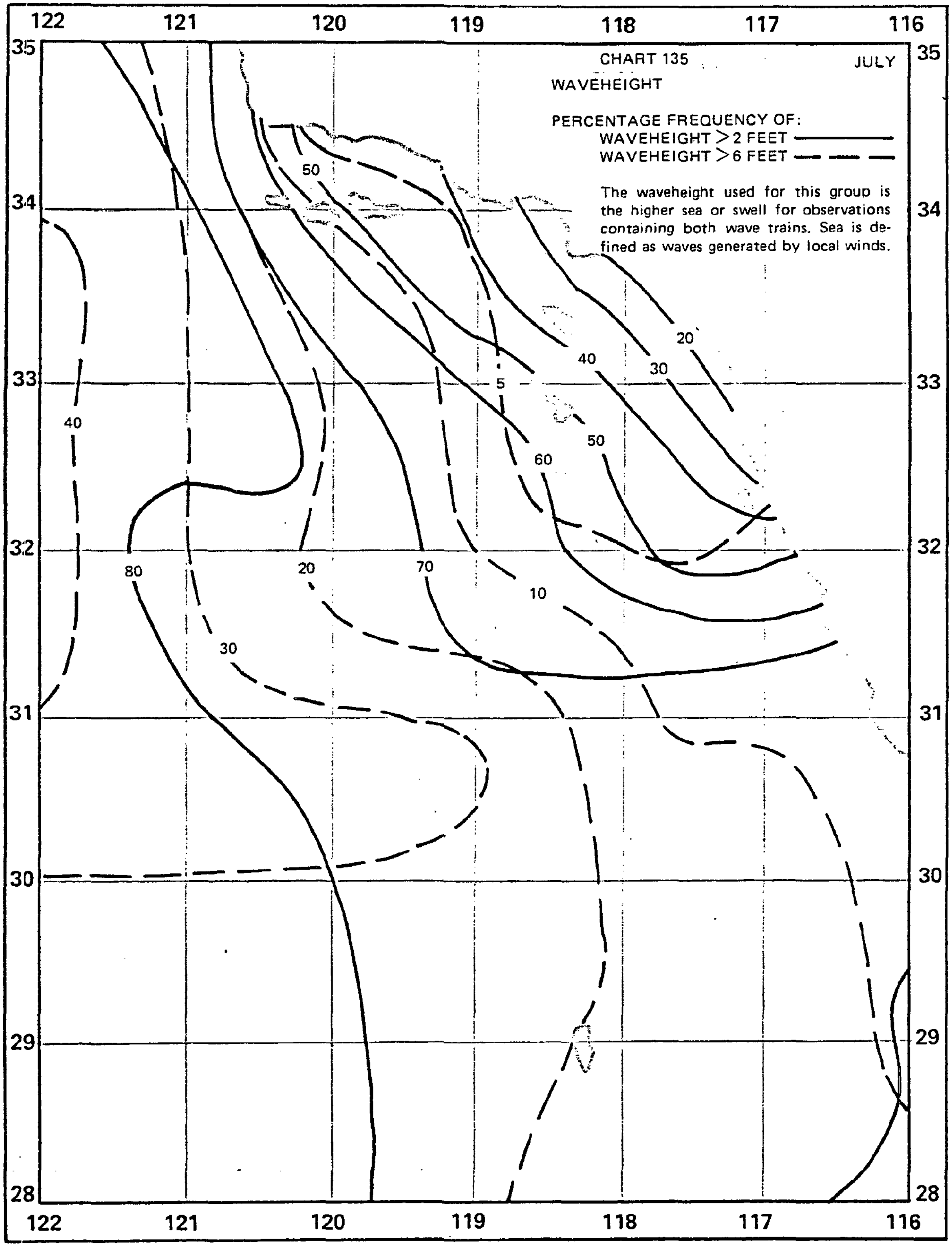
CHART 135
JULY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT > 2 FEET
WAVEHEIGHT > 6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122 121 120 119 118 117 116
35 34 33 32 31 30 29 28
50
40
30
20
5
60
10
70
80

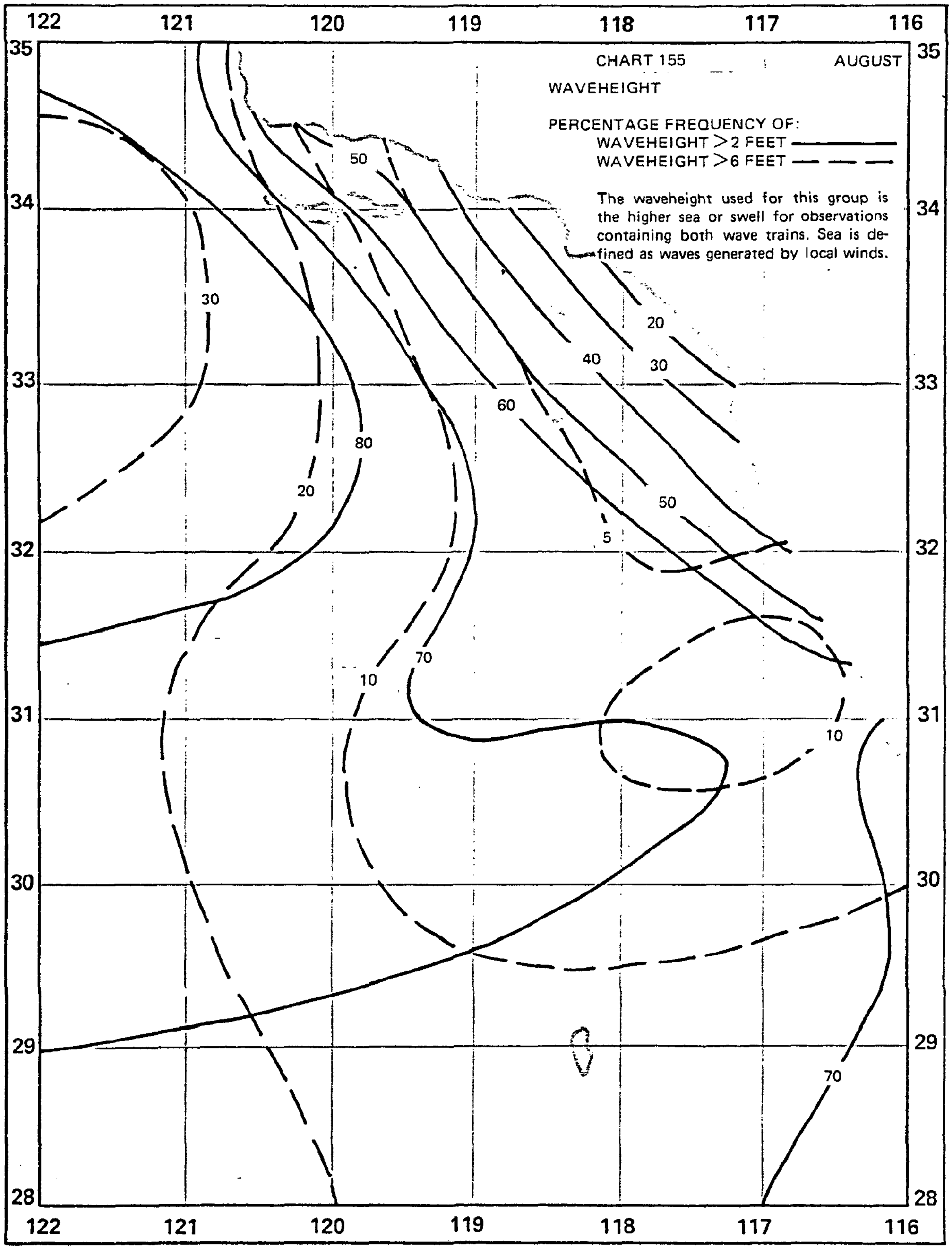

CHART 155
AUGUST
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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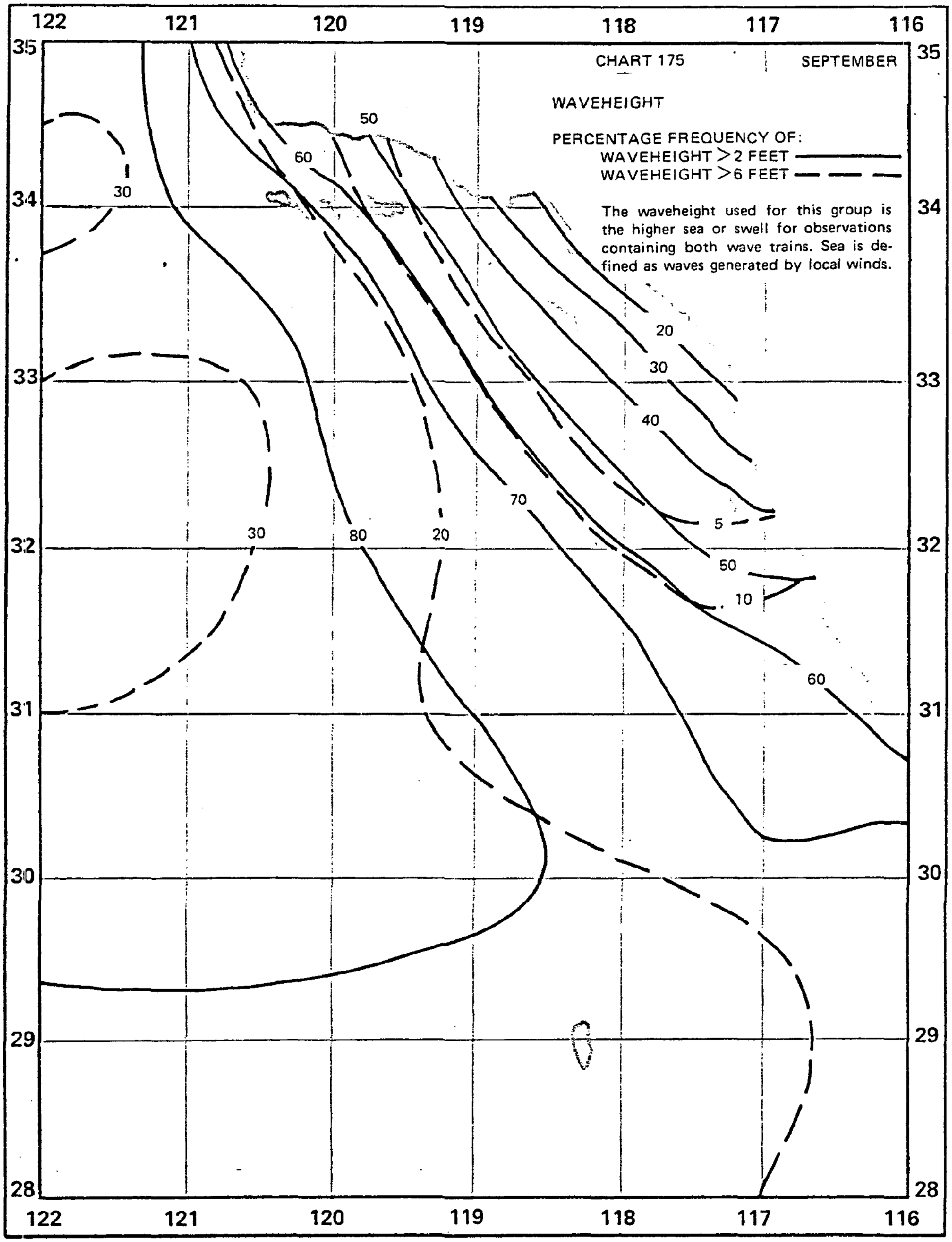

CHART 175
SEPTEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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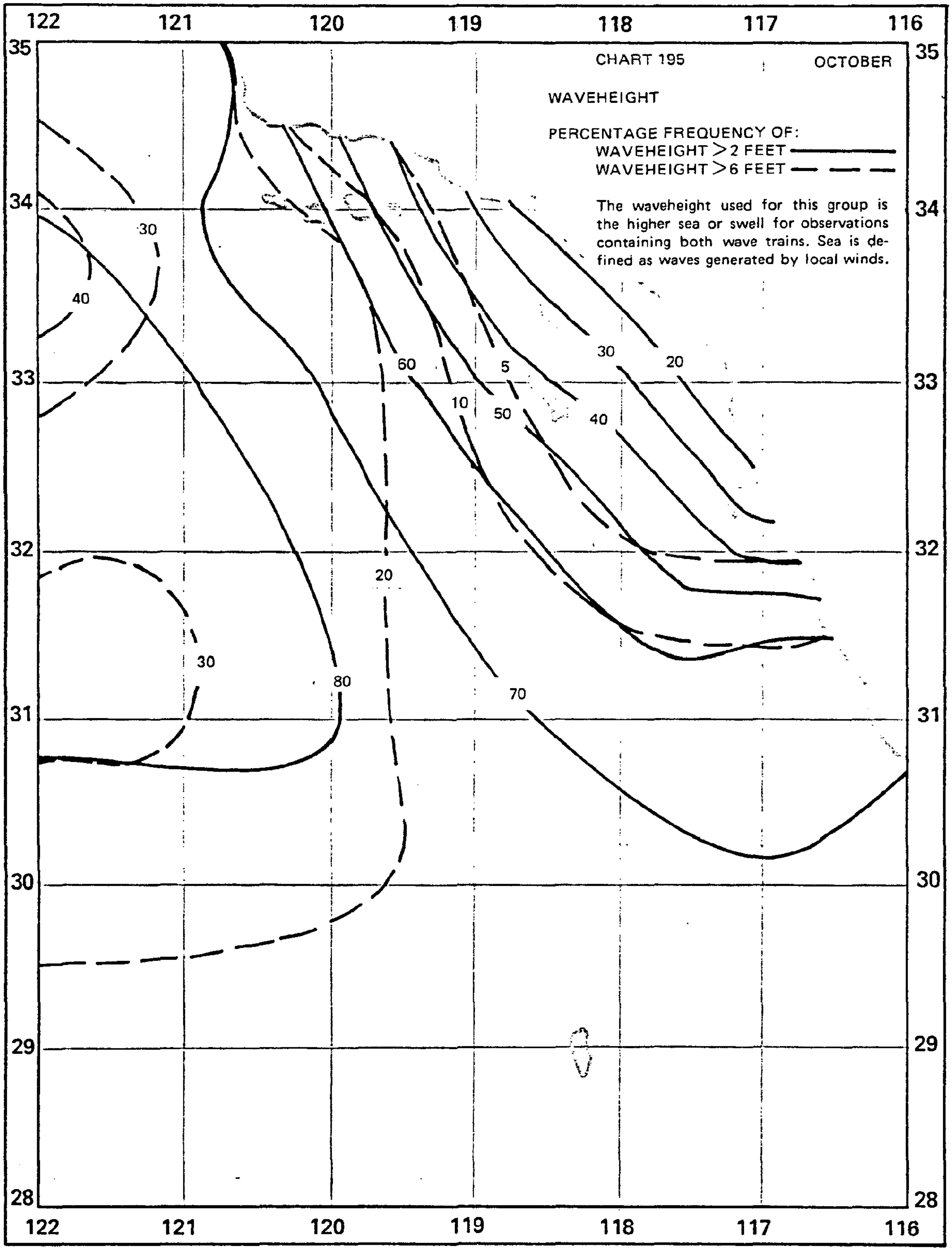
CHART 195
OCTOBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
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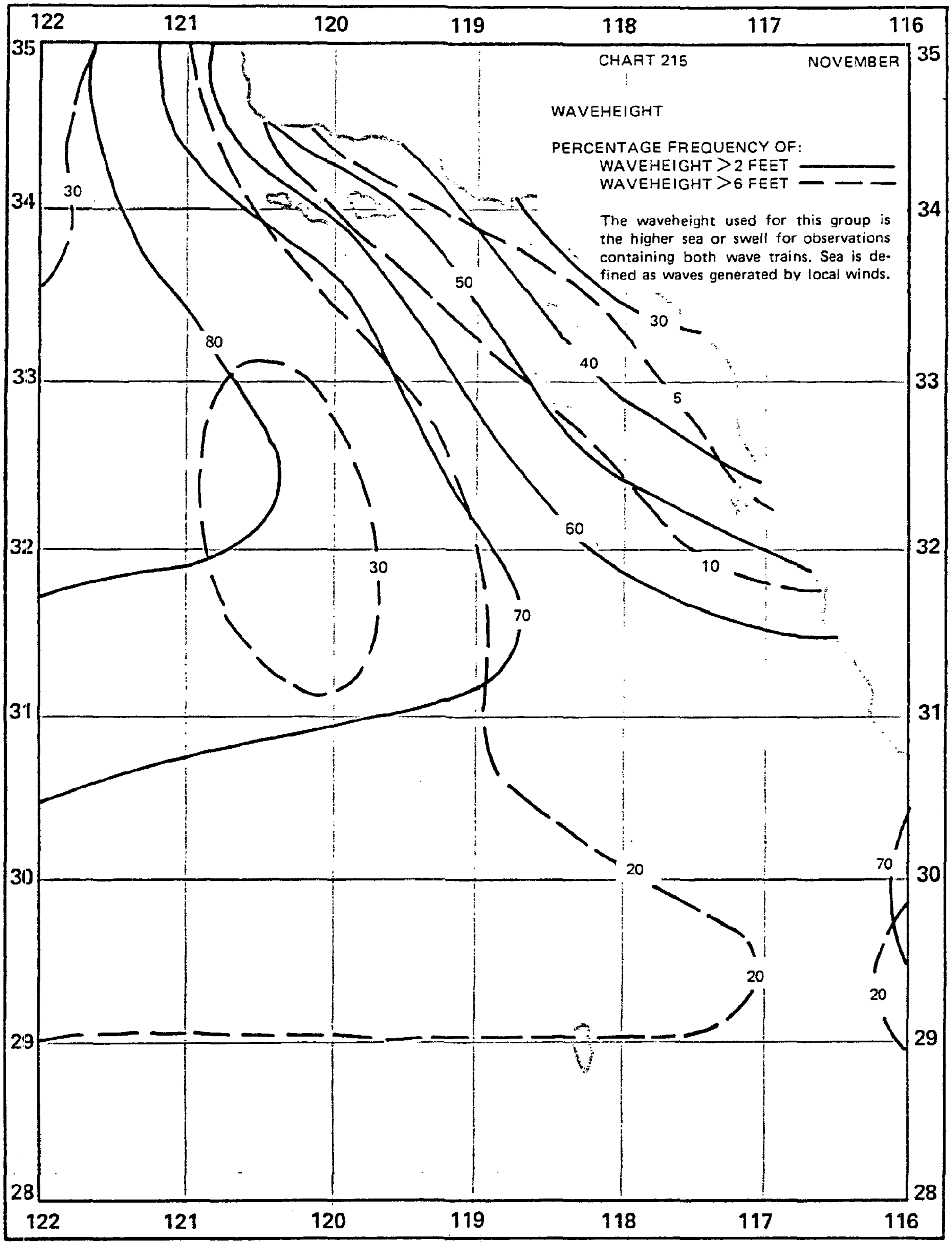
CHART 215
NOVEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
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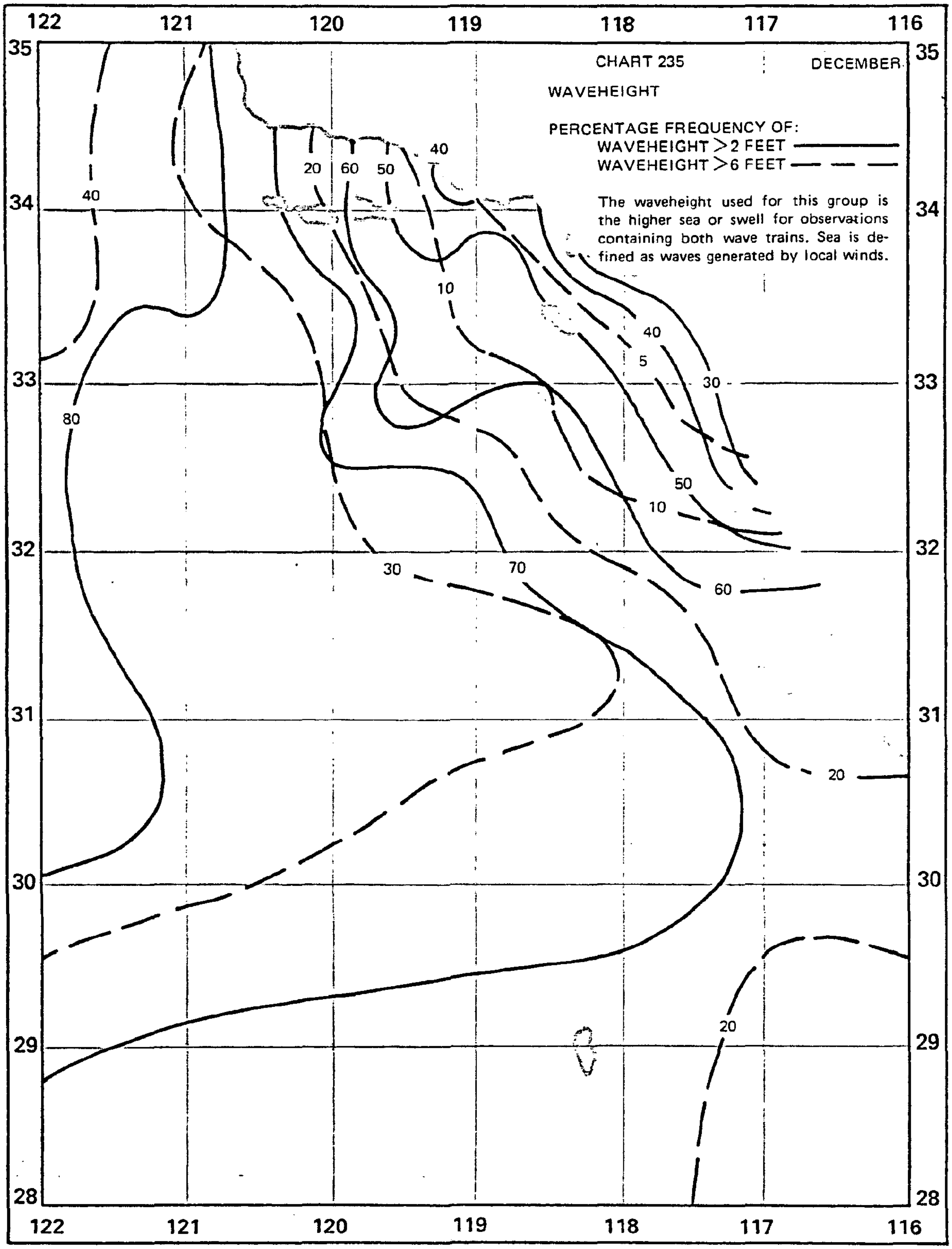
CHART 235
DECEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >2 FEET
WAVEHEIGHT >6 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
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70
60
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20

Percentage Frequency of Occurrence of Wave Height > 9 Feet and > 12 Feet

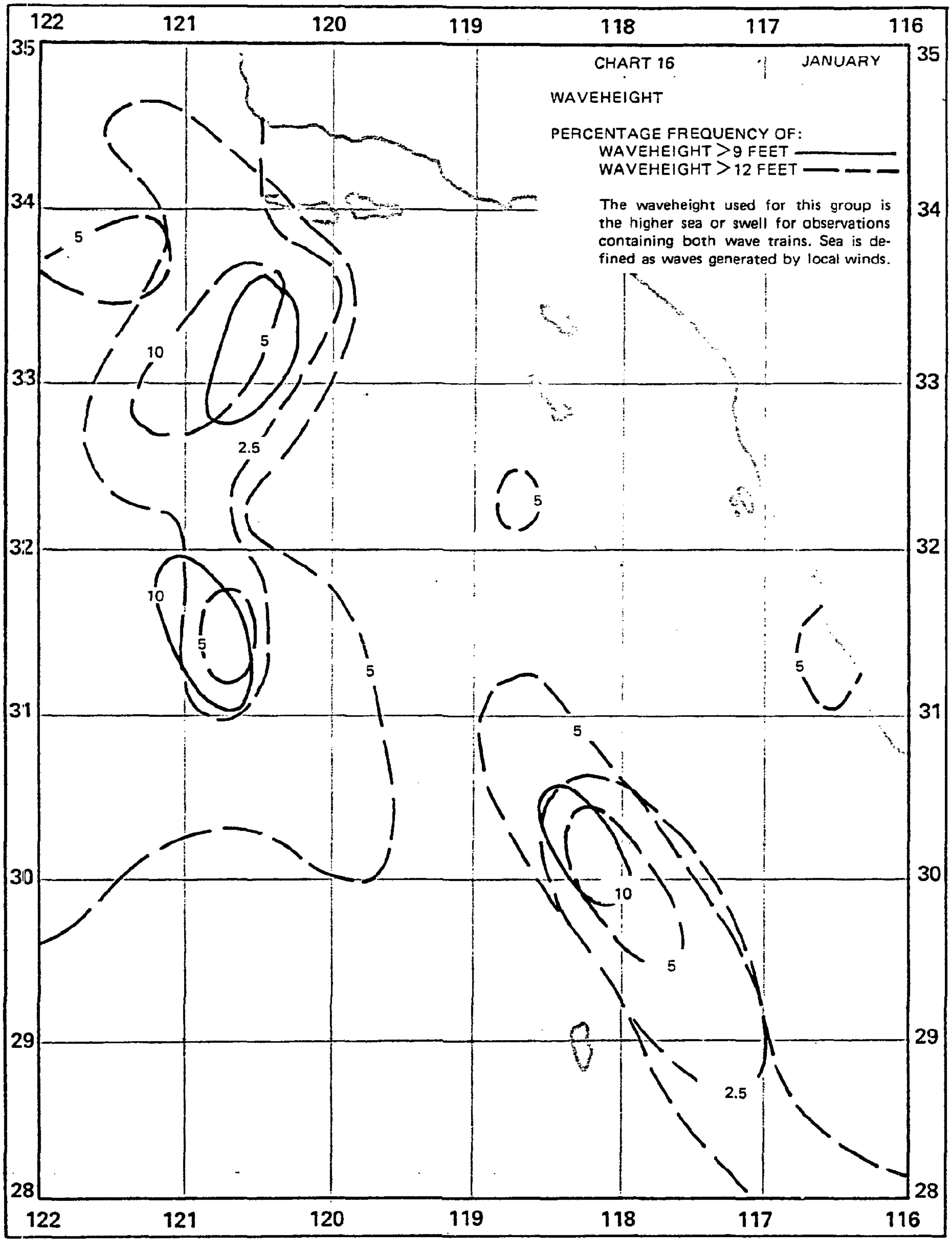
CHART 16
JANUARY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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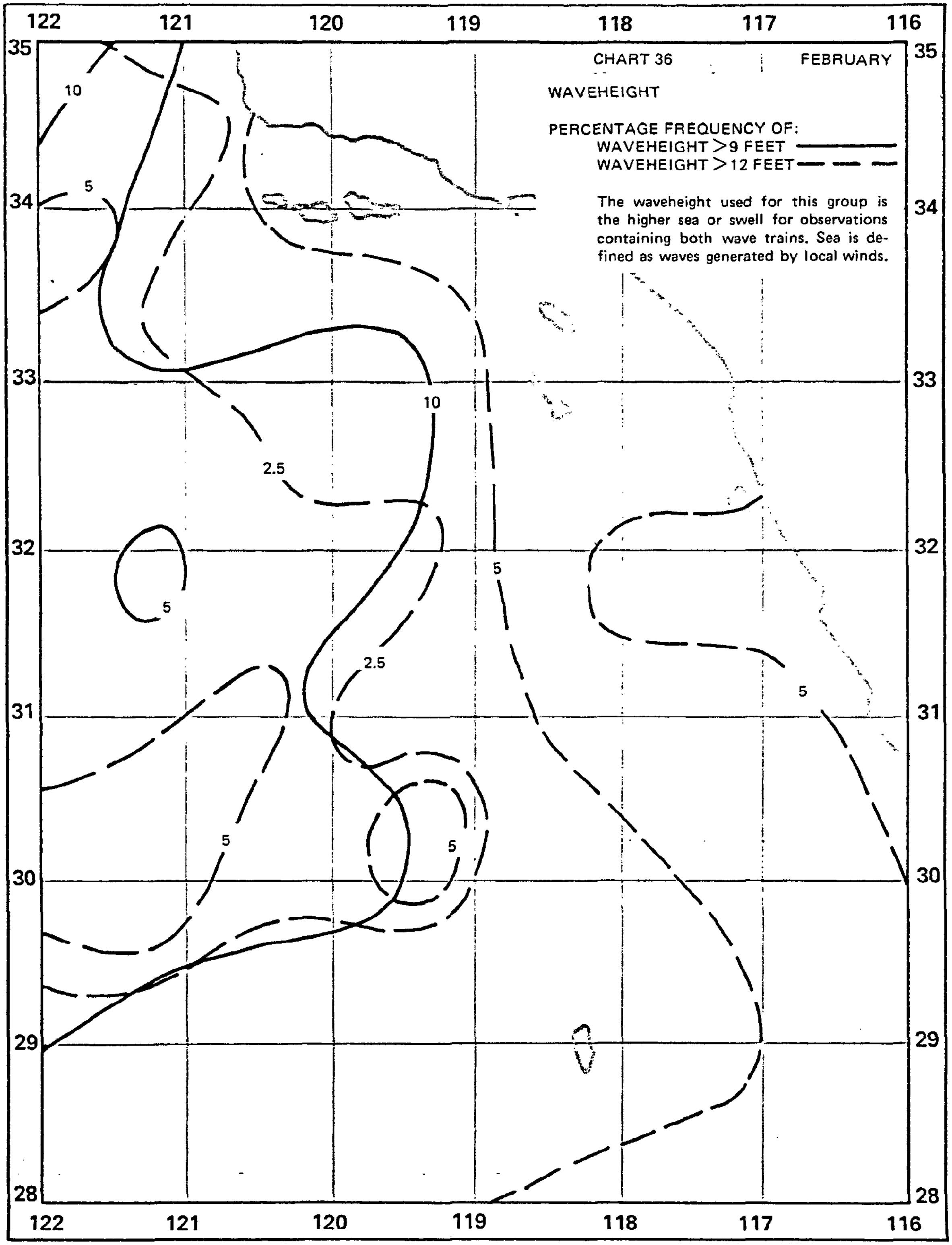

CHART 36
FEBRUARY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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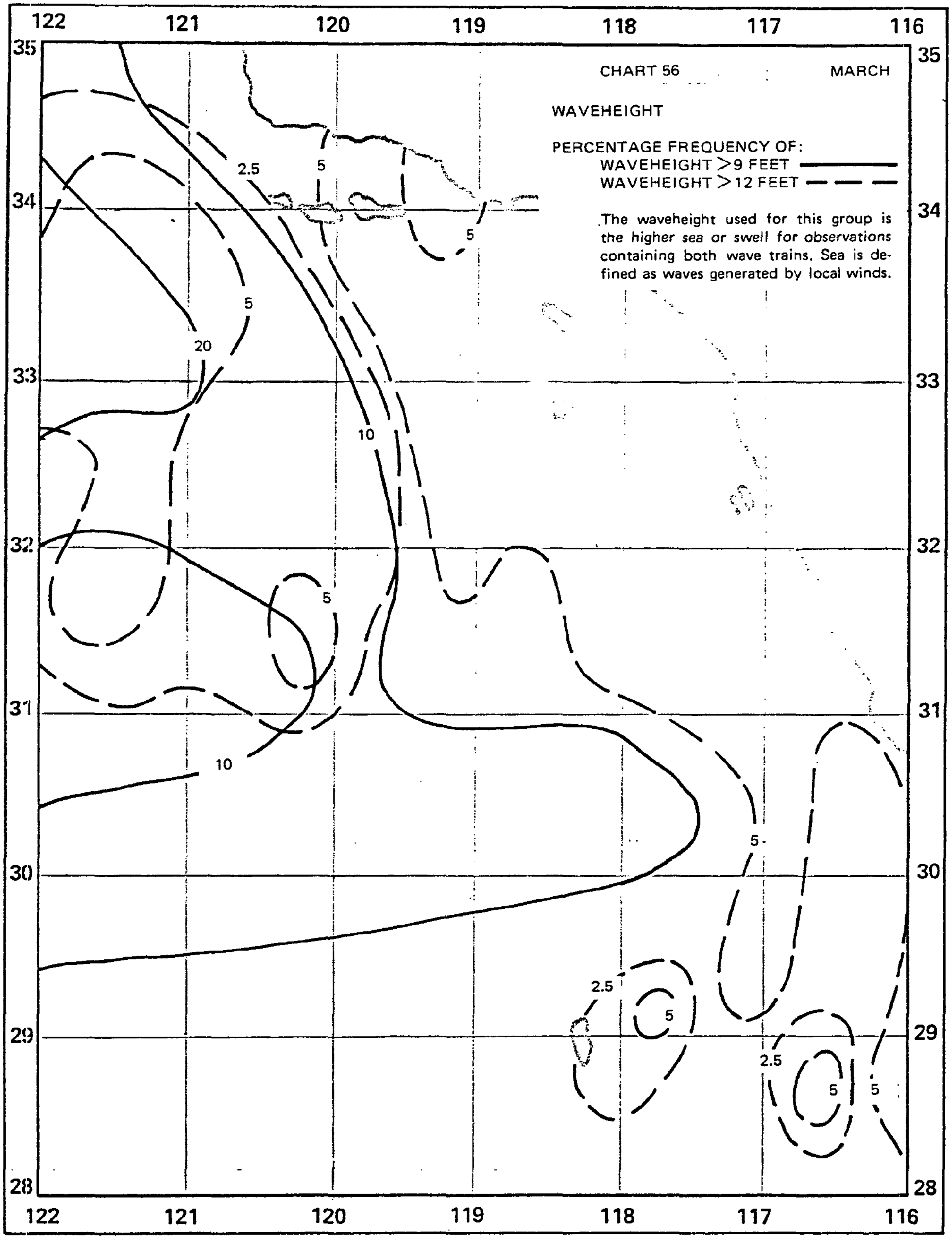
10
5
2.5


122
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28
CHART 56
MARCH
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
2.5
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20
10

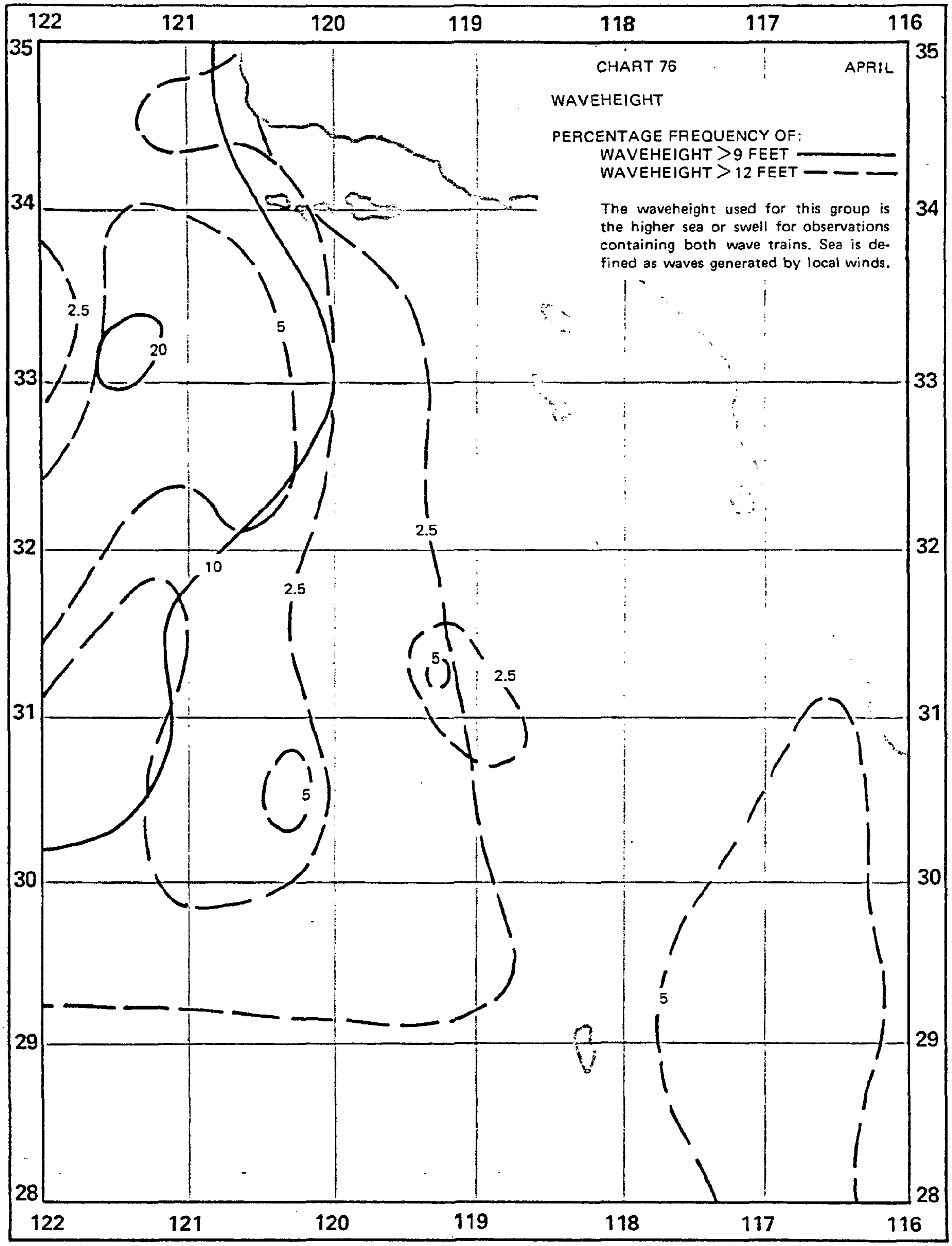
CHART 76
APRIL
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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2.5
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2.5
5
5

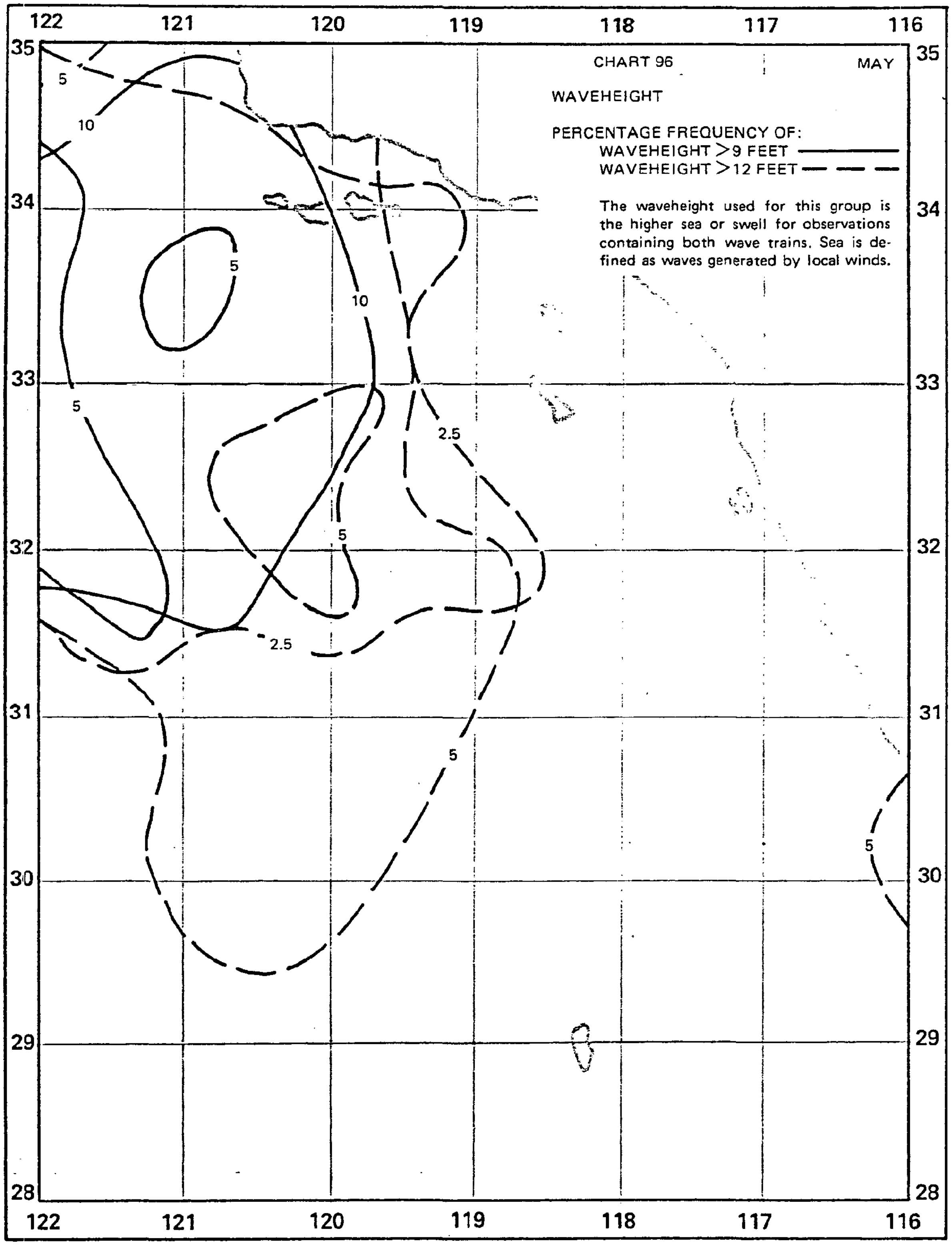
CHART 96
MAY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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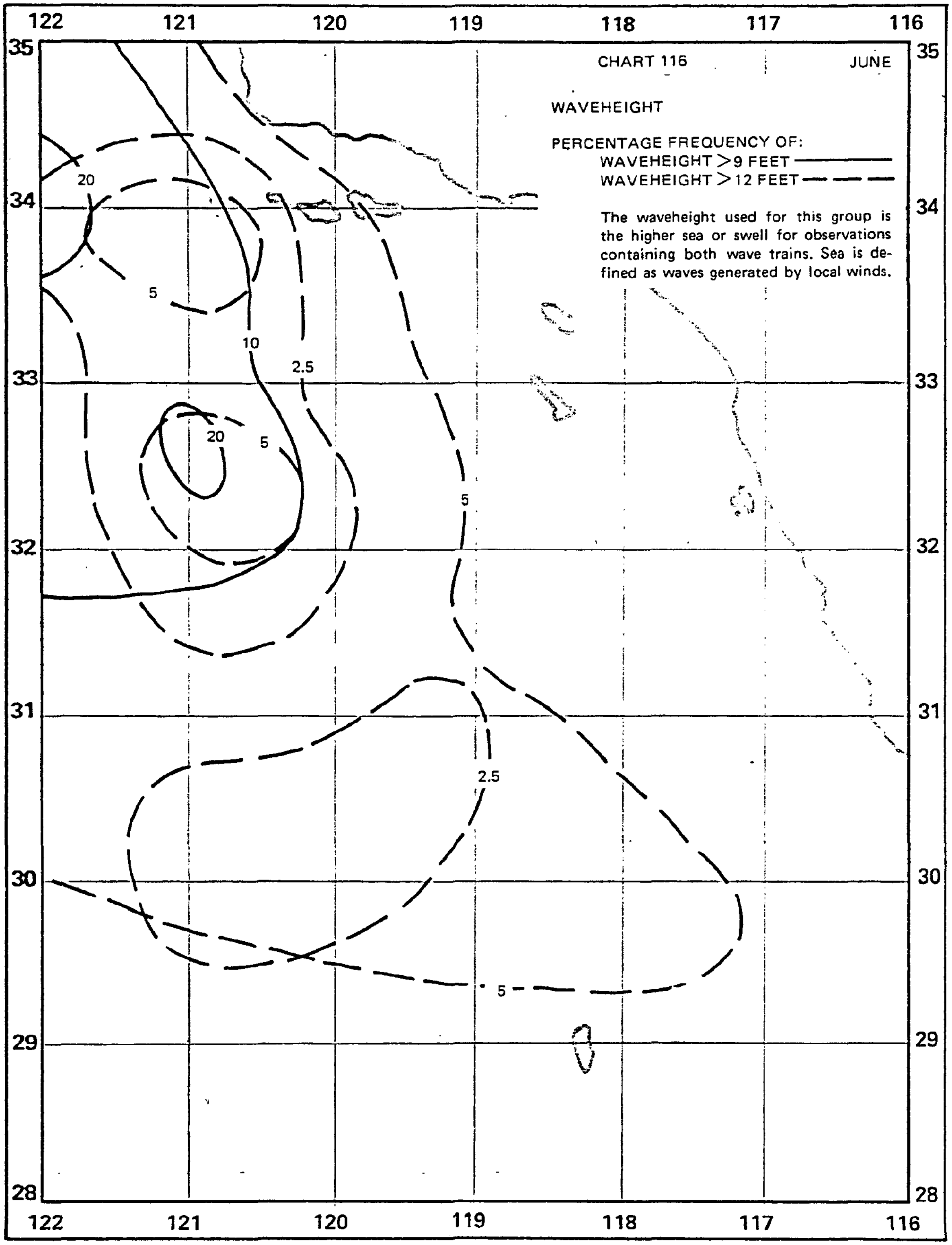
CHART 116
JUNE
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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2.5
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2.5
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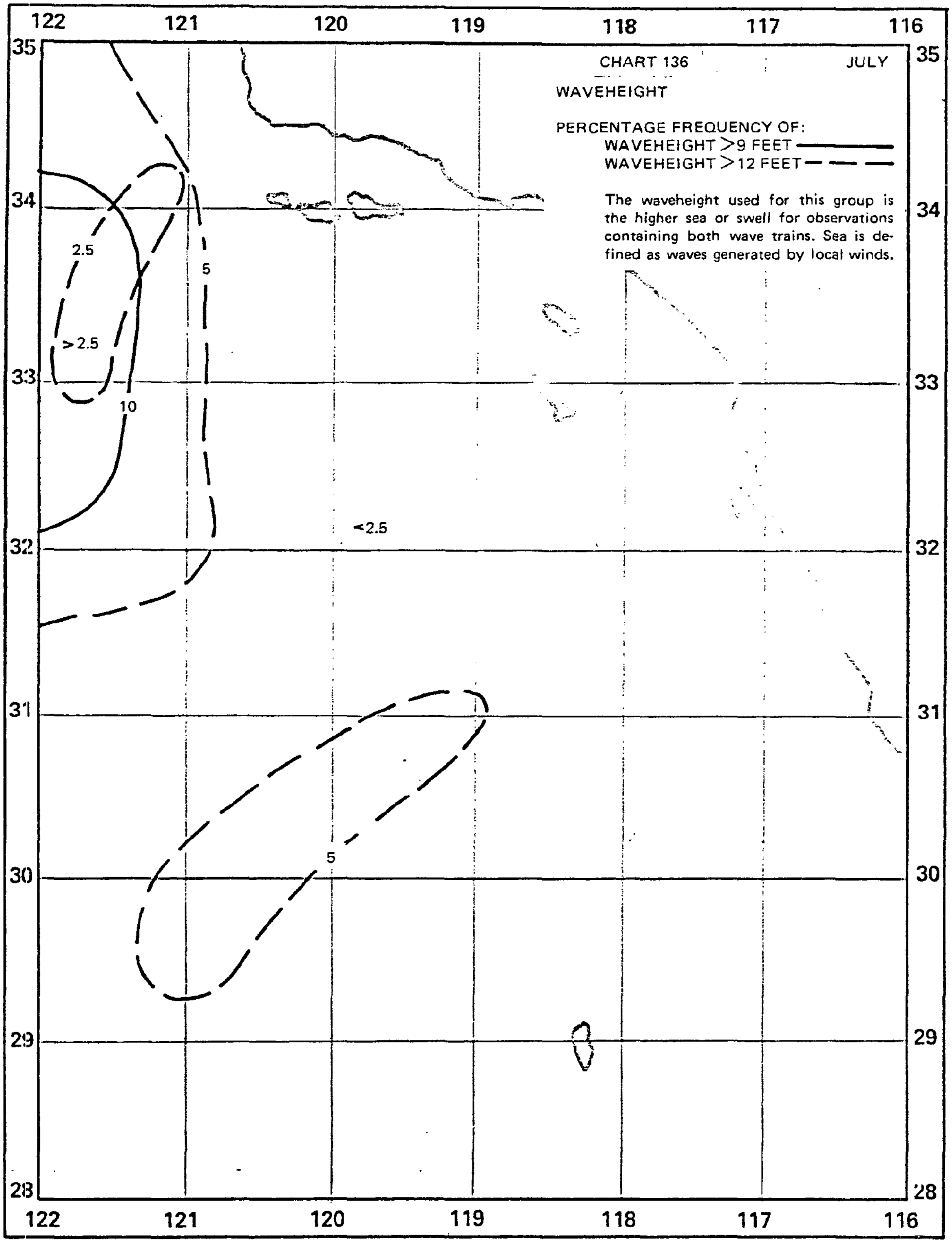
CHART 136
JULY
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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28
2.5
>2.5
10
5
<2.5
5

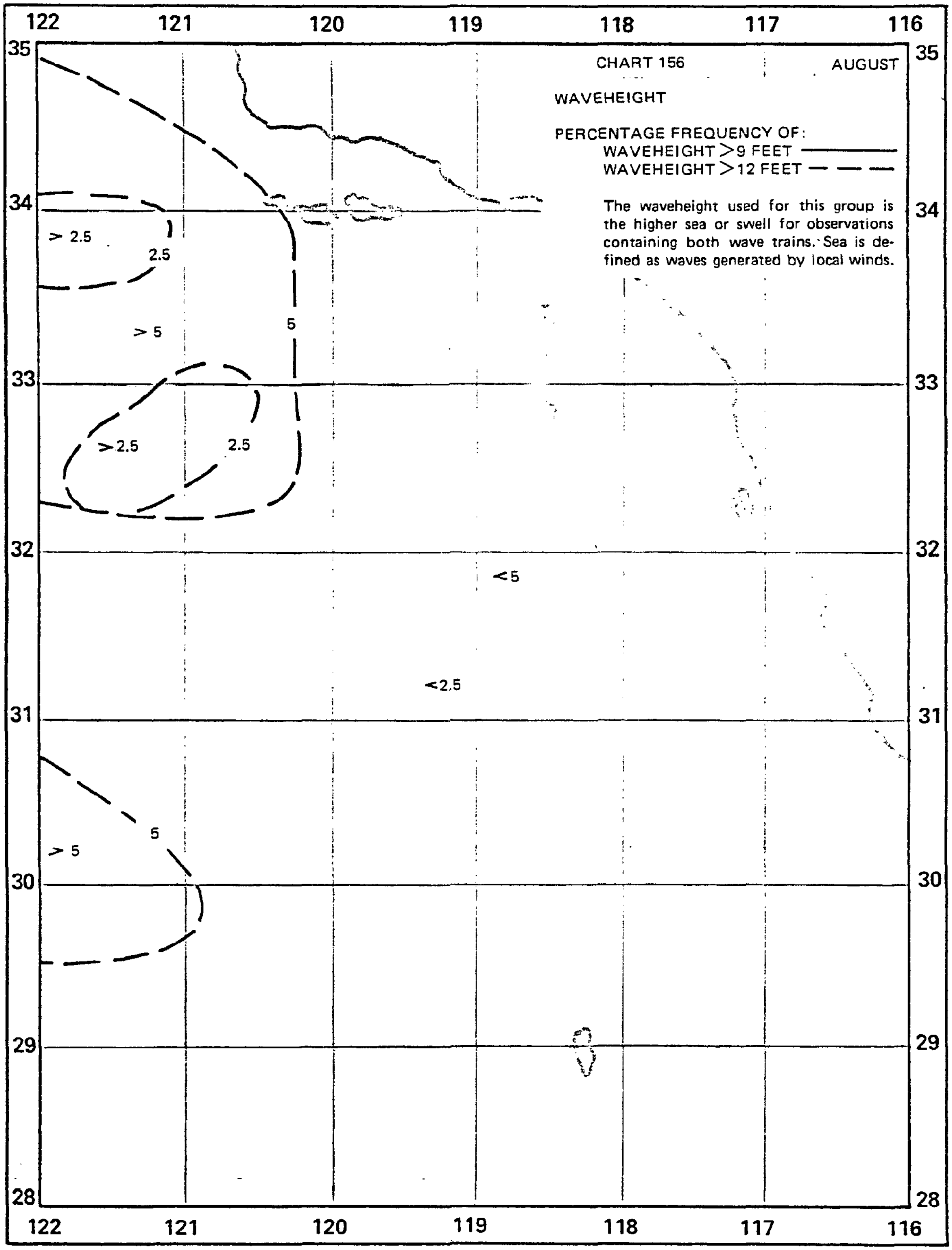
CHART 156
AUGUST
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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> 2.5
2.5
> 5
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>2.5
2.5
<5
<2.5
> 5
5

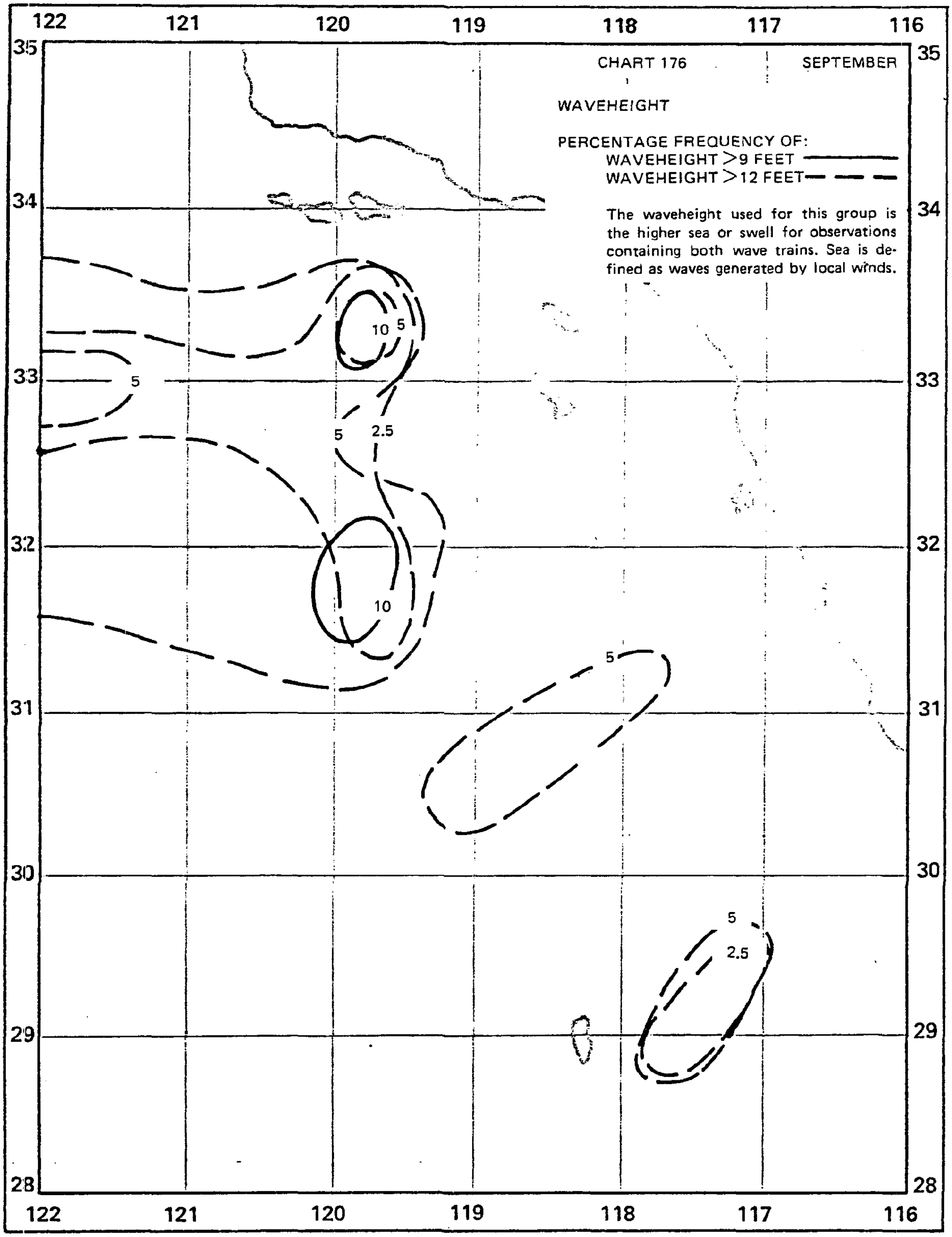
CHART 176
SEPTEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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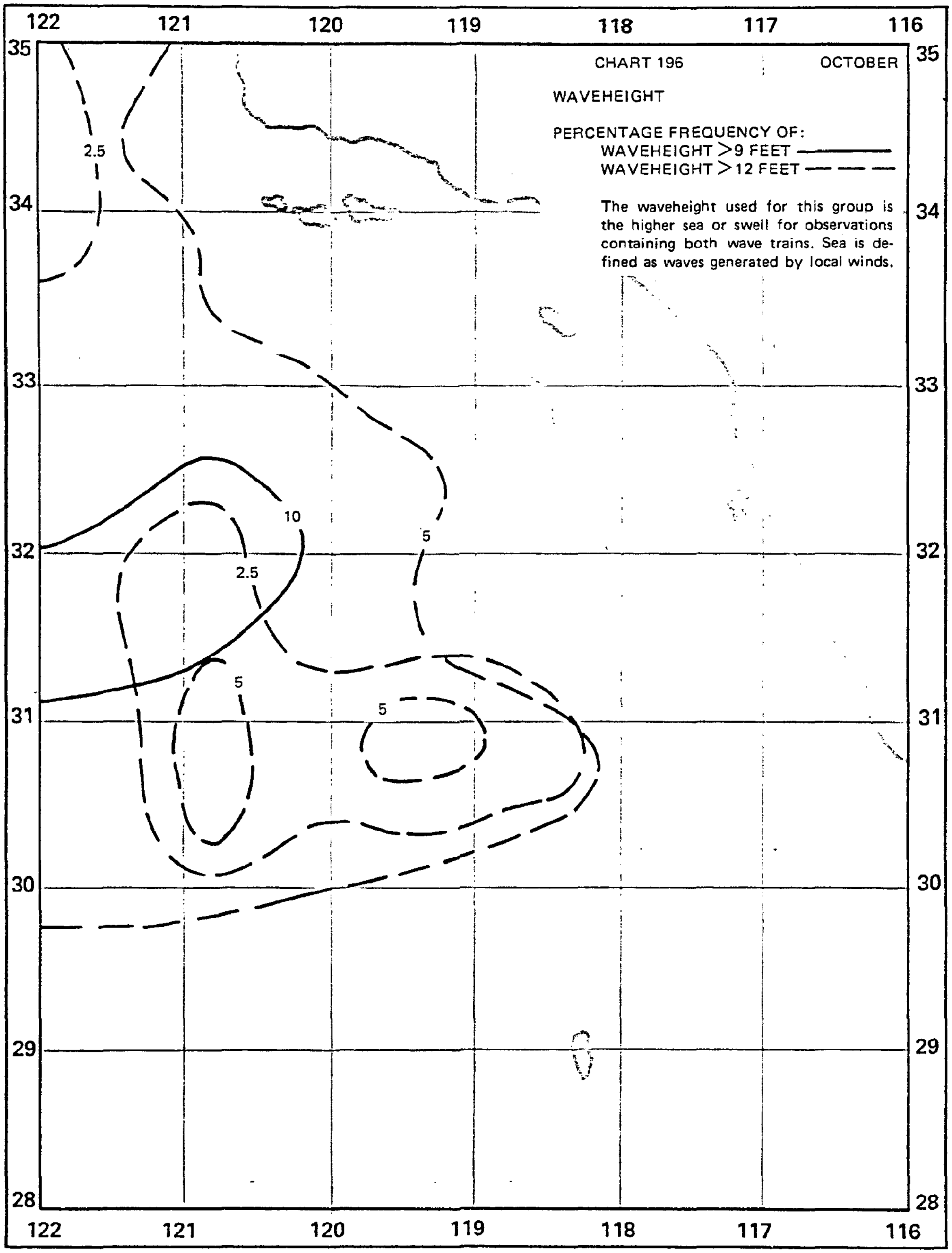
122
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CHART 196
OCTOBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
2.5
10
5
2.5
5
5

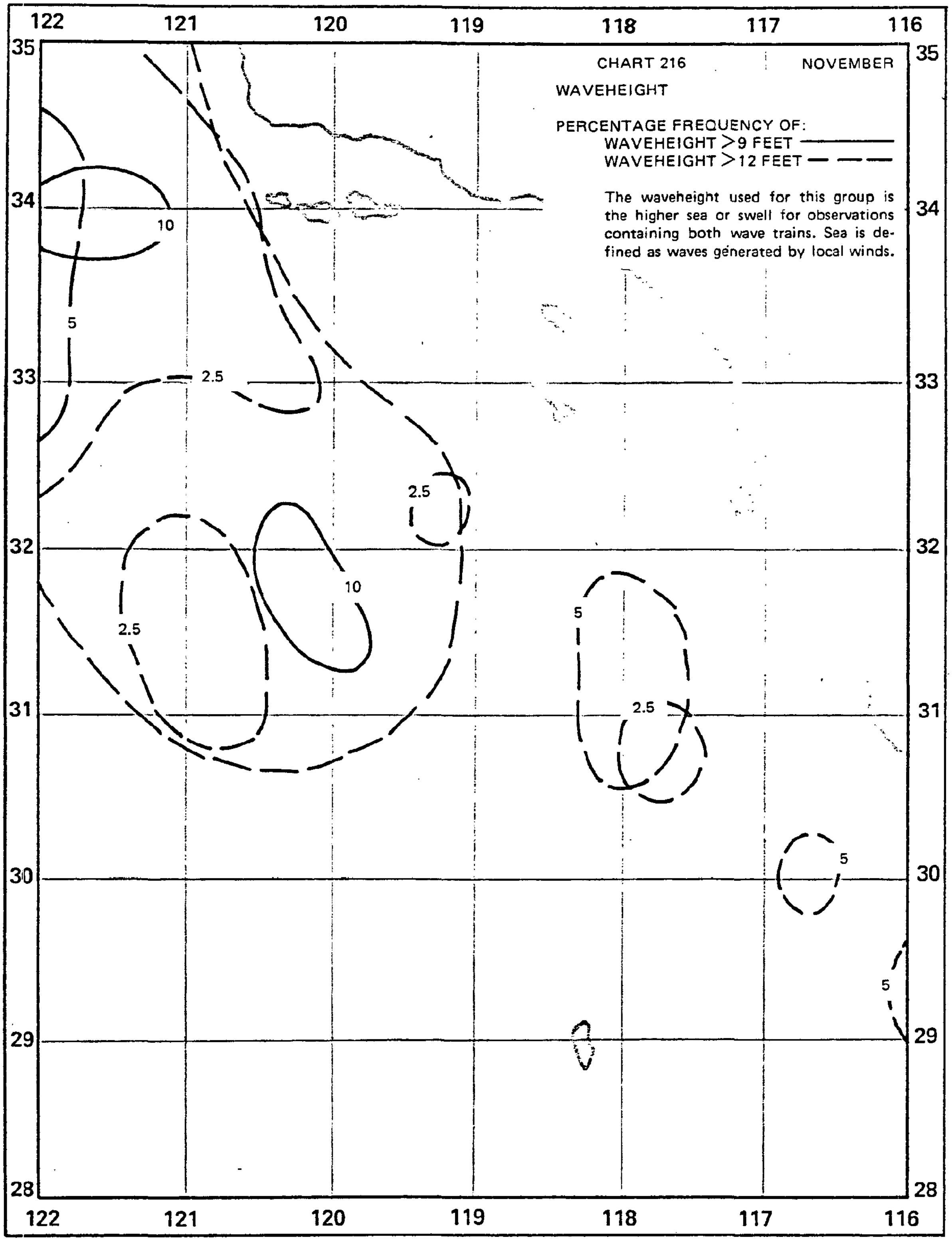
CHART 216
NOVEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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2.5
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2.5
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5

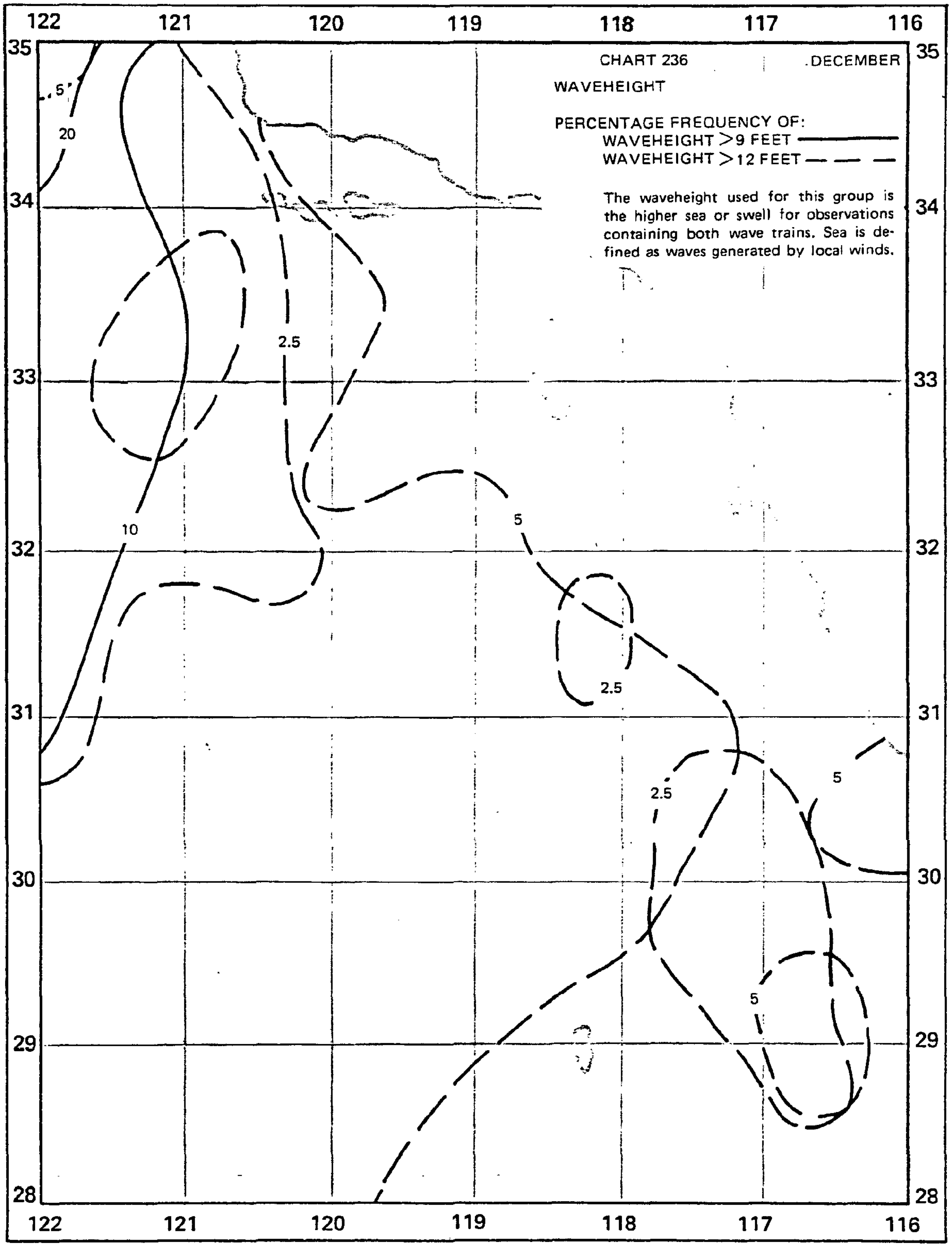

CHART 236
DECEMBER
WAVEHEIGHT
PERCENTAGE FREQUENCY OF:
WAVEHEIGHT >9 FEET
WAVEHEIGHT >12 FEET
The waveheight used for this group is the higher sea or swell for observations containing both wave trains. Sea is defined as waves generated by local winds.
122
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10
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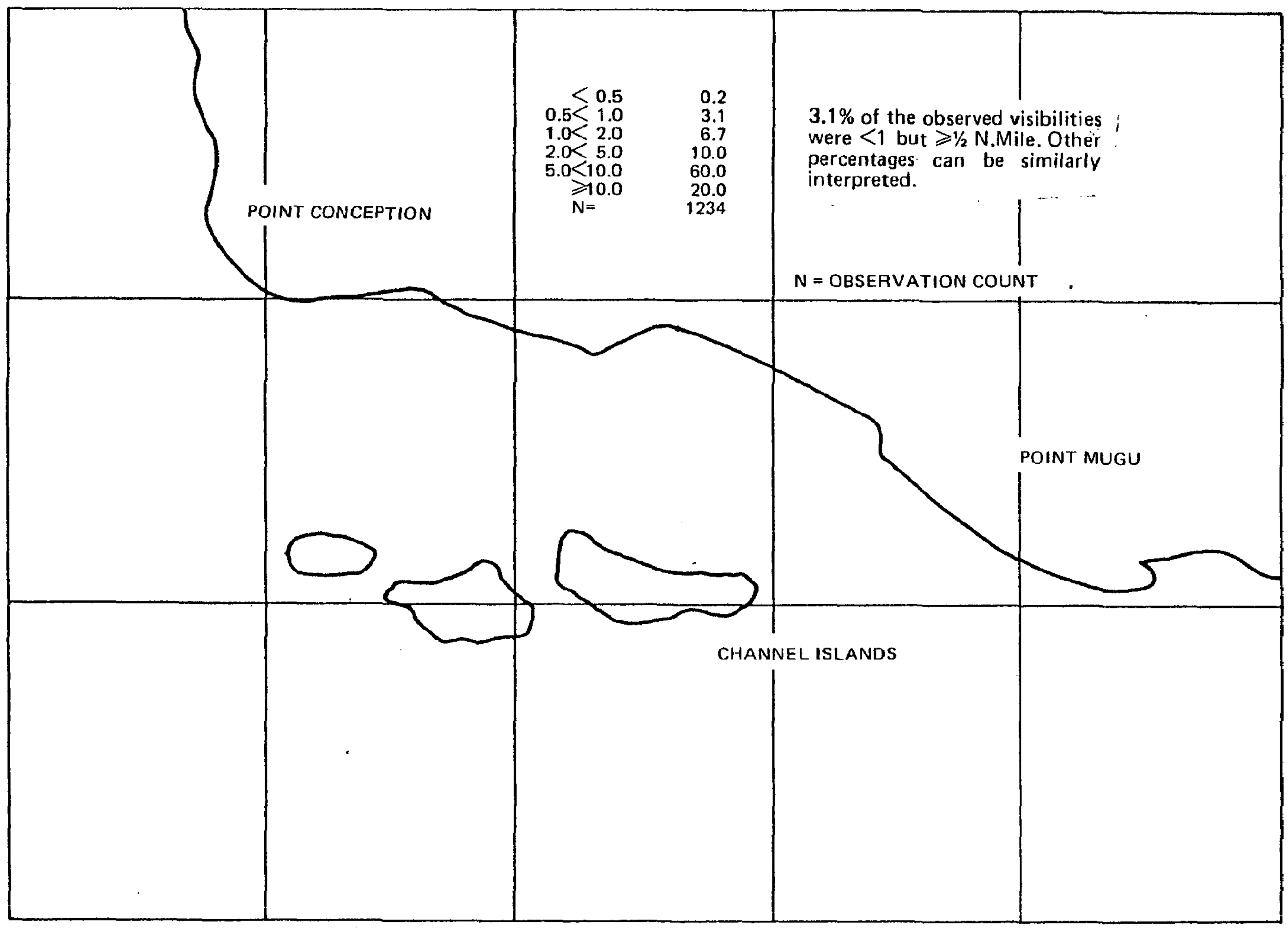
2.5

Percentage Frequency of Occurrence of Various Ranges of Visibility (Nautical Miles)

VISIBILITY (NAUTICAL MILES)

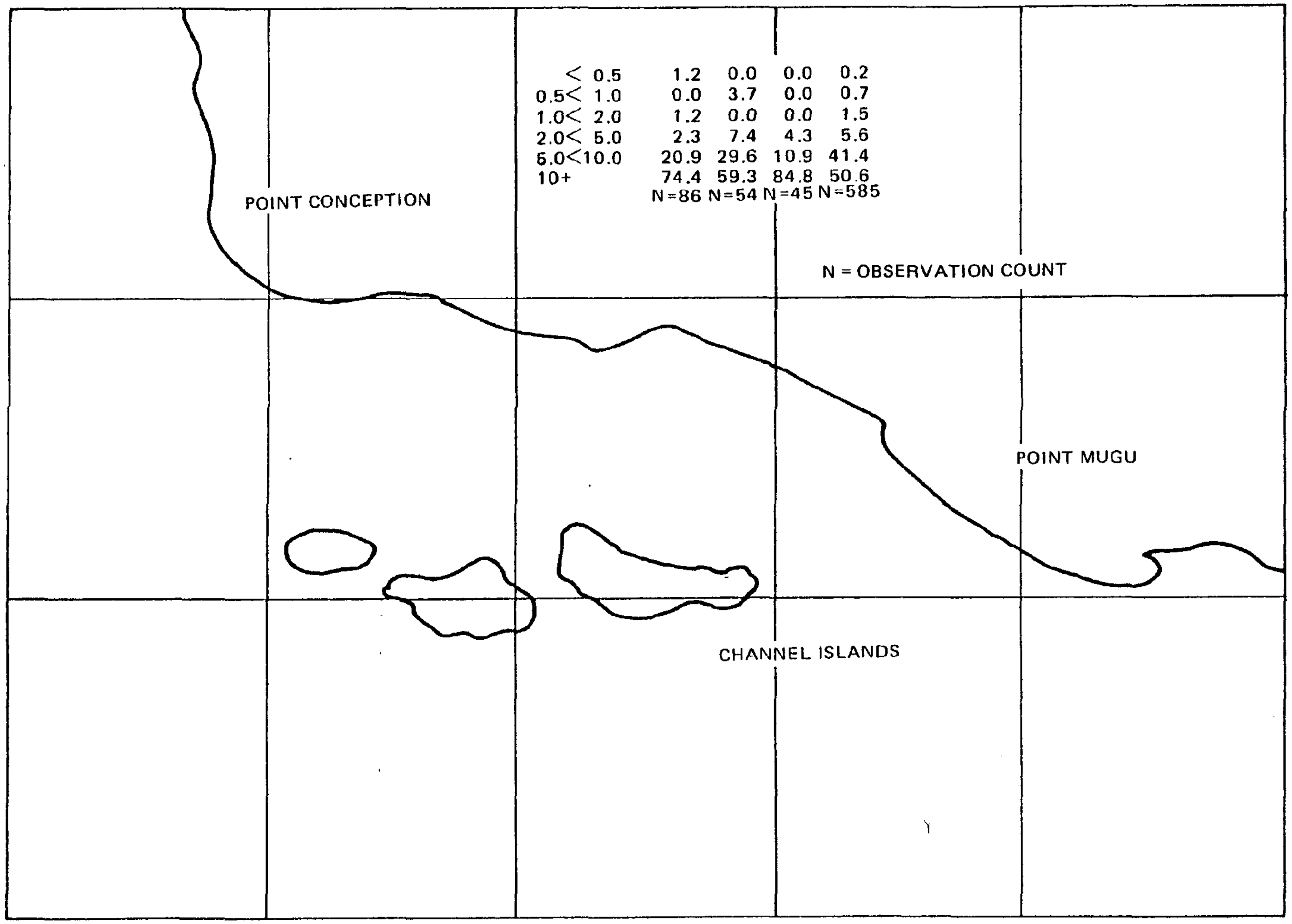
KEY

PERCENTAGE FREQUENCY OF VARIOUS RANGES WITHIN ½ DEGREE QUADRANGLES



VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

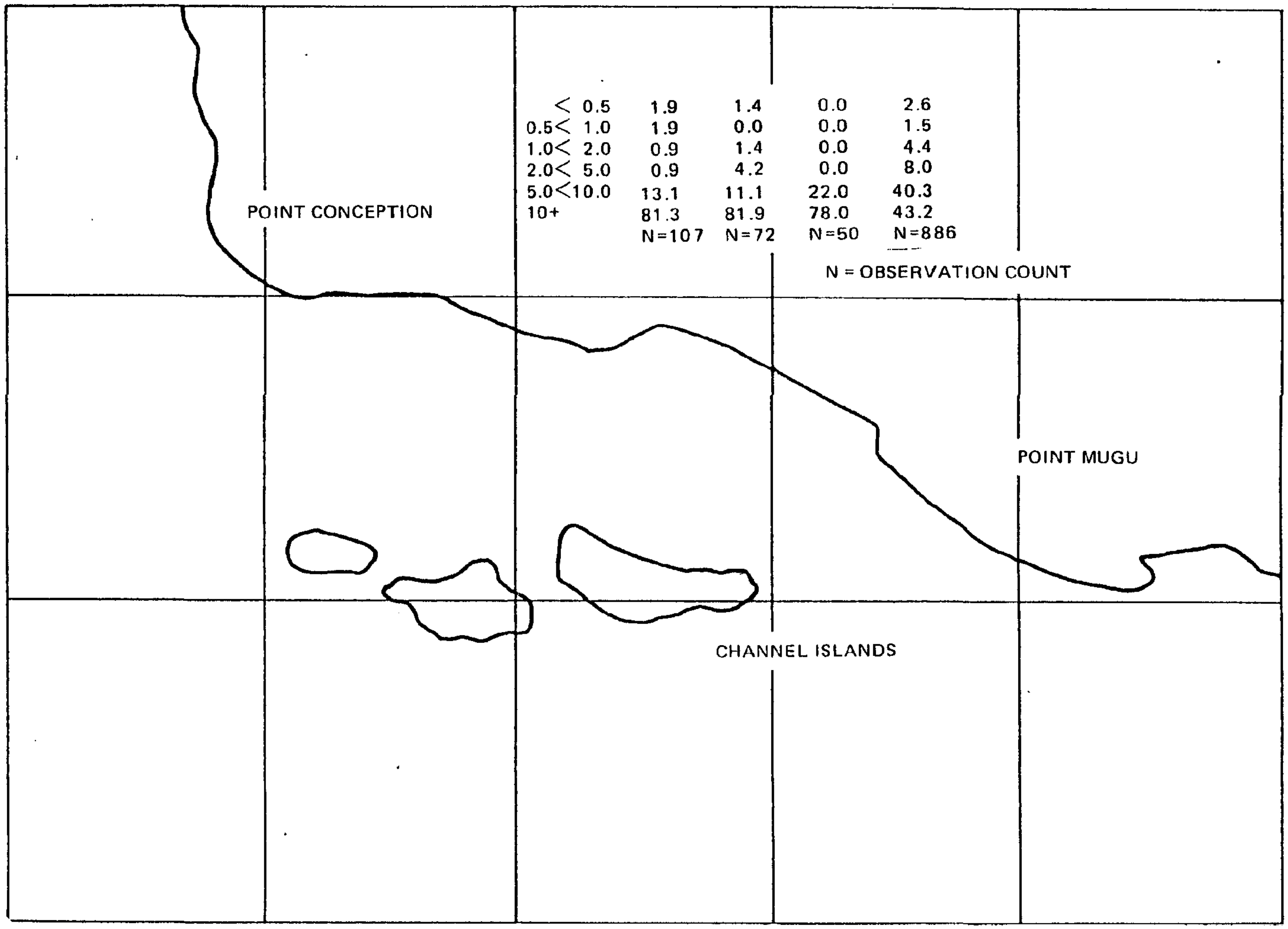
JANUARY



< 0.5	1.2	0.0	0.0	0.2
0.5< 1.0	0.0	3.7	0.0	0.7
1.0< 2.0	1.2	0.0	0.0	1.5
2.0< 5.0	2.3	7.4	4.3	5.6
5.0<10.0	20.9	29.6	10.9	41.4
10+	74.4	59.3	84.8	50.6
	N=86	N=54	N=45	N=585

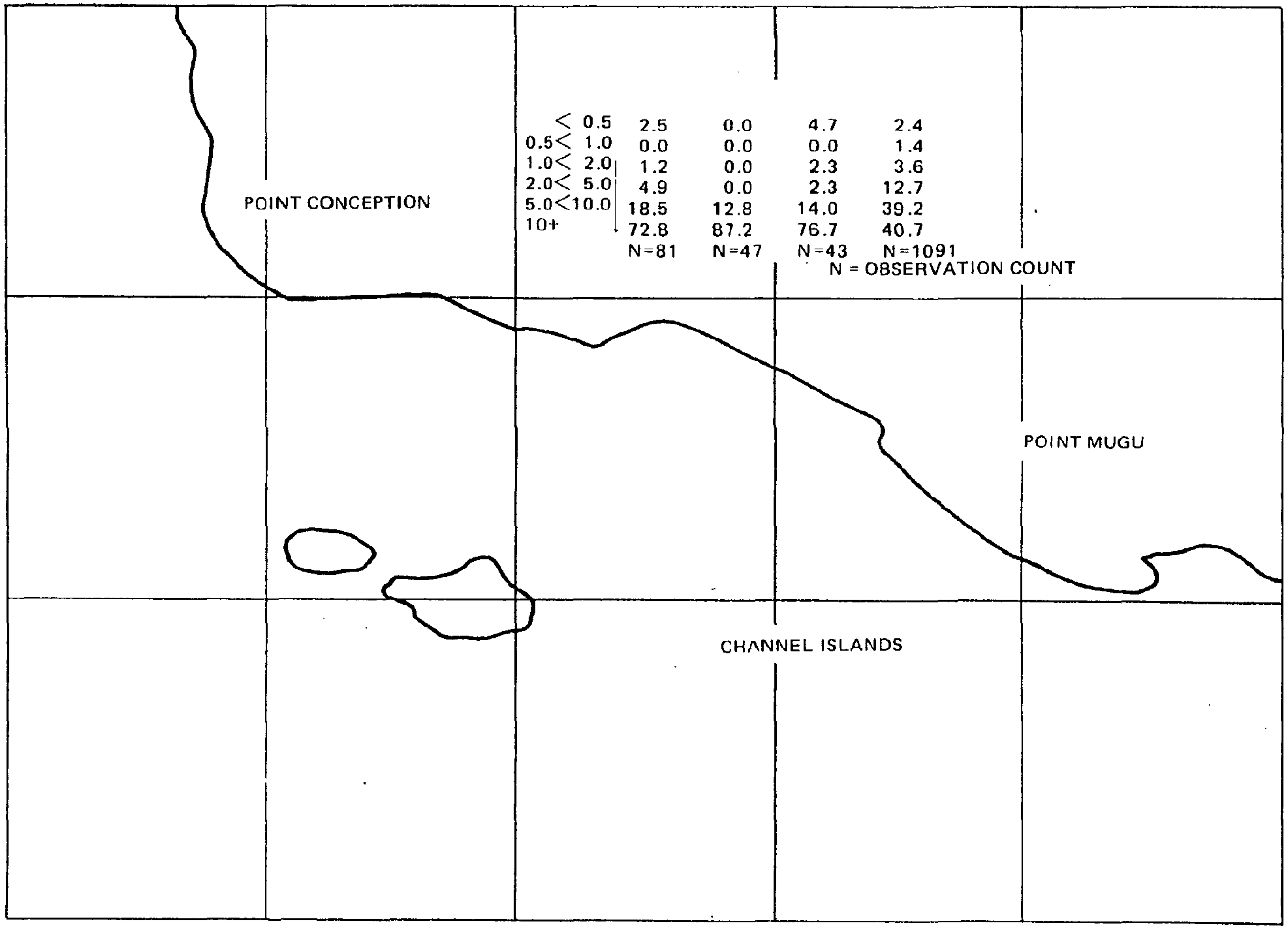
VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

FEBRUARY



VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

MARCH

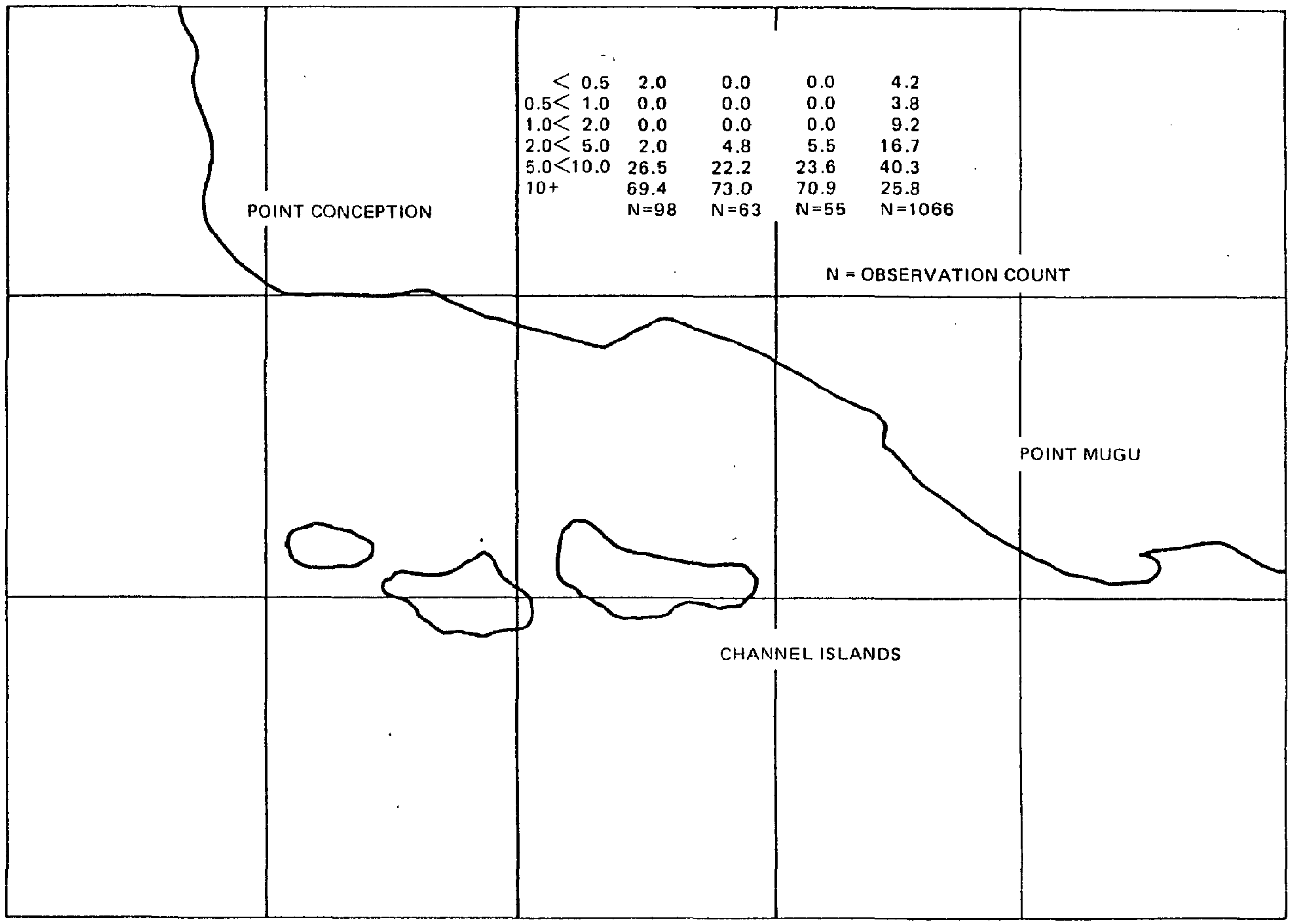


< 0.5	2.5	0.0	4.7	2.4
0.5< 1.0	0.0	0.0	0.0	1.4
1.0< 2.0	1.2	0.0	2.3	3.6
2.0< 5.0	4.9	0.0	2.3	12.7
5.0<10.0	18.5	12.8	14.0	39.2
10+	72.8	87.2	76.7	40.7
	N=81	N=47	N=43	N=1091

N = OBSERVATION COUNT

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

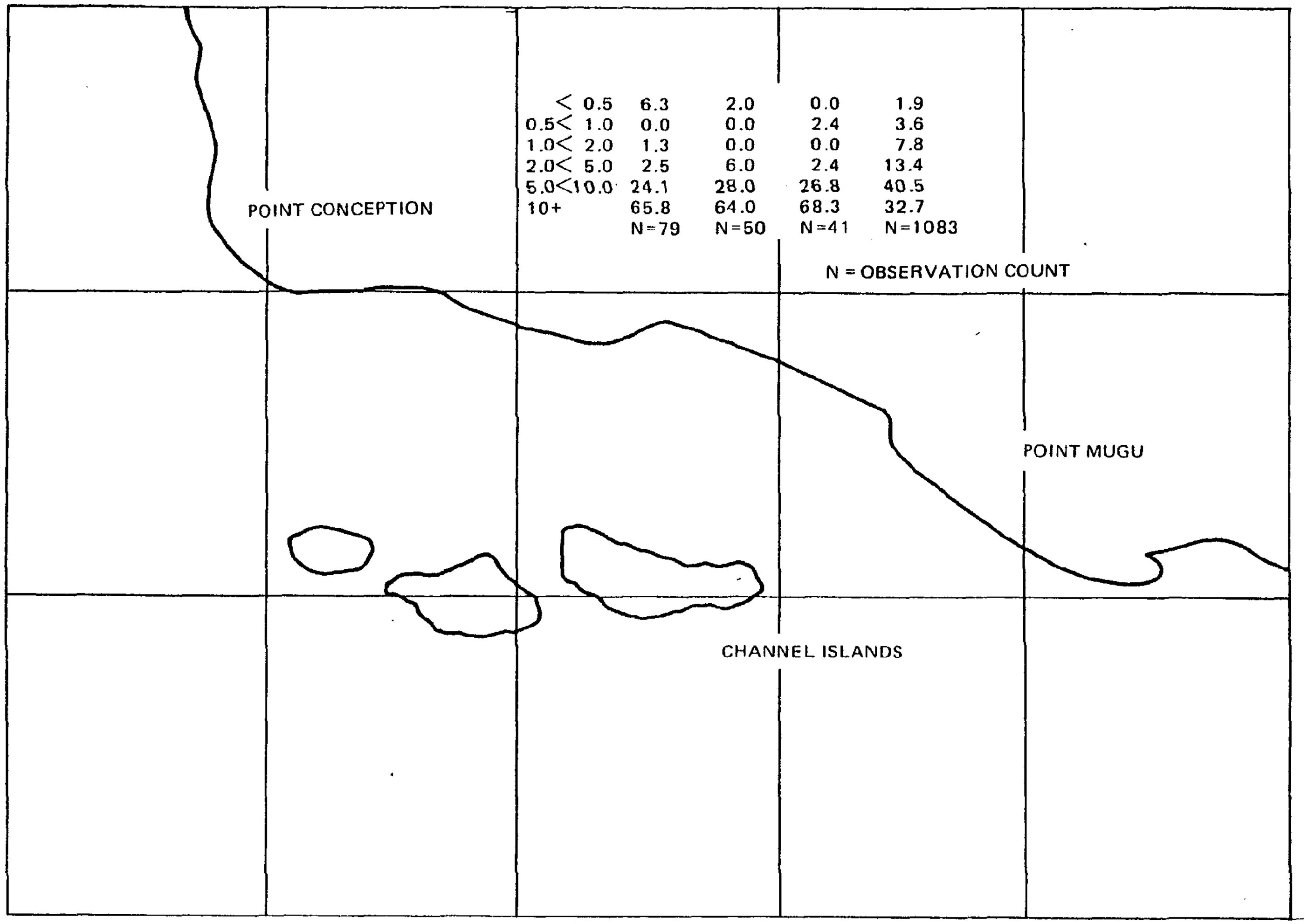
APRIL



< 0.5	2.0	0.0	0.0	4.2
0.5< 1.0	0.0	0.0	0.0	3.8
1.0< 2.0	0.0	0.0	0.0	9.2
2.0< 5.0	2.0	4.8	5.5	16.7
5.0<10.0	26.5	22.2	23.6	40.3
10+	69.4	73.0	70.9	25.8
	N=98	N=63	N=55	N=1066

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

MAY

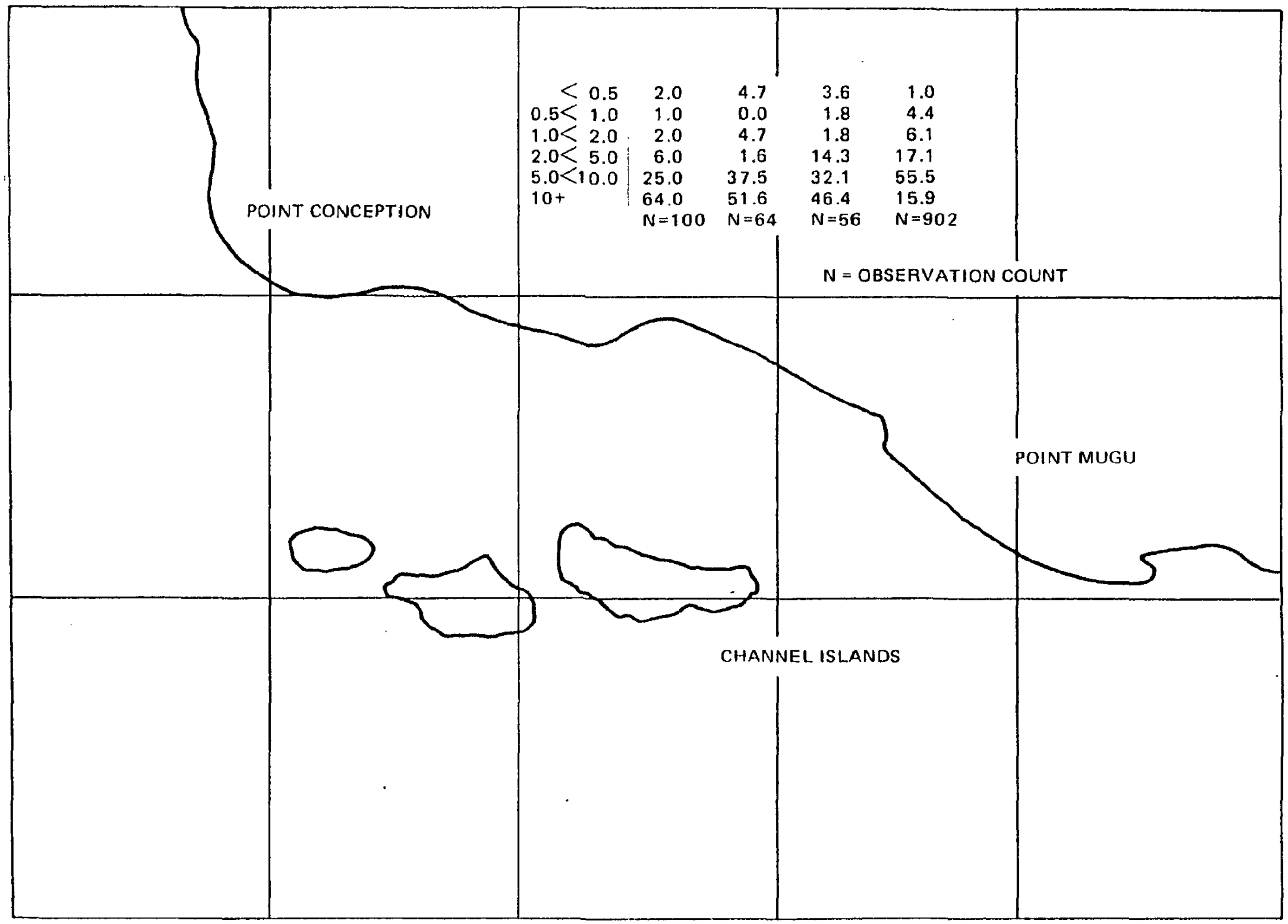


< 0.5	6.3	2.0	0.0	1.9
0.5< 1.0	0.0	0.0	2.4	3.6
1.0< 2.0	1.3	0.0	0.0	7.8
2.0< 5.0	2.5	6.0	2.4	13.4
5.0<10.0	24.1	28.0	26.8	40.5
10+	65.8	64.0	68.3	32.7
	N=79	N=50	N=41	N=1083

N = OBSERVATION COUNT

JUNE

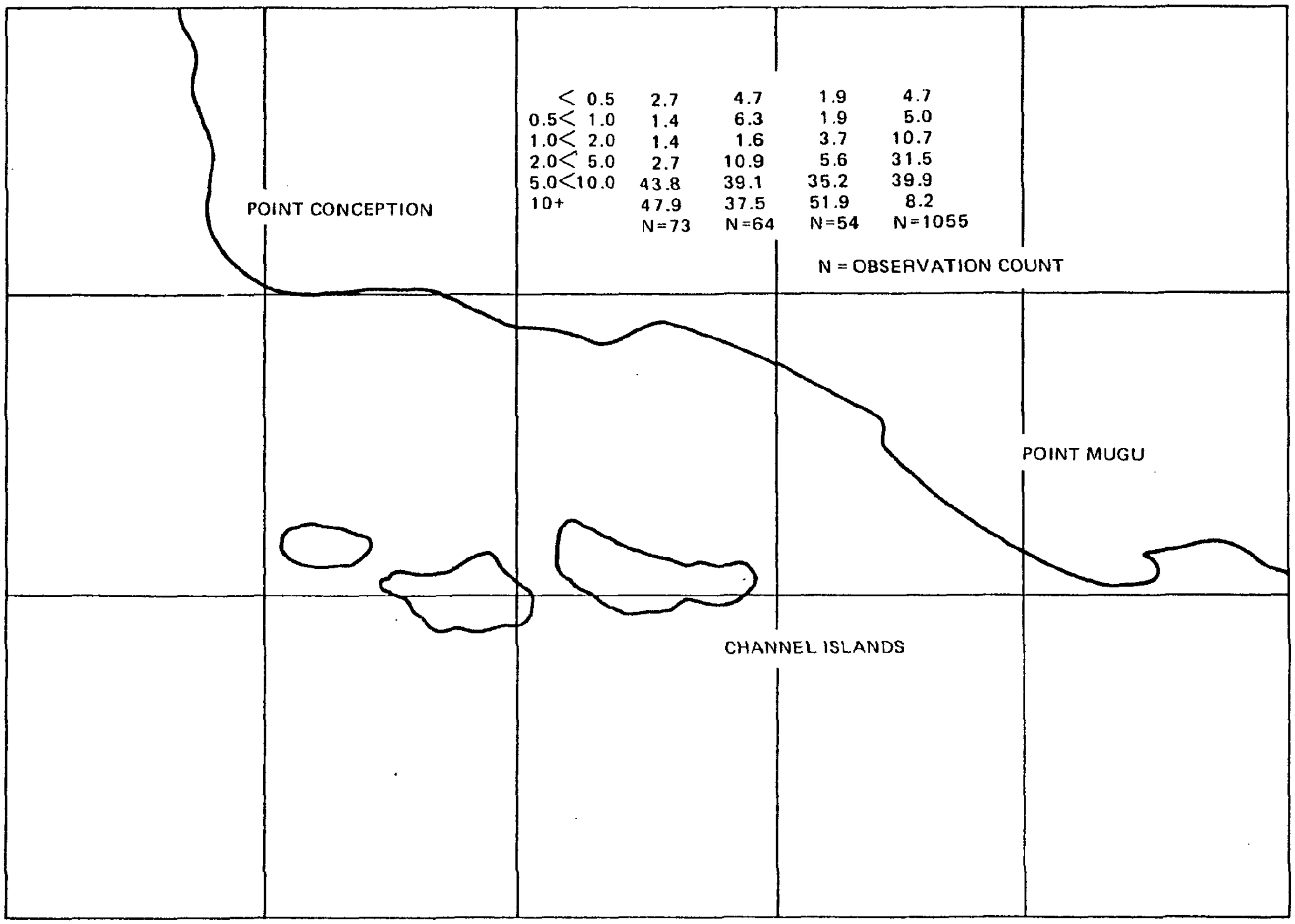
VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES



< 0.5	2.0	4.7	3.6	1.0
0.5< 1.0	1.0	0.0	1.8	4.4
1.0< 2.0	2.0	4.7	1.8	6.1
2.0< 5.0	6.0	1.6	14.3	17.1
5.0<10.0	25.0	37.5	32.1	55.5
10+	64.0	51.6	46.4	15.9
	N=100	N=64	N=56	N=902

JULY

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES



< 0.5	2.7	4.7	1.9	4.7
0.5< 1.0	1.4	6.3	1.9	5.0
1.0< 2.0	1.4	1.6	3.7	10.7
2.0< 5.0	2.7	10.9	5.6	31.5
5.0<10.0	43.8	39.1	35.2	39.9
10+	47.9	37.5	51.9	8.2
	N=73	N=64	N=54	N=1055

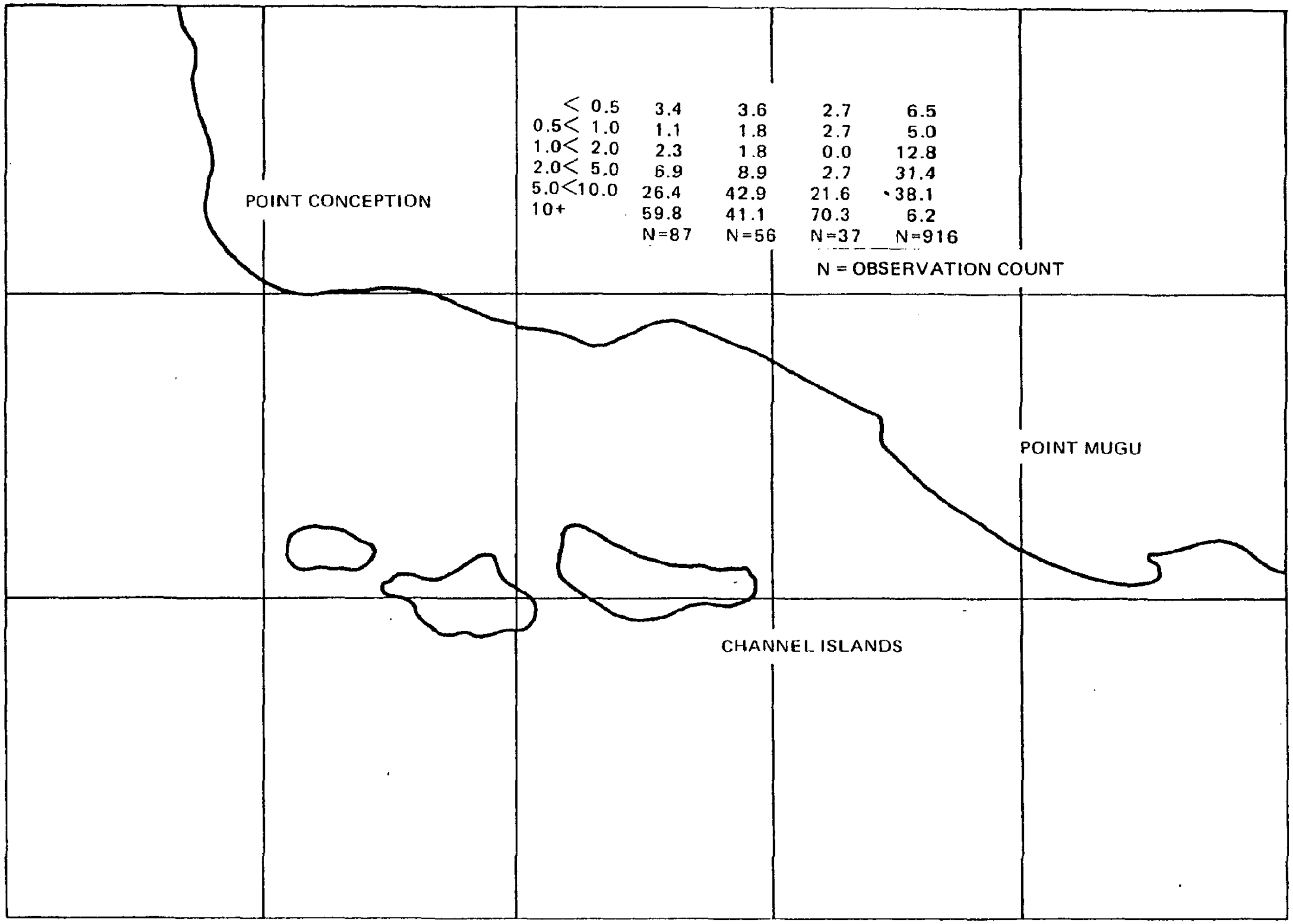
N = OBSERVATION COUNT

AUGUST

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

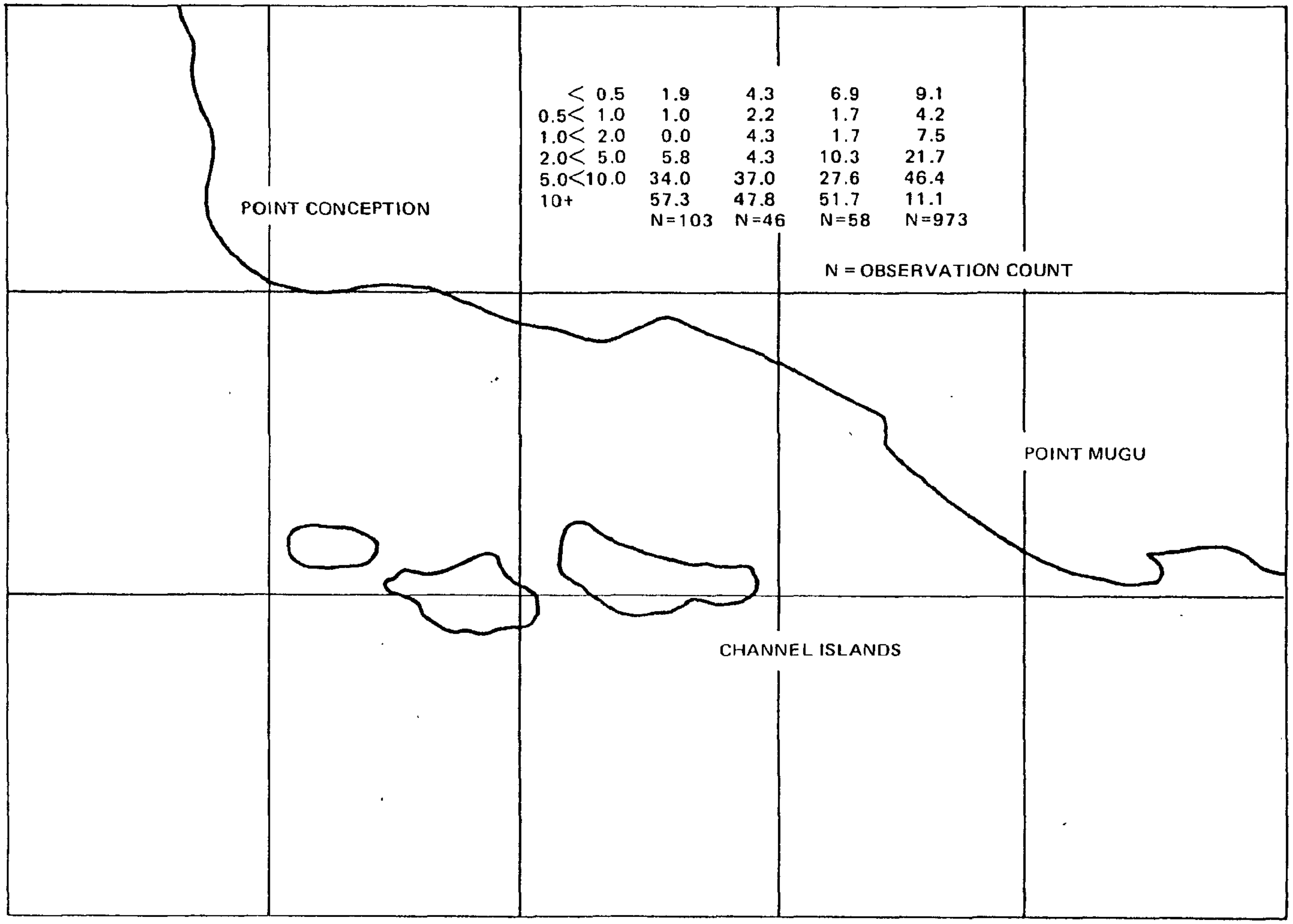
< 0.5	3.4	3.6	2.7	6.5
0.5< 1.0	1.1	1.8	2.7	5.0
1.0< 2.0	2.3	1.8	0.0	12.8
2.0< 5.0	6.9	8.9	2.7	31.4
5.0<10.0	26.4	42.9	21.6	38.1
10+	59.8	41.1	70.3	6.2
	N=87	N=56	N=37	N=916

N = OBSERVATION COUNT



VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

SEPTEMBER



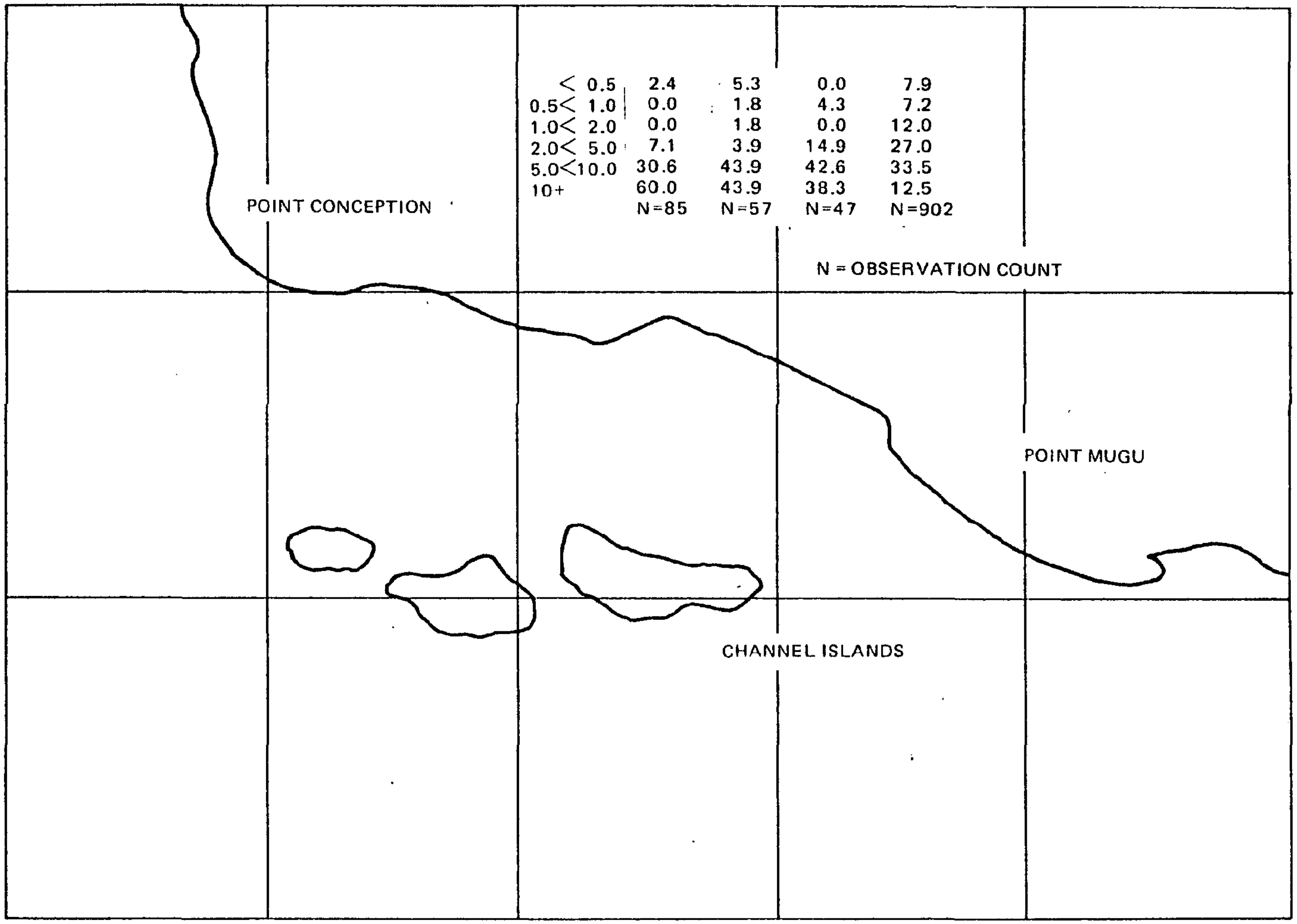
< 0.5	1.9	4.3	6.9	9.1
0.5< 1.0	1.0	2.2	1.7	4.2
1.0< 2.0	0.0	4.3	1.7	7.5
2.0< 5.0	5.8	4.3	10.3	21.7
5.0<10.0	34.0	37.0	27.6	46.4
10+	57.3	47.8	51.7	11.1
	N=103	N=46	N=58	N=973

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

OCTOBER

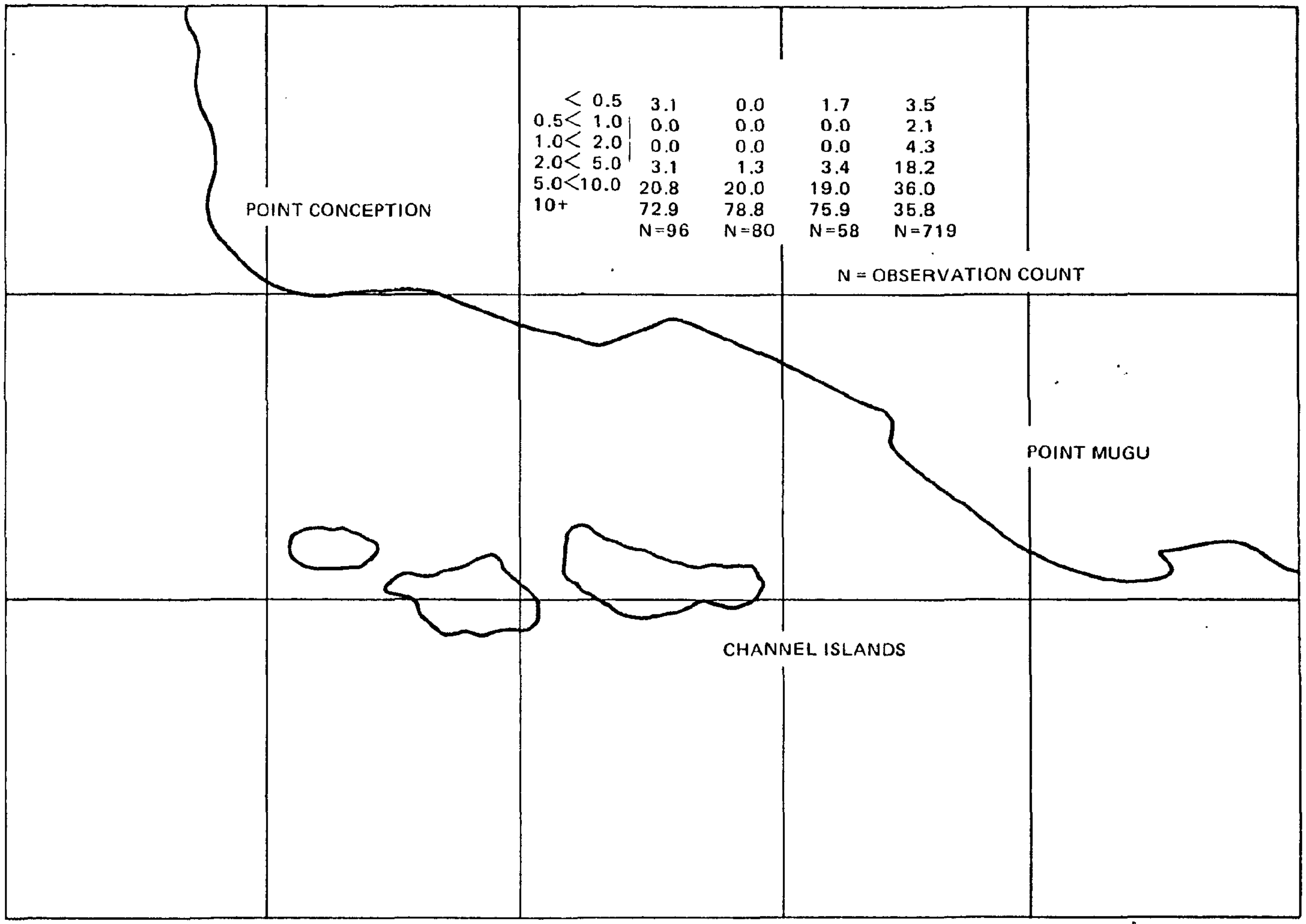
< 0.5	2.4	5.3	0.0	7.9
0.5< 1.0	0.0	1.8	4.3	7.2
1.0< 2.0	0.0	1.8	0.0	12.0
2.0< 5.0	7.1	3.9	14.9	27.0
5.0<10.0	30.6	43.9	42.6	33.5
10+	60.0	43.9	38.3	12.5
	N=85	N=57	N=47	N=902

N = OBSERVATION COUNT



VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES

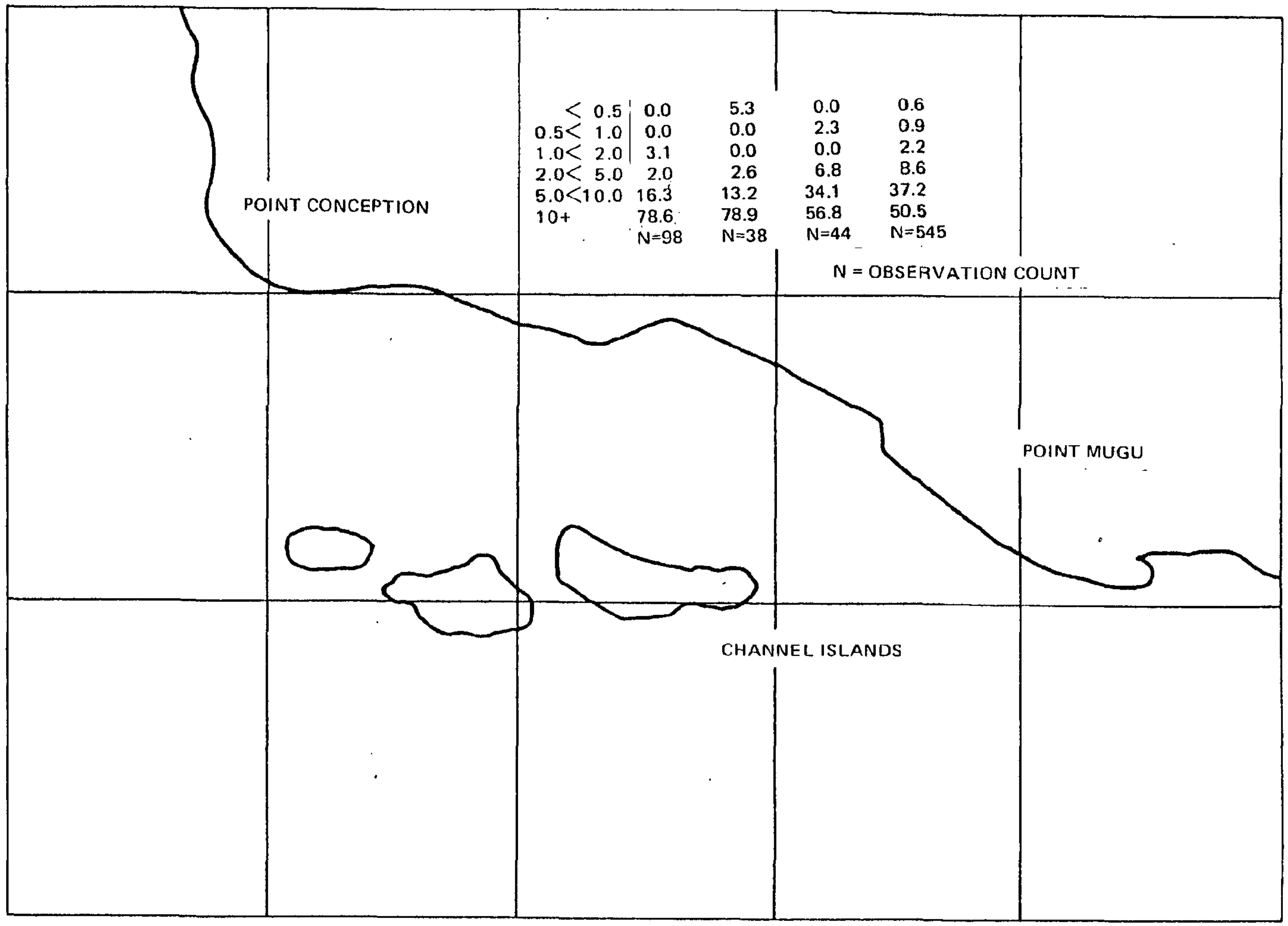
NOVEMBER



< 0.5	3.1	0.0	1.7	3.5
0.5< 1.0	0.0	0.0	0.0	2.1
1.0< 2.0	0.0	0.0	0.0	4.3
2.0< 5.0	3.1	1.3	3.4	18.2
5.0<10.0	20.8	20.0	19.0	36.0
10+	72.9	78.8	75.9	35.8
	N=96	N=80	N=58	N=719

DECEMBER

VISIBILITY (NAUTICAL MILES)
PERCENTAGE FREQUENCY OF VARIOUS RANGES



SECTION D-2

EXTRACTS FROM MARITIME FACTORS ANALYSIS, OFFSHORE LNG FACILITY PREPARED BY JOHN J. MC MULLEN ASSOCIATES, INC., JUNE 1978

Applicable locations:

(1) **Chinese Harbor** — off the northern coast of Santa Cruz Island, near its eastern end.

(2) **Ventura Flats** — approximately 10 miles west-southwest of Pitas Point.

(Maps illustrating these locations begin the section.)

GENERAL WIND REGIME

The moderating influence of the ocean is the basis for the stable, persistent weather regime along the coastal region of Southern California. The ocean provides a nearly constant, continuous supply of cool, moist, marine air to the coast. Although the coastal waters experience a very small seasonal and diurnal variation in temperature, the coastal strip forms the boundary separating the marine air from the land air; it is here that the discontinuity of temperature and humidity provides diurnal local variations of intensity and effects. The California Ocean Current, flowing southward, is relatively cold and induces a band of cool surface air from 200 to 300 miles wide between the coast and the warmer water out to sea. The onshore flow of this cool, moist air, which is further trapped in the coastal basin, results in a relatively cool shoreline climate with frequent periods of fog, particularly during the summer months.

The daytime seabreeze and nighttime land breeze cycle dominates the coastal wind regime 80 to 90 percent of the time. During these prevailing conditions, the land heats in the morning to higher temperatures than the adjacent ocean. The seabreeze sets in and increases in intensity through the afternoon and dies out toward nightfall when the land and sea temperature differentials are equalized. At night the rapid radiational cooling of the land causes lower air temperatures above the land than over the water. Thus, while the land breeze resembles, to a degree, the reverse flow of the seabreeze, winds are generally gentle.

The basic air flow along the Southern California coastal area is northwesterly, resulting from the semi-permanent Pacific high pressure cell. The northwest winds are strongest and most constant during the warm months when the Pacific High is most intense. During the colder part of the year, the basic air flow is still northwesterly, but weaker.

The wind flow north of Point Arguello and Point Conception is relatively strong and has a northerly component. The transition zone of climatic and meteorological regions occurs at Point Conception primarily because the north-south orientation of the coastline changes to an east-west alignment. The prevailing northwest wind at Point Conception changes to a westerly wind along the Santa Barbara Channel to the east. Consequently, wind and sea conditions become progressively moderate to the east within the Santa Barbara Channel region at the Ventura Flats site area and are further moderated along the Southern California Bight. The moderating influences consist of the change of wind direction (refraction), frictional forces, the drawing of winds up mainland canyons and valleys, and turbulence along the mainland coast.

The outstanding wind feature of the Santa Barbara Channel Islands, especially to the west of Santa Rosa Island, is the long fetch of northwest winds from Point Arguello and the open Pacific Ocean beyond. As these winds encounter the islands, the flow is generally around such obstructions, and local eddies and deflection of flow occur, resulting in a west-northwest direction of flow at Santa Cruz Island. Local refraction and eddy turbulence tend to decrease wind velocities, while convergence along steep bluffs at the shoreline increases velocities. A belt of rough seas, known as "windy lane," lies along the north shore of the Channel Islands and is about six miles wide.

Primarily during the winter season, frontal systems moving southeastward along the California coast move across the offshore site areas to modify prevailing wind speeds and directions. When these storms approach, winds are from the east and southeast, and at times these winds are strong with sustained speeds of 25 to 35 knots, accompanied by local gusts of 40 to 45 knots. As the front approaches, the area experiences southeasterly-to-southerly winds of up to 30 knots, with locally higher gusts caused by convergence along the shoreline bluffs and mountains of the islands. Winter storm winds with velocities over 25 knots seldom persist more than 12 hours.

During the fall and winter, the pressure gradient after the passage of a cold ront, discussed above, is further increased because the ocean off Southern California is warmer than the land and high plateaus. A flow of winds between these high and low pressure areas results. Forced and drawn through mountain passes, these warm downslope (Santa Ana) winds reach velocities of over 50 knots in the Santa Barbara Channel region in the vicinity of the Ventura Flats. The streamline flow of Santa Ana winds is shown in Figure 3.1.1-1.

The following general and comparative wind regime assessments of Chinese Harbor and Ventura Flats are based on streamline analyses, aerial photographs, Navy data, Army and Coast Guard wind data on Santa Cruz and Santa Rosa Islands, on-site surveys by JJMA and Environmental Science Consultants staff, ship master interviews, and measurements by research ships.

Two streamline analysis charts are provided for Chinese Harbor and the Ventura Flats. One chart shows wind patterns for daytime and is generally representative of the period of time between late morning and sunset. The other chart shows the dominant flow expected at night and generally portrays winds between midnight and sunrise. While the streamline charts more specifically pertain to prevailing wind patterns during the summer months, these winds generally occur during the other seasons.

Seasonal and diurnal variations of winds occur at Ventura Flats due to its closeness to the mainland. During the wintertime, the nighttime mountain-land breeze combined effects become stronger to weaken or completely dominate over the prevailing seabreeze.

a. Chinese Harbor. The prevailing strong northwest wind off Point Arguello is refracted around Point Conception. This refraction combines with the deflection off of the northern mountain slopes and coastal bluffs of Santa Cruz Island to change the prevailing northwesterlies to a westerly wind near Chinese Harbor. Further refraction occurs at Diablo Point which provides a slight reduction in wind velocity and changes the wind to a northwesterly flow into the area, as shown in Figure 3.1.1-8.

The streamline analysis for nighttime winds (Figure 3.1.1-13) shows little change from the daytime dominance of the prevailing westerly wind. The nighttime drainage winds produce convergence which deflects westerly winds slightly to the north of Chinese Harbor, thereby reducing wind velocities throughout the area.

The predominant west-northwest wind at Chinese Harbor is illustrated in Figure 3.1.1-12.

b. Ventura Flats. The prevailing westerly wind undergoes divergence at the Ventura Flats due to the drawing forces of the river valleys and canyons to the north and east along the mainland coast (Figure 3.1.1-8). This divergence, combined with the general progressive weakening wind regime toward the eastern portion of the Santa Barbara Channel region accounts for the generally moderate wind velocities throughout the area. The dominance of the prevailing westerlies is shown by the wind rose in Figure 3.1.1-18.

During Santa Ana conditions, these strong east winds are drawn through mountain passes and forced down the Santa Clara River Valley to reach velocities of 50 knots in the area. Velocities over 25 knots are rarely sustained more than 8 hours due to the strong counterinfluence of the afternoon seabreeze.

The prevailing westerlies generally continue through the night, as shown by the streamline analysis in Figure 3.1.1-13. During the winter months, the nighttime mountain breeze-land breeze combination is stronger and convergence occurs at the site; however, velocities are low.

Table 3.1.1-1 illustrates the annual percentage of time wind velocity is 25 knots or greater and 30 knots or greater at Chinese Harbor and Ventura Flats.

Severe Weather and Extreme Wind Conditions

Severe weather conditions that produce high winds in the Santa Barbara Channel are usually the result of frontal activity or Santa Ana winds. Primarily during the winter season, frontal systems moving southeastward along the California coast move across the areas of Chinese Harbor and Ventura Flats. Winds of 25-35 knots, accompanied by local gusts of 40-45 knots, may be experienced. As the front approaches, the area experiences southeasterly winds of about 30 knots, with locally higher gusts. These winds can persist for up to 12 hours. Following frontal passage, winds may be expected to become westerly or northwesterly, and as strong as the prefrontal winds. Frontal type winds generally diminish after one day, but may persist through the next day.

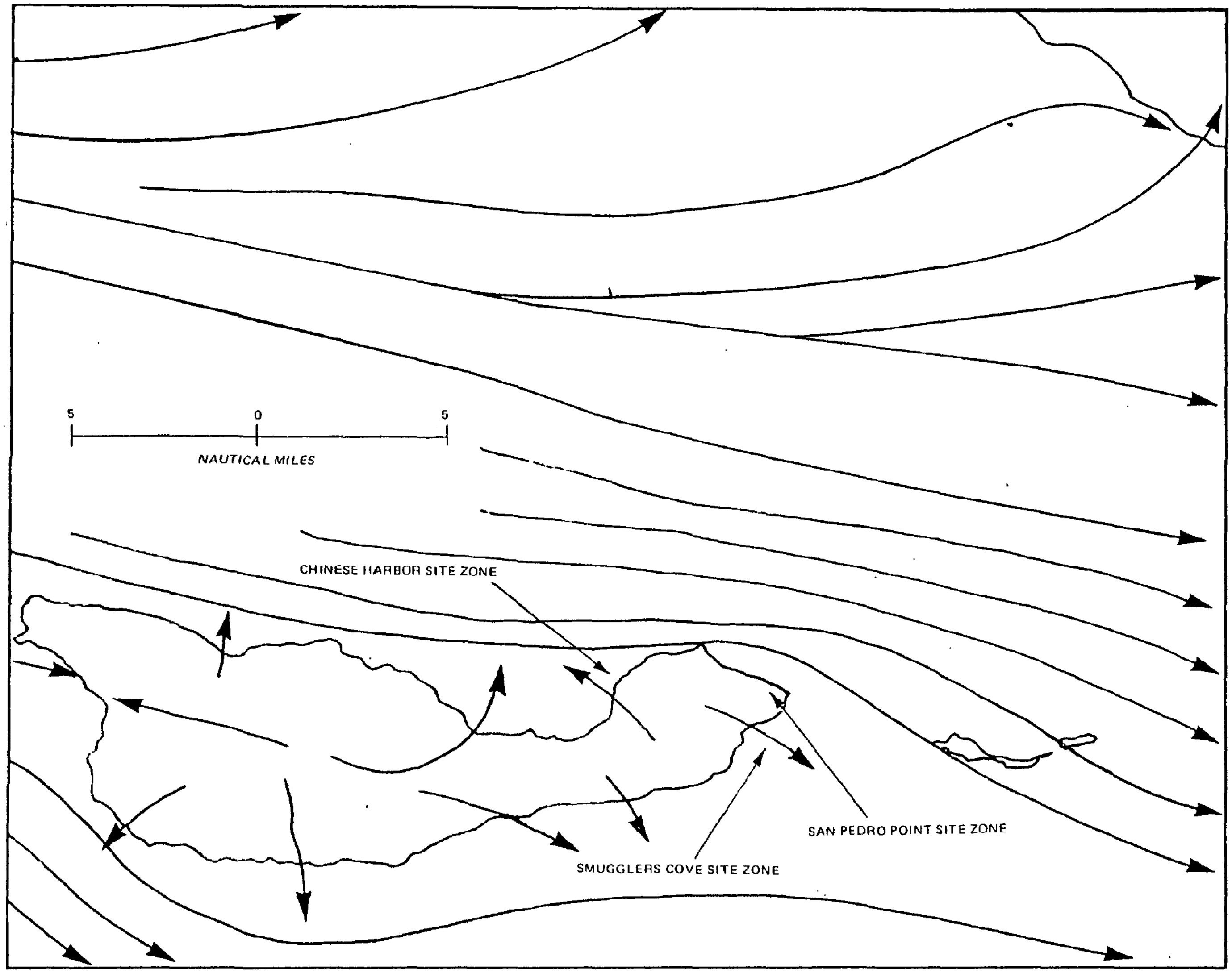


Figure 3.1.1-13. Ventura Flats and Santa Cruz Island Site Zones Stream Analysis Nighttime (5:00 AM) Prevailing W to WNW Wind (71)

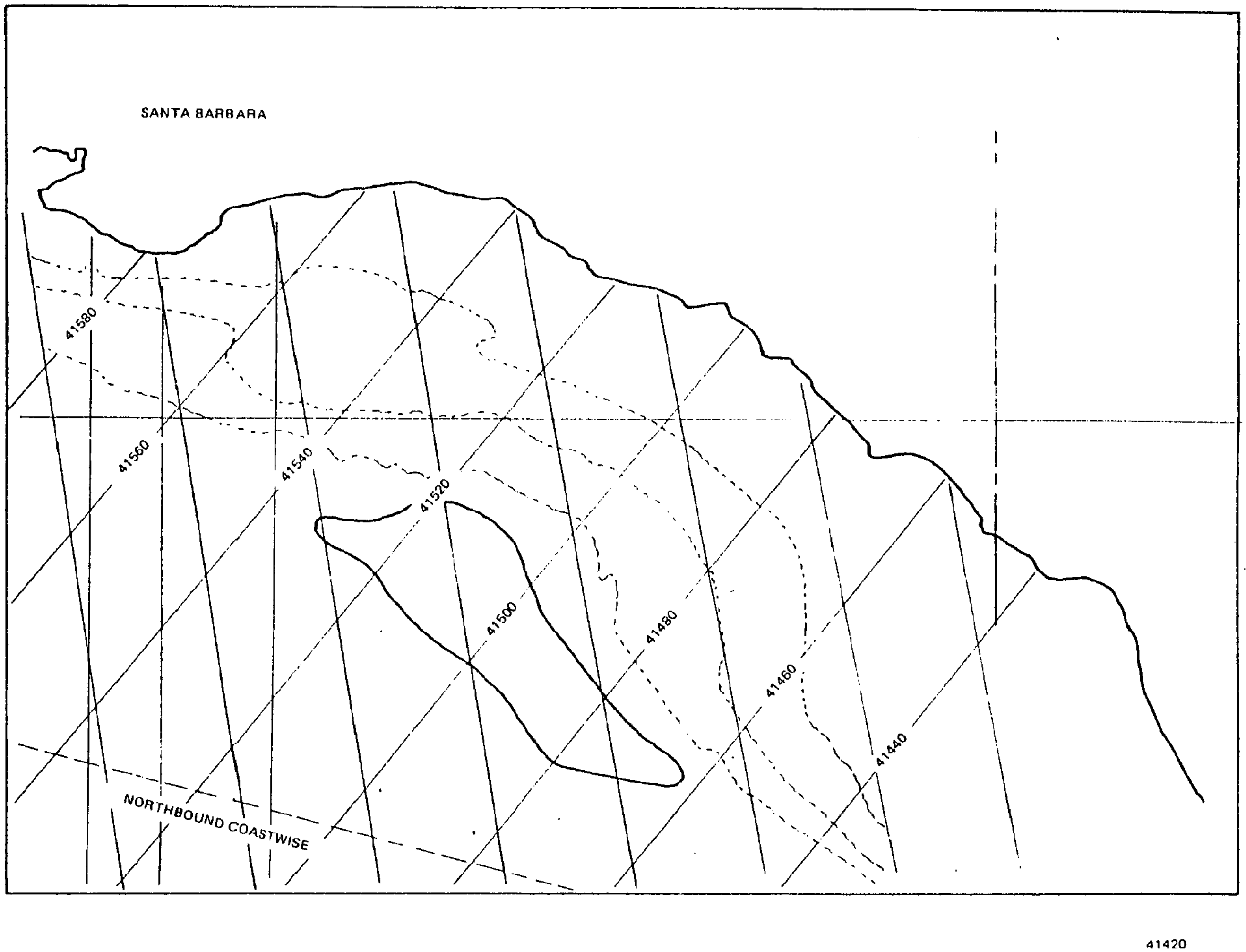


Figure 2.1-3. East Channel Shelf (Ventura Flats) Site Zone 5

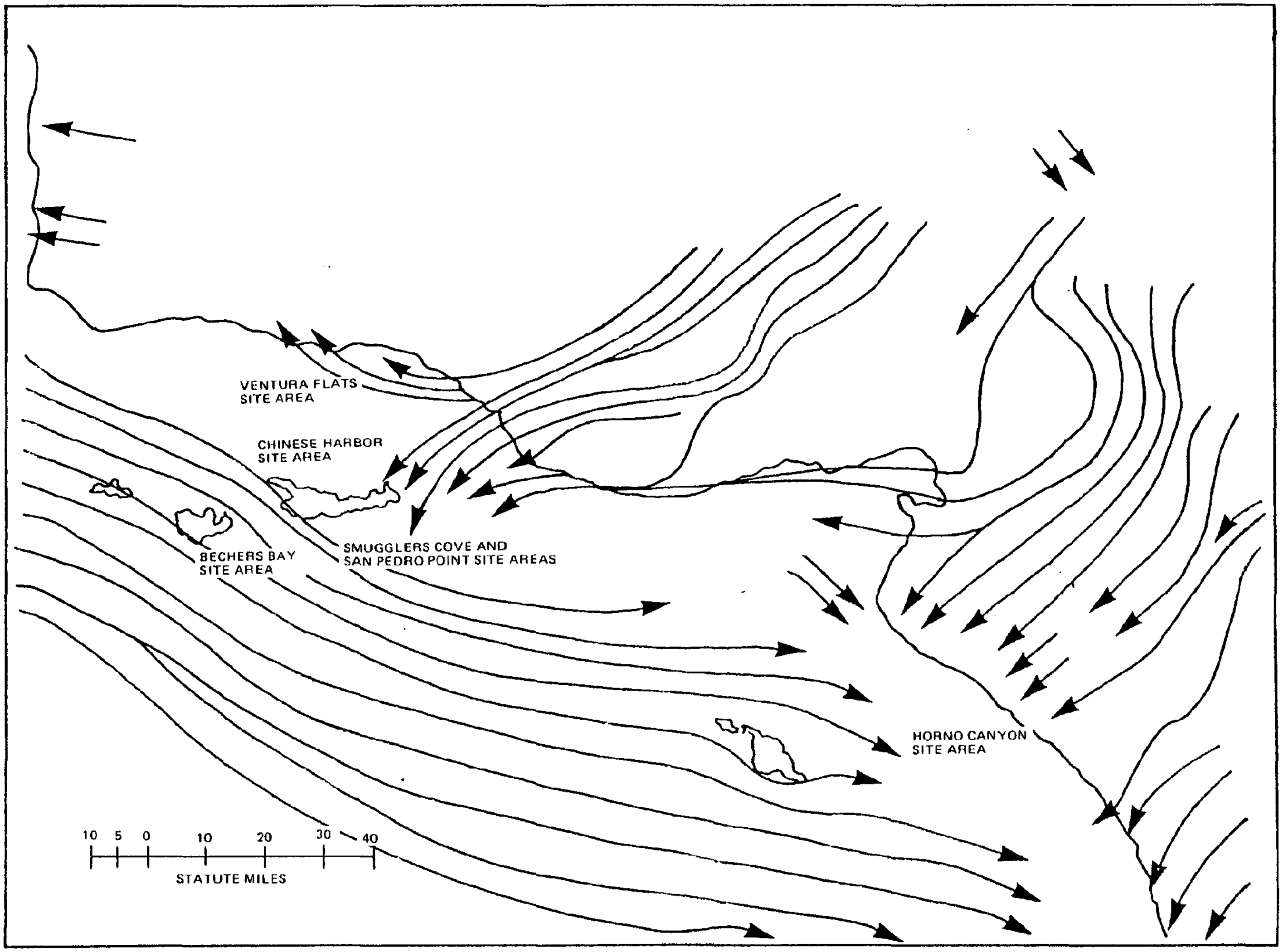


Figure 3.1.1-1. Santa Ana Conditions (71)

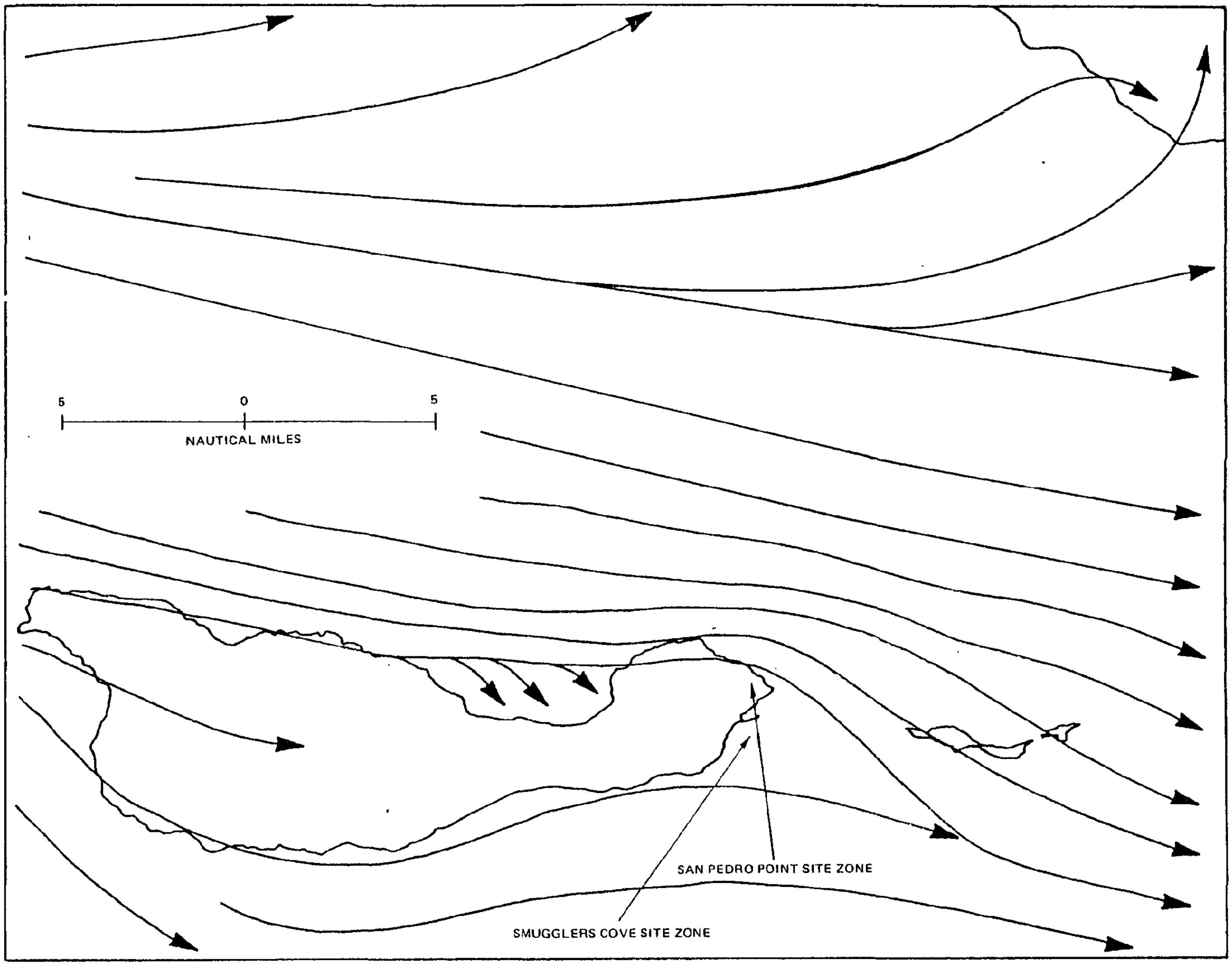
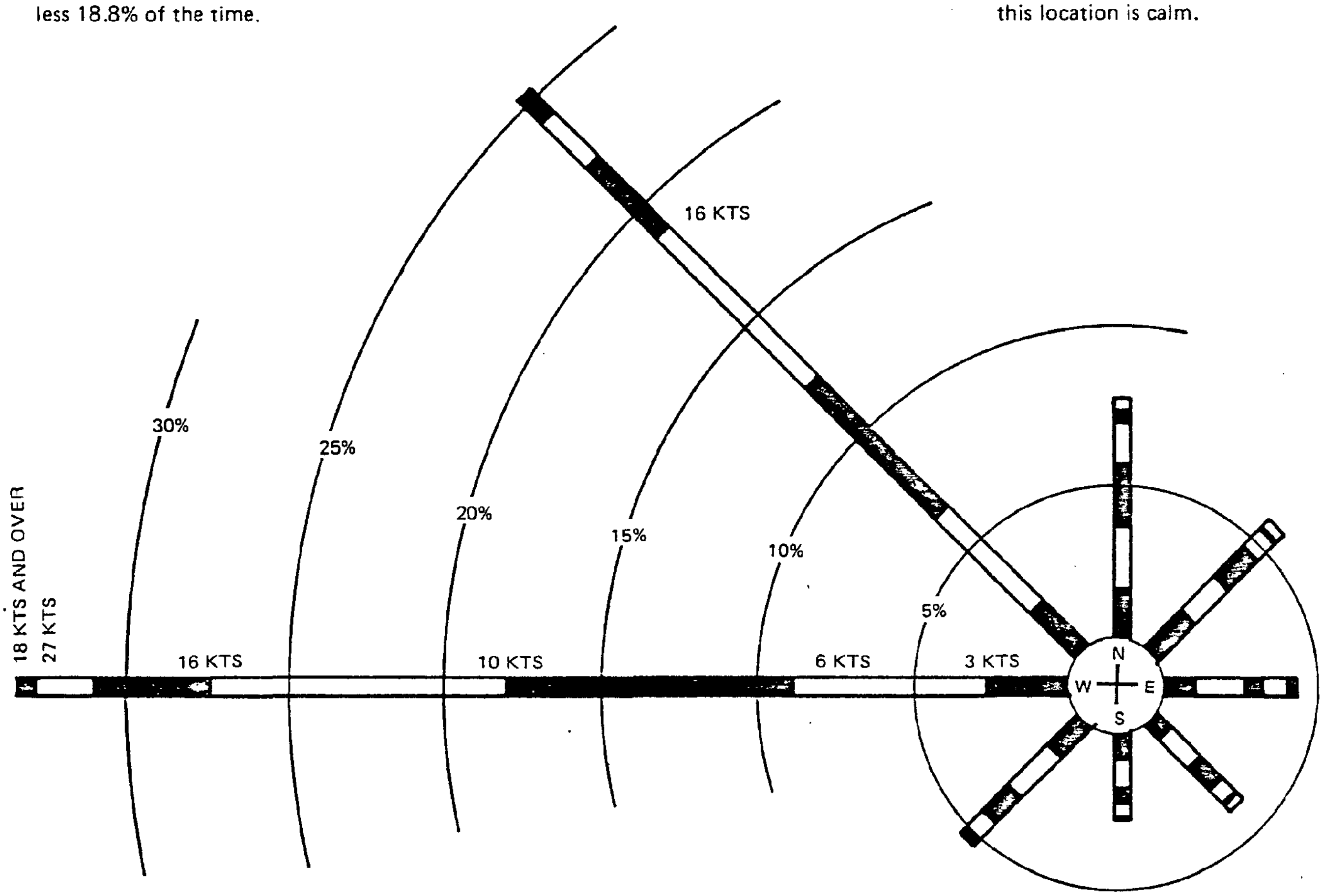


Figure 3.1.1-8. Ventura Flats and Santa Cruze Island Site Zones Streamline Analysis Daytime (Afternoon) Prevailing W to WNW Wind (71)

TO READ THIS CHART:
Wind Speed is 16 knots or less 18.8% of the time.

NOTE: 11.9% of the wind speed for this location is calm.



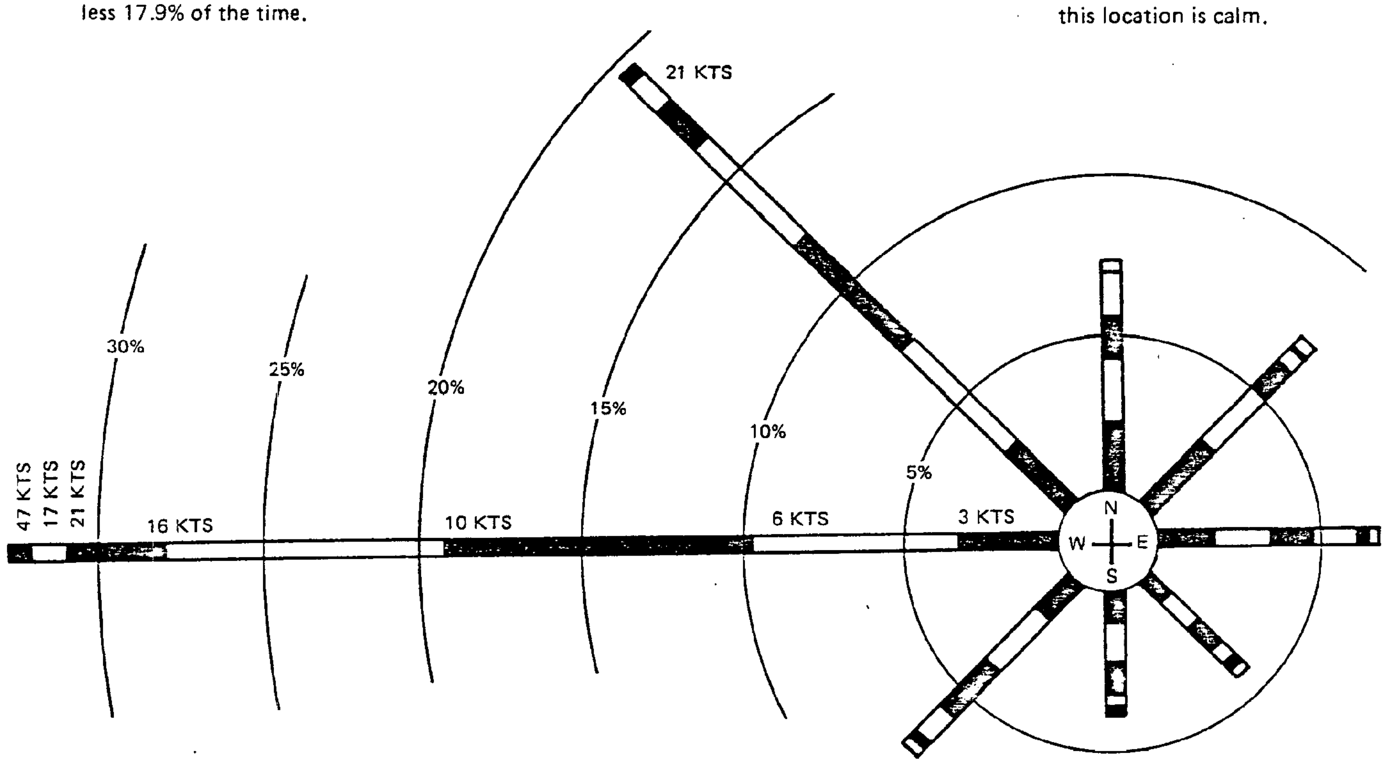
Micrometeorological Analysis, June 1978 (17) based on:

- Site Specific and local terrain configuration.
- U.S. Weather Bureau, Statistics Division, data from U.S. Army Air Force Weather Station, Santa Rosa Island, June 1943 through February 1944.
- Wind observations made at Anacapa Island lighthouse, 1949, 1950, 1954, 1955 and 1965-1968.
- U.S. Navy Fleet Weather Facility Climatological Study, Southern California Operating Area, 1971 (11).
- Station Climatic Summary by Naval Weather Service Environmetnal Detachment, Naval Weather Service Command, Ashville, North Carolina, 1978 (55).
- Research vessel delta measurements and interview program (See Appendix C).

Figure 3.1.1-12. Wind Data for Chinese Harbor, 50 Fathom Area

TO READ THIS CHART:
Wind Speed is 21 knots or less 17.9% of the time.

NOTE: 11.8% of the wind speed for this location is calm.



Micrometeorológical Analysis, June 1978 (17) based on:

- Site Specific and local terrain configuration.
- Wind observations made at Anacapa Island lighthouse, 1949, 1950, 1954, 1955 and 1965-1968.
- U.S. Navy Fleet Weather Facility Climatological Study, Southern California Operating Area, 1971 (11).
- Wind data from Airways Weather Report, U.S. Department of Agriculture for Santa Barbara (Goleta) airport, July 1, 1921 to December 31, 1939.
- Station Climatic Summary by Naval Weather Service Environmetnal Detachment, Naval Weather Service Command, Ashville, North Carolina, 1978 (55).
- Research vessel delta measurements and interview program (See Appendix C).
- Monthly records from the weather station at Pacific Missile Range (now PMTC).
- Wind Observations made at the Port Hueneme lighthouse, Port Hueneme, California November 1874 to February 1935.

Figure 3.1.1-18. Wind Data for Ventura Flats

TABLE 3.1.1-1
WIND REGIME SUMMARY
ANNUAL PERCENTAGE WIND VELOCITY IS 25 KNOTS OR GREATER
AND 30 KNOTS OR GREATER AT THE OFFSHORE SITE ZONE BERTH AREAS

SITE ZONE	DEPTH (FATHOMS)	TYPE FACILITY	≥ 25 KNOTS	≥ 30 KNOTS
BECHERS BAY	10	SHALLOW WATER BOTTOM SUPPORTED ISLAND SUPPORTED ARTIFICIAL ISLAND OFFSHORE PLATFORM WITH SALMS	4.4	NA
	13	FLOATING BARGE	7.9	NA
CHINESE HARBOR	10	SHALLOW WATER BOTTOM SUPPORTED ARTIFICIAL ISLAND OFFSHORE PLATFORM WITH SALMS	2.1	NA
	20	FLOATING BARGE	3.5	NA
	45	DEEP WATER BOTTOM SUPPORTED	NA	0.9
	50	DEEP WATER BOTTOM SUPPORTED	NA	1.5
SMUGGLERS COVE AND SAN PEDRO POINT	10	SHALLOW WATER BOTTOM SUPPORTED ISLAND SUPPORTED ARTIFICIAL ISLAND OFFSHORE PLATFORM WITH SALMS	1.1	NA
	20	FLOATING BARGE	1.2	NA
VENTURA FLATS	50	DEEP WATER BOTTOM SUPPORTED	NA	1.1
CAMP PENDLETON	10	SHALLOW WATER BOTTOM SUPPORTED ARTIFICIAL ISLAND OFFSHORE PLATFORM WITH SALMS	1.4	NA
	20	FLOATING BARGE	1.4	NA
	50	DEEP WATER BOTTOM SUPPORTED	NA	0.2

Table 3.1.1-3 summarizes estimated extreme winds at a recurrence interval of 100 years that may be experienced at Chinese Harbor and Ventura Flats.

Only one or two tornadoes (funnel clouds touching the ground) are reported in California a year. Tornadoes occurring in California are much smaller and weaker than those that occur in the midwest and, as a consequence, do less damage. Funnel clouds that touch the surface (waterspouts) in the Santa Barbara Channel region, while sighted more often, are much smaller than waterspouts that occur along the Gulf States when tornadoes touch the water. Seven waterspouts were sighted in the Santa Barbara Channel region on April 7, 1978; typically, each was small and no damage was reported.

Currents*

The direction of the current along the California coast is generally toward the southeast, parallel to the coastline. It is strongly influenced by the prevailing northwesterly winds, and the current averages about 0.2 knots. Between San Diego and Point Conception there is a weak seasonal countercurrent known as the Davidson Inshore Current (29), which is evident running in a northwesterly direction close to the shore from July through February. Currents in the Santa Barbara Channel are variable and depend largely upon the wind. A tidal current of 0.5 to 1.0 knot sets along the northern shore of the Channel, including the Ventura Flats site. In the prevailing northwesterly winds, the current makes into the south side of the west entrance to the Channel and along the north shore of the Channel Islands. Eddies then form in the lee of the islands and projecting points. Tidal currents of about 1.0 knot set through the passages between the islands (29). Oceanographic Services, Inc., in their study (17) of the California coast, estimates the 50 years maximum current between San Diego and Point Conception to be somewhat less than 2.0 knots. An oceanographic study (55) of San Onofre, which is just a few miles northwest of Camp Pendleton, reports results of a current monitoring program conducted from 1963 to 1969. In this study, the average surface current was 0.24 knots with no current greater than 1.0 knot. Table 3.1.6-1 presents estimates of average currents in the areas of Chinese Harbor and Ventura Flats. This table was prepared using the sources already discussed plus micro-oceanographical analysis of the specific site zones and data from experienced ship and small boat operators in the areas. The table of average currents shows all values well below 1.5 knots; however, reports of occasional observations of currents as high as 3.0 knots have been received. Estimates of maxima also indicate that currents as high as 3.0 knots can occur at the sites; however, there has been no evidence of statistically significant occurrence of currents as high as 1.5 knots near any of the sites. There have also been oral reports of bottom tidal currents as high as 8 knots running in Anacapa Passage east of Santa Cruz Island. These reports indicate that these strong currents are the result of convergence in the tidal flow between the individual Channel Islands, and, since the ocean water has high vertical stability, the convergence, or venturi effect, is more marked in the narrower, deeper portions of the passages. Reports of surface currents of such high speed were not received. Surface tidal currents of only about 1.0 knot are reported in the passages, as a rule.

Other Tables

Tables indicating the average number of days per month that various climatological and oceanographic conditions are exceeded at Chinese Harbor and Ventura Flats follow.

*For references, see the original document.

TABLE 3.1.1-3
EXTREME WIND SPEEDS (KNOTS) 100 YEAR RECURRENCE

SITE ZONE	DEPTH (FATHOMS)	MAXIMUM INSTANTANEOUS GUST/DIRECTION	SUSTAINED 1 MINUTE	SUSTAINED 1 HOUR	SUSTAINED 3 HOURS	SUSTAINED 6 HOURS
BECHERS BAY	10	74 NW	57	44	39	37
	13	85 NW	65	50	45	43
	10	60 N	46	35	31	30
CHINESE HARBOR	20	72 NE	55	42	38	36
	45	81 NE	62	48	43	41
	50	90 NE	69	53	48	45
SMUGGLERS COVE AND	10	95 NE	73	56	51	48
SAN PEDRO POINT	20	90 NE	69	53	48	45
VENTURA FLATS	50	90 NE-SE	69	53	48	45
HORNO CANYON	10					
	20	63 W	48	37	34	29
	50					

Environmental Science Consultants, June 1978. Data sources were U.S. Navy S.C.O.A. (55), shore-based weather facilities on the Channel Islands and mainland, micrometeorological analysis of terrain influences; recurrence values are derived from method of H. C. S. Thom, 1968 (59).

Other sources as listed on Figures 3.1.1-4, -8, -10, -13, -16, and -19.

References 16, 23, 25, 26

TABLE 3.1.6-1
CURRENT IN THE OFFSHORE LNG SITE ZONES

Average Current in Knots – Direction Flow is Towards

GEOGRAPHICAL ZONES	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
ZONE 1 BECHERS BAY	0.6 W	0.6 SE	0.5 SE	0.7 SE	0.5 SE	0.5 S	0.5 S	0.5 SE	0.7 W	0.5 WNW	0.7 W	0.7 W	0.58
ZONE 2 CHINESE HARBOR	0.7 W	0.6 E	0.5 E	0.7 ESE	0.5 E	0.5 E	0.4 E	0.5 E	0.7 W	0.5 NW	0.7 W	0.7 W	0.58
ZONES 3 & 4 SAN PEDRO POINT & SMUGGLERS COVE	0.7 W	0.6 E	0.5 E	0.7 ESE	0.5 ESE	0.5 E	0.4 ESE	0.5 ESE	0.7 SE	0.4 SE	0.7 W	0.7 W	0.58
ZONE 5 VENTURA FLATS	0.6 W	0.6 E	0.5 E	0.7 ESE	0.5 SE	0.5 E	0.4 E	0.5 E	0.7 W	0.5 NW	0.7 W	0.7 W	0.58
ZONE 6 OFF CAMP PENDLETON	0.5 SE	0.5 NW	0.5 SE	0.5 SE	0.5 NW/ SE	0.4 SE	0.6 NW	0.5 N	VAR	0.5 W	0.5 SE	0.4 N	0.45

TABLE E-3

DAYS PER MONTH OF EXCEEDANCE OF OPERATIONAL LIMITATIONS AND CALCULATED EFFECTS ON LNG OPERATIONS AT SHALLOW WATER TYPE AT CHINESE HARBOR (WITHOUT BREAKWATER)

OPERATIONAL LIMITATION	JAN 31	FEB 28	MAR 31	APR 30	MAY 31	JUN 30	JUL 31	AUG 31	SEP 30	OCT 31	NOV 30	DEC 31	ANNUAL AVERAGE
WAVES > 8 FEET	1.17	2.92	1.79	2.12	0.15	0.37	0.04	0.07	0	0.07	0.37	0.95	10.02
SWELL > FIG. 3.2.1.-1 At Both Fixed Berths	0.80	0.84	0.55	0.58	0.62	0.37	0.37	0.44	0.55	0.62	0.77	0.77	7.28
WIND > 25 KNOTS	0.37	0.65	1.17	0.88	1.02	0.66	0.34	0.37	0.24	0.37	0.50	0.85	7.42
VISIBILITY < 1.0 N. MILE	0.11	0.21	0.22	0.57	0.56	0.93	1.07	1.19	0.89	1.72	0.32	0.50	8.29
CURRENT > 1.5 KNOTS	0	0	0	0	0	0	0	0	0	0	0	0	0
CALCULATED EFFECTS													
DAYS DOWNTIME	2.06	3.92	2.56	3.04	1.41	1.22	1.03	1.17	1.07	1.59	1.33	2.03	22.43
PERCENTAGE BERTH AVAILABILITY	93.4	86.0	91.8	89.4	95.4	95.9	96.9	96.7	96.4	94.9	95.6	93.5	93.8
PROBABILITY OF DELAYS OF: 2 DAYS	0.52	0.84	0.67	0.75	0.20	0.10	0.03	0.08	0.04	0.30	0.16	0.51	0.35
3 DAYS	0.18	0.68	0.36	0.51	0.01	0.00	0.00	0.00	0.00	0.04	0.01	0.17	0.16
4.5 DAYS	0.01	0.38	0.06	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.05
TWO 3-DAY DELAYS	0.04	0.34	0.13	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.06

TABLE E-9

DAYS PER MONTH OF EXCEEDANCE OF OPERATIONAL LIMITATIONS AND CALCULATED EFFECTS ON LNG OPERATIONS AT FLOATING BARGE TYPE AT VENTURA FLATS

OPERATIONAL LIMITATION	JAN 31	FEB 28	MAR 31	APR 30	MAY 31	JUN 30	JUL 31	AUG 31	SEP 30	OCT 31	NOV 30	DEC 31	ANNUAL AVERAGE
WAVES > 8 FEET	3.23	4.98	3.08	2.41	1.51	0.84	0.07	0.13	0.11	0.58	1.50	0.82	19.26
SWELL > FIG. 3.2.1.-1 On Weathervaned Barge	3.61	5.66	4.87	4.73	2.83	4.14	2.43	2.52	2.21	2.77	2.21	2.35	40.33
WIND > 25 KNOTS	0.93	0.83	1.46	1.74	1.97	0.84	0.78	2.02	0.50	0.42	1.20	3.19	15.86
VISIBILITY < 1.0 N. MILE	0.14	0.57	1.32	1.20	1.22	1.62	2.09	2.62	3.29	3.01	1.10	0.59	18.77
CURRENT > 1.5 KNOTS	0	0	0	0	0	0	0	0	0	0	0	0	0
CALCULATED EFFECTS													
DAYS DOWNTIME	7.00	10.98	8.69	7.85	5.09	5.79	3.77	4.74	3.96	4.75	4.33	4.37	71.32
PERCENTAGE BERTH AVAILABILITY	77.4	60.8	72.0	73.8	83.6	80.7	87.8	84.7	86.8	84.7	85.6	85.9	80.32
PROBABILITY OF DELAYS OF: 2 DAYS	0.92	0.95	0.94	0.93	0.89	0.90	0.83	0.88	0.84	0.88	0.86	0.86	0.89
3 DAYS	0.87	0.93	0.90	0.89	0.79	0.83	0.66	0.77	0.69	0.77	0.73	0.74	0.80
4.5 DAYS	0.76	0.88	0.83	0.80	0.59	0.67	0.35	0.54	0.39	0.54	0.47	0.48	0.61
TWO 3-DAY DELAYS	0.47	0.50	0.48	0.48	0.42	0.44	0.35	0.40	0.35	0.40	0.38	0.38	0.42

SECTION D-3

EXTRACTS FROM MARITIME FACTORS ANALYSIS, ONSHORE LNG FACILITY PREPARED BY JOHN J. MC MULLEN ASSOCIATES, INC., MAY 1978

General Wind Regime

The following general and comparative wind regime assessments provide two streamline analysis charts for the Point Conception and Las Varas Canyon sites. One chart shows wind patterns for daytime and is generally representative of the period of time between late morning and sunset. The other chart shows the dominant flow expected at night and generally portrays winds between midnight and sunrise. While the charts more specifically pertain to prevailing wind patterns during the summer months, these winds generally occur during the other seasons. The mountain breeze-land breeze combined effects become stronger during the wintertime to weaken or completely dominate over the prevailing seabreeze at each site.

a. The prevailing westerly wind at the Point Conception (Little Cojo) site, caused by the refraction of the northwest wind around Point Arguello and Point Conception, is shown by the streamline analysis in Figure 3.1.1-5 and wind rose in Figure 3.1.1-6. The barrier presented by the Santa Ynez Mountains to strong northerly winds associated with migratory storms is also evident. Drainage and downslope wind at nighttime and early morning are shown in Figure 3.1.1-7. These winds are occasionally channelized by canyons north of the site and high wind gusts of short duration are produced. Santa Ana winds converge from the southeast off of Santa Ynez Mountains; however, these winds are diminished well below those at the eastern end of the Santa Barbara Channel region. The Point Conception site is exposed to winds from the west counterclockwise to the southeast.

b. The Las Varas Canyon site experiences a weaker wind regime than the Point Conception site due to further refraction, frictional forces, vectoring of wind energy up the canyons to the north, and turbulence associated with these effects. The weakening of winds and the change of the prevailing wind to the west is shown by Figure 3.1.1-5 and the wind rose in Figure 3.1.1-8. Like the Point Conception site, the Las Varas site is exposed to winds from the west counterclockwise to the southeast. Santa Ana wind velocities are below 25 knots.

Table 3.1.1-1 indicates the average number of days per month that wind velocity is greater than or equal to 25 knots at the Point Conception and Las Varas Canyon sites.

Extreme Wind Conditions

Table 3.1.1-2 summarizes estimated extreme winds at a recurrence interval of 100 years that may be experienced at the Point Conception and Las Varas Canyon sites.

Waves

Figure 3.1.2-6 presents the average time that wave height exceeds six feet at the Point Conception and Las Varas Canyon sites.

Extreme Wave Conditions

The California State Lands Commission in 1976 suggested that from 4 to 16 tsunamis have been generated from seismic disturbances within the Santa Barbara Channel. Such an earthquake occurred in 1812 and is reported to have attained run-up heights of 50 feet at Gaviota, 25 to 35 feet at Santa Barbara, and 15 feet at Ventura. Some doubt exists among the scientific community as to the accuracy of the foregoing reports. Other sources support the following table of major tsunami heights in feet recorded since 1945. These recordings have a direct application to the Santa Barbara Channel.

Date of Earthquake	4-11-46	11-4-52	3-9-57	5-23-60	3-28-64
Location	Aleutians	Kamchatka	Aleutians	Chile	Alaska
Magnitude (Richter Scale)	7.4	8.3	8.0	8.5	8.4
Recording Station (Wave Height in Feet)					
Crescent City	5.9	6.8	4.3	10.9	13.0*
Avila Beache	8.5	9.5*	3.5	0	10.4*
Rincon Island					5.9*
Port Hueneme	5.5	4.7	3.5	8.8	0
Santa Monica	0	3.6	3.0	9.1*	6.5
San Diego	1.2	2.3	1.5	4.6	3.7

*Gauge limit exceeded.
References: Berkman and Symons, 1964; Spaeth and Berkman, 1967.

Visibility

Restriction of visibility in the Santa Barbara Channel is due almost entirely to the California coastal fog and status clouds, which are caused by complex effects of the atmospheric and oceanic circulations. Atmospheric pollution from the cities has occasional contributory effects. The season of greatest intensity of the coastal fog is from spring through summer and into late fall. The location and the intensity or transmissivity of the fog fluctuates. Generally the fog tends to become lower and more intense at night and to move in close to shore and over the land during late night and early morning. Late in the morning the fog tends to dissipate over land, move out to sea, and to become less intense. These diurnal variations dominate fluctuations in the visibility, but other larger scale effects disrupt the diurnal pattern. Occasionally the fog persists over the shore for several days, and at other times it remains well out to sea for long periods. There are significant annual variations in the occurrence and spatial distribution of coastal fog also, but no quantitative analyses of these longer period fluctuations were available.

Estimates of the percentage of time that visibility is less than one nautical mile are presented in Table 3.1.3-1.

Currents

A study of currents along the California coast reveals that they are generally less than one knot at the Point Conception and Las Varas Canyon sites. Table 3.1.4-1 presents estimates of average currents. The highest monthly average shown is 0.8 knots; however, reports of occasional observations of currents as high as 3.0 knots have been received. Estimates of maxima also indicate that currents as high as 3.0 knots can occur near the sites; however, there has been no evidence of statistically significant occurrence of curents as high as 1.5 knots near any of the sites.

Other Tables

Tables F-2 and F-3 present average number of days per month that various climatological and oceanographic conditions are exceeded at the Point Conception and Las Varas Canyon sites.

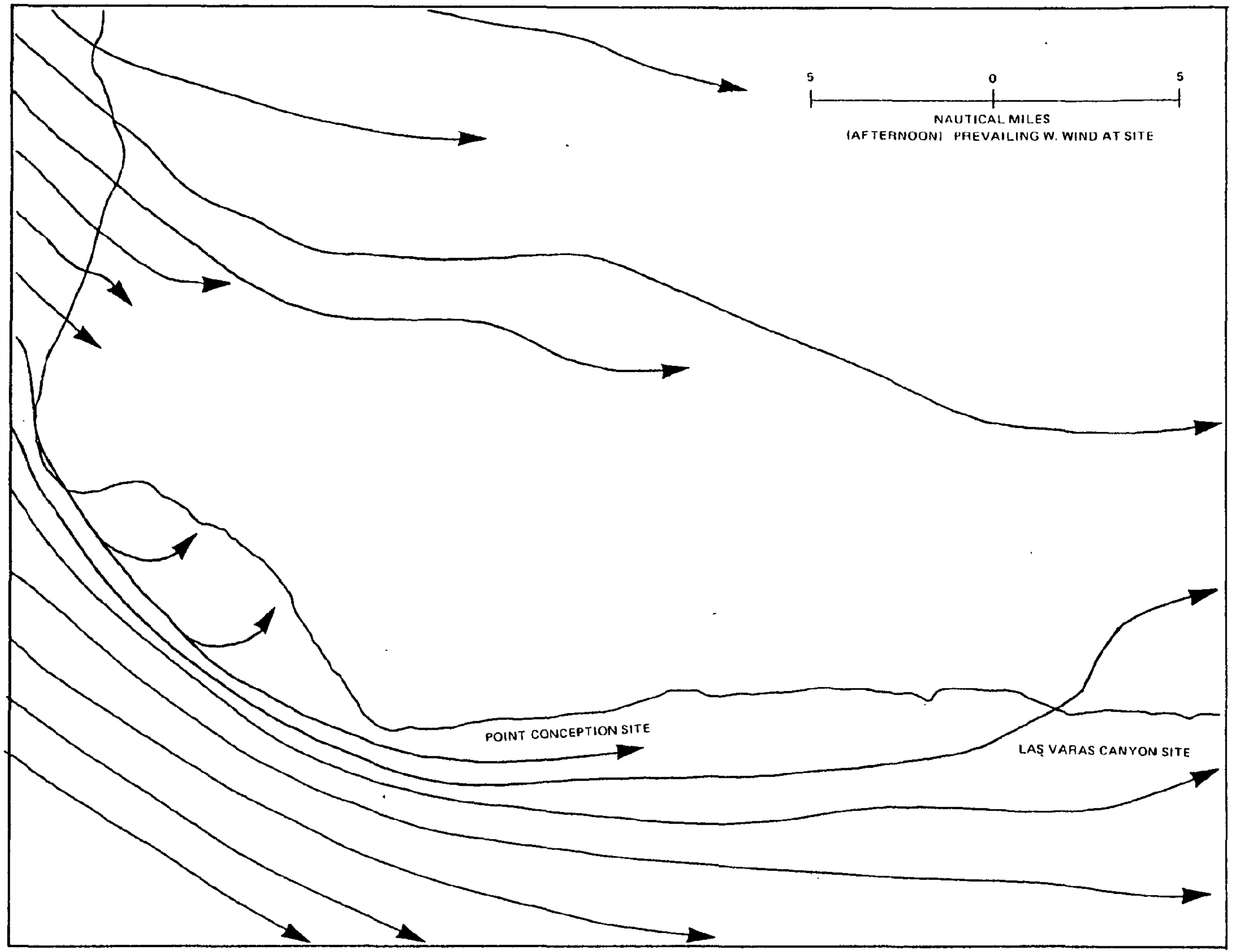
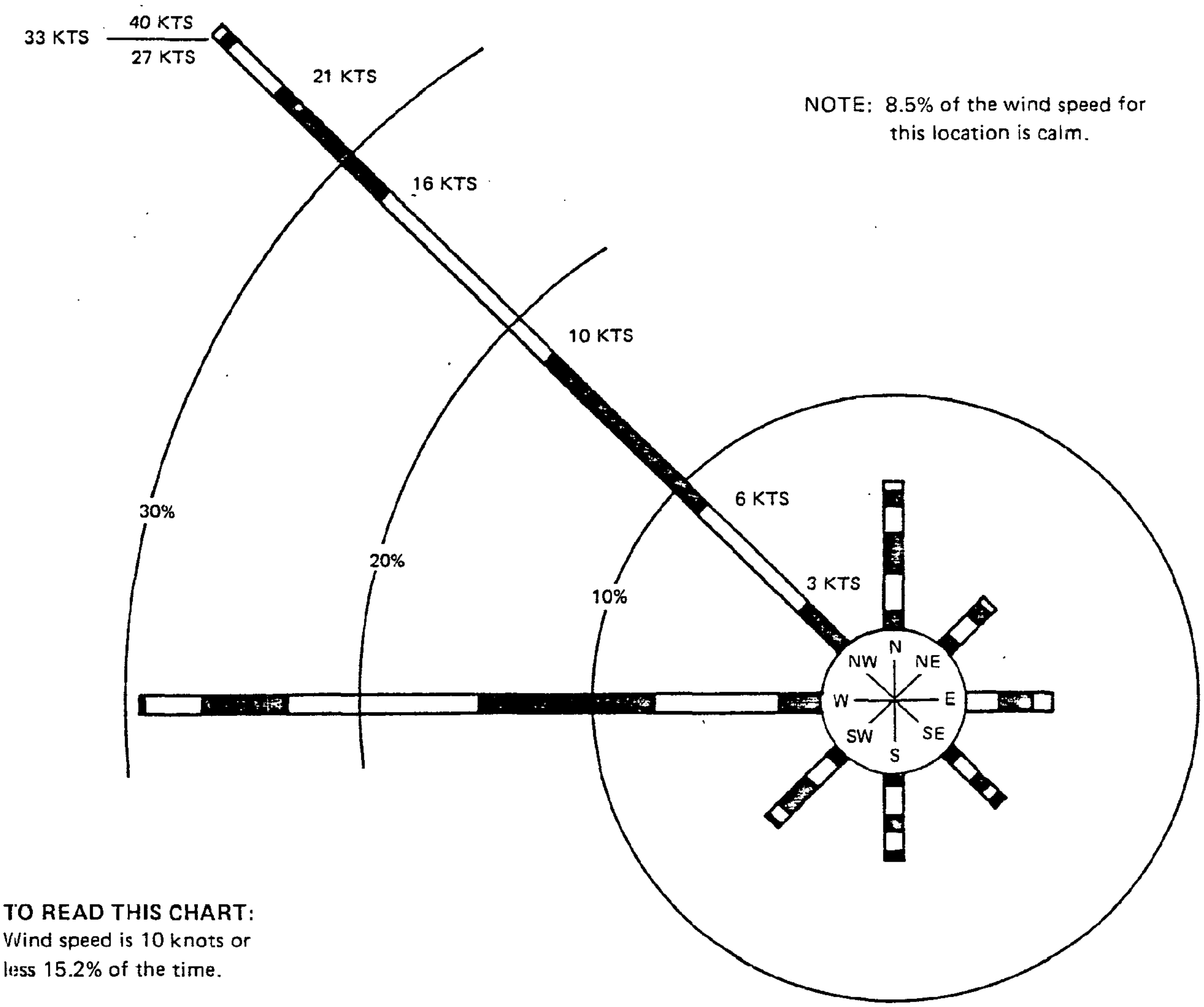


Figure 3.1.1-5. Point Conception and Las Varas Sites Streamline Analysis, Daytime



Source: Environmental Science Consultants, Inc., micrometeorological analysis, 1978, based on:

- Site specific and local terrain configuration
- U.S. Weather Bureau, Statistics Division, data from U.S. Army Air Force weather station, Santa Rosa Island, June 1943 through February 1944
- Data from Marine Coastal Weather Log at U.S. Coast Guard Light Station, Pt. Conception, October 1, 1972 through February 15, 1973, 3 hour interval readings
- Station Climatic Summary by Naval Weather Service Environmenal Detachment, Naval Weather Service Command, Asheville, North Carolina (57)
- U.S. Navy Fleet Weather Facility Climatological Study, Southern California Operating Area, 1971 (11)
- Interview Program (See Appendix C)

Figure 3.1.1-6. Wind Data for Point Conception

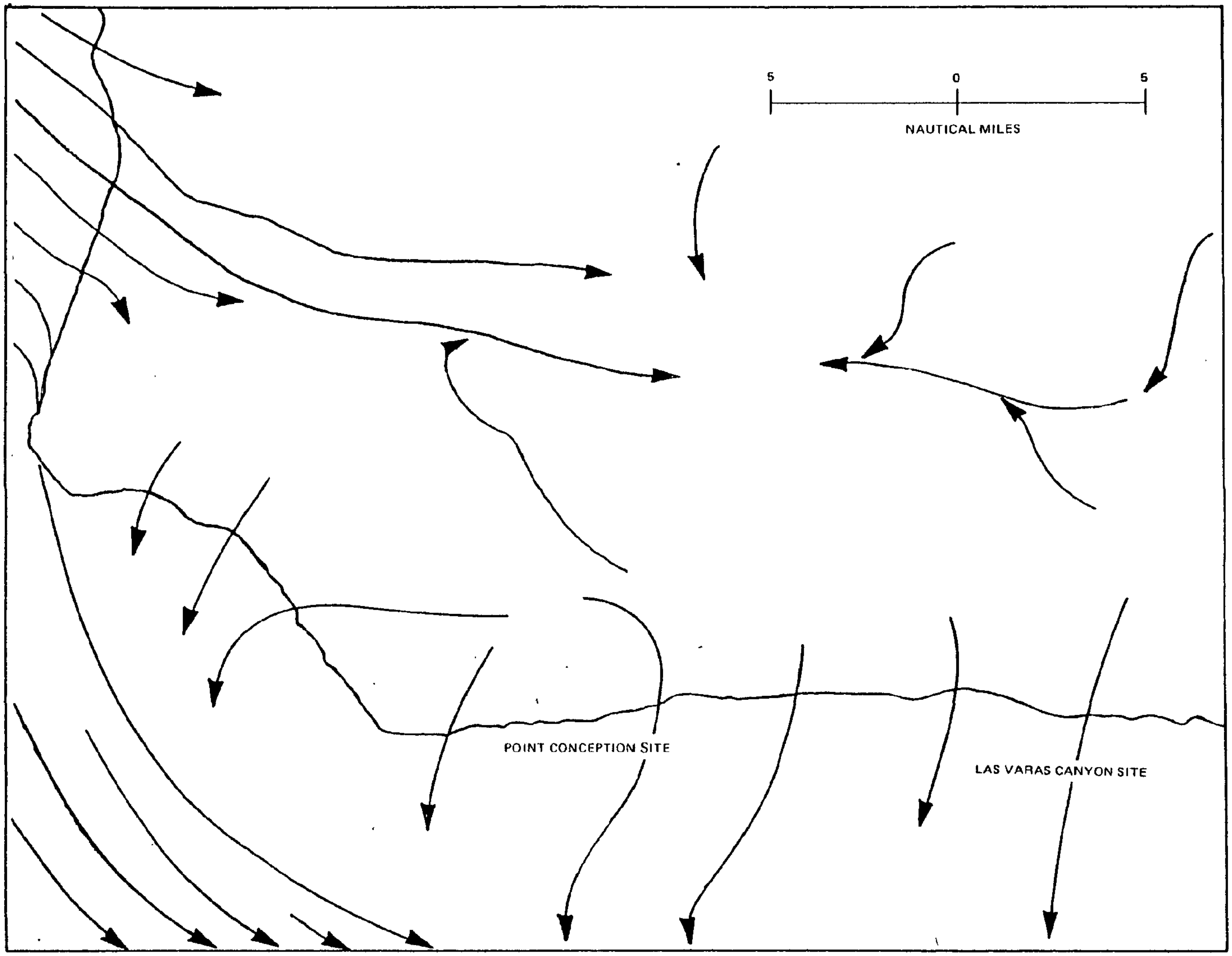
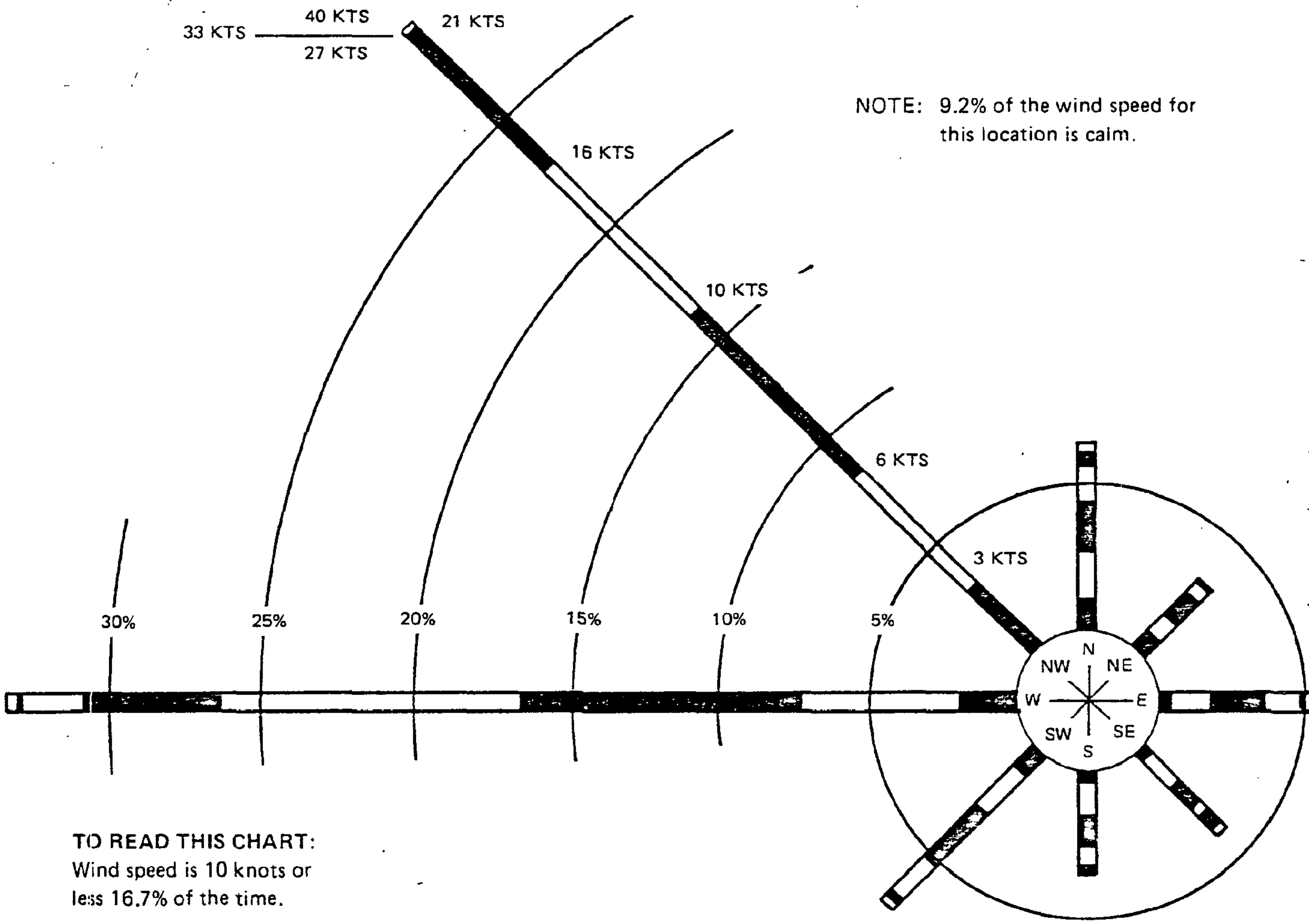


Figure 3.1.1-7. Point Conception and Las Varas Site Streamline Analysis, Nighttime (5:00 AM)



Source: Environmental Science Consultants, Inc., micrometeorological analysis, 1978, based on:

- Site specific and local terrain configuration
- Wind diagrams from Airways Weather Report, U.S. Dept. of Agriculture, for Santa Barbara (Goleta) airport, July 1, 1929 to December 31, 1939
- U.S. Weather Bureau, Statistics Division, data from U.S. Army Air Force weather station, Santa Rosa Island, June 1943 through February 1944
- U.S. Navy Fleet Weather Facility Climatological Study, Southern California Operation Area, 1971 (11)
- Station Climatic Summary by Naval Weather Service Environmenal Detachment, Naval Weather Service Command, Asheville, North Carolina (57)
- Data from CALTRANS, San Luis Obispo, on Tajiguas and Santa Barbara areas
- Interview Program (See Appendix C)

Figure 3.1.1-8. Wind Data for Las Varas Canyon

TABLE 3.1.1-1

WIND

AVERAGE DAYS PER MONTH THAT THE WIND VELOCITY IS 25 KNOTS OR GREATER AT THE ONSHORE LNG SITES

SITE	DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
RATTLESNAKE CANYON	DAYS	3.44	1.77	5.24	7.53	3.81	6.78	3.04	0.59	1.98	2.51	3.66	3.57	43.92
POINT CONCEPTION	DAYS	1.41	2.29	2.28	2.90	3.56	.83	1.38	2.21	1.70	.76	1.39	2.03	22.74
LAS VARAS CANYON	DAYS	1.01	1.01	1.14	1.90	2.75	.91	.81	2.28	1.04	.32	1.07	2.20	16.44
DEER CANYON	DAYS	0.67	1.28	1.49	0.79	1.08	.96	0.53	0.12	0.46	.067	1.18	1.36	10.59
CAMP PENDLETON	DAYS	0.72	2.37	0.22	0.69	0.10	0.08	0.06	0.05	0.05	0.27	0.35	0.30	5.26

Sources: Environmental Science Consultants, Inc. utilized data of U.S. Navy S.C.O.A. (11) modified by shore-based data sources and micrometeorological analysis of local terrain.

Other sources as listed on Figures 3.1.1-3, -6, -8, -10, and -13.

TABLE 3.1.1-2

EXTREME WIND SPEEDS (KNOTS), 100 YEAR RECURRENCE

Site	Maximum Instantaneous Gust	Sustained 1 Minute	Sustained 1 Hour	Sustained 3 Hours	Sustained 6 Hours
Rattlesnake Canyon	94	72	55	50	47
Point Conception	98	75	58	53	49
Las Varas Canyon	91	70	54	49	46
Deer Canyon	101	78	60	55	51
Camp Pendleton	63	48	37	34	29

Source: Environmental Science Consultants, Inc., April, 1978 utilized data of U.S. Navy S.C.O.A. shore-based weather facilities, and micrometeorological analysis of terrain influences; recurrence values are derived from method of H. C.S. Thom, 1968 (16).

Other sources as listed on Figures 3.1.1-3, -6, -8, -10, and -13.

References 16, 23, 25, 26

WAVES

AVERAGE TIME THAT WAVE HEIGHT EXCEEDS SIX FEET AT THE ONSHORE LNG SITES

SITE		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
RATTLESNAKE CANYON	%	15.3	19.6	23.5	25.6	37.7	34.0	20.0	18.8	9.7	10.6	11.0	13.0	19.9
	DAYS	4.75	5.48	7.30	7.67	11.7	10.2	6.21	5.84	3.92	3.29	3.29	4.02	72.6
POINT CONCEPTION	%	10.6	13.0	15.3	9.70	4.70	3.70	0.0	1.20	1.20	3.50	7.30	8.30	6.5
	DAYS	3.29	3.65	4.75	2.92	1.46	1.10	0.00	0.37	0.37	1.10	2.19	2.56	23.7
LAS VARAS CANYON	%	7.10	7.80	10.6	8.50	4.70	2.40	0.00	1.20	1.20	1.20	6.10	5.90	4.7
	DAYS	2.19	2.19	3.29	2.56	1.46	0.73	0.00	0.37	0.37	0.37	1.83	1.83	17.2
DEER CANYON	%	5.90	9.10	7.10	7.30	4.70	4.90	1.20	1.20	1.20	2.40	37.70	5.90	4.5
	DAYS	1.83	2.56	2.19	2.19	1.46	1.46	0.37	0.37	0.37	0.73	1.10	1.83	16.4
CAMP PENDLETON	%	4.70	6.50	7.10	7.30	10.6	13.4	5.90	3.50	2.40	1.20	2.40	2.40	5.6
	DAYS	1.46	1.83	2.19	2.19	3.29	4.02	1.83	1.10	0.73	0.37	0.73	0.73	20.4

Reference: Waterways Experiment Station Report (54), April 1978.

Figure 3.1.2-6

TABLE 3.1.3-1

VISIBILITY

AVERAGE PERCENTAGE OF TIME THAT THE VISIBILITY IS LESS THAN ONE NAUTICAL MILE AT THE ONSHORE LNG SITES

SITE	% DAYS	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
RATTLESNAKE CANYON	%	3.5	4.3	5.2	4.7	9.0	13.7	23.5	23.9	17.7	12.3	7.7	6.5	11.0%
	DAYS	1.1	1.2	1.6	1.4	2.8	4.1	7.3	7.4	5.3	3.8	2.3	2.0	40.3 days
POINT CONCEPTION	%	1.2	2.6	1.3	1.0	4.2	3.9	7.6	5.0	4.2	4.8	1.6	2.7	3.4%
	DAYS	0.4	0.7	0.4	0.3	1.3	1.2	2.4	1.6	1.3	1.5	0.5	0.8	12.4 days
LAS VARAS CANYON	%	1.9	0.7	2.4	0.0	2.2	5.1	7.4	5.4	7.1	5.7	0.9	3.8	3.6%
	DAYS	0.6	0.2	0.7	0.0	0.7	1.5	2.3	1.7	2.1	1.8	0.3	1.2	13.1 days
DEER CANYON	%	2.7	3.1	2.8	4.1	2.6	2.8	3.2	4.2	7.8	7.6	4.3	3.1	4.0%
	DAYS	0.8	0.9	0.9	1.2	0.8	0.8	1.0	1.3	2.3	2.4	1.3	1.0	14.7 days
CAMP PENDLETON	%	3.0	2.0	1.0	2.3	2.0	0.7	1.7	2.8	8.1	3.6	5.6	2.9	3.0%
	DAYS	0.9	0.6	0.3	0.7	0.6	0.2	0.5	0.9	2.4	1.1	1.7	0.9	10.8 days

TABLE 3.1.4-1

CURRENT AT LNG SITES

Average Current in Knots — Direction Flow is Towards

SITE	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL AVERAGE
RATTLESNAKE CANYON	GENERALLY LESS THAN 1.5 KNOTS												
POINT CONCEPTION	0.7 W	0.6 W	0.6 SE	0.7 SSE	0.5 SE	0.6 SSW	0.3 W	0.6 W	0.4 SE	0.3 S	0.5 WNW	0.5 W	0.525
LAS VARAS CANYON	0.7 W	0.6 W	0.5 E	0.7 SE	0.5 E	0.5 E	0.4 E	0.5 WSW	0.7 W	0.5 NW	0.7 W	0.7 W	0.583
DEER CANYON	0.4 NW	0.5 NW	0.5 ESE	0.7 ESE	0.5 SE	0.5 E	0.4 ESE	0.6 WNW	0.6 W	0.4 W	0.7 W	0.8 W	0.55
CAMP PENDLETON	0.5 SE	0.5 NW	0.5 SE	0.5 SE	0.5 NW/ SE	0.4 SE	0.6 NW	0.5 N	VAR	0.5 W	0.5 SE	0.4 N	0.5

DAYS/MONTHS OF CONDITIONAL EXCEEDANCE

TABLE F2 FOR THE

POINT CONCEPTION LNG SITE (NO BREAKWATER)

Days / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Waves > 6.0 ft.	3.29	3.65	4.75	2.92	1.46	1.10	0	0.37	0.37	1.10	2.19	2.56	23.76
Swell > Fig. 3.2-1	0.07	0.04	0.15	0.07	0.73	0	1.10	0.73	0.73	0	0	0.04	3.66
Wind > 25.0 Kts.	1.41	2.29	2.28	2.90	3.56	0.83	1.38	2.21	1.70	0.76	1.39	2.03	22.74
Visibility < 1.0 nm.	0.4	0.7	0.4	0.3	1.3	1.2	2.4	1.6	1.3	1.5	0.5	0.8	12.4
Current > 1.5 Kts.	0	0	0	0	0	0	0	0	0	0	0	0	0

DAYS/MONTHS OF CONDITIONAL EXCEEDANCE

TABLE F3 FOR THE

LAS VARAS CANYON LNG SITE (NO BREAKWATER)

Days / Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Average
Waves > 6.0 ft.	2.19	2.19	3.29	2.56	1.46	0.73	0	0.37	0.37	0.37	1.83	1.83	17.19
Swell > Fig. 3.2-1	0.07	0.04	0.15	0.07	0.73	0	0.33	0.07	0.15	0.11	0	0.04	1.10
Wind > 25.0 Kts.	1.01	1.01	1.14	1.90	2.75	0.91	0.81	2.28	1.04	0.32	1.07	2.20	16.44
Visibility < 1.0 nm.	0.6	0.2	0.7	0	0.7	1.5	2.3	1.7	2.1	1.8	0.3	1.2	13.1
Current > 1.5 Kts.	0	0	0	0	0	0	0	0	0	0	0	0	0

SECTION D-4

EXTRACTS FROM OFFSHORE OIL AND GAS DEVELOPMENT: SOUTHERN CALIFORNIA PREPARED BY THE OCS PROJECT TASK FORCE, OFFICE OF PLANNING AND RESEARCH, OCTOBER 1977

Winds and Water Currents Off Southern California

The major winds and water currents operating in the Southern California Outer Continental Shelf (OCS) are powered by phenomena operating far offshore in the open Pacific. Seaward of a line drawn southeast from Point Arguello, the winds and water currents generally reflect undisturbed, open-ocean conditions and, as such, are relatively constant and predictable. The summer winds, originating in the semi-permanent East Pacific High Pressure area, usually flow from the northwest at speeds up to 15 knots (Figure 2). In winter, as the East Pacific High moves south, the winds weaken and become more erratic, though still generally coming from the west quadrant. The California current moves to the southeast throughout the year at speeds ranging from 0.25 to 0.75 knots.

Within the Southern California Bight, local and regional forces come into play, complicating wind and water current patterns. The configuration of southern California Bight and the array of coastal mountains splinter the oceanic northwest winds entering the Bight into weaker and more erratic breezes, with considerable local variation (see Figure 3).

The daily land-breeze/sea-breeze cycle, driven by the differential heating and cooling of ocean and land during every 24-hour period, influences wind patterns in a belt along the coast extending at least 50 miles to sea (Figure 4). Much of the Santa Barbara Channel is in the wind shadow ofthe Santa Ynez and Topa Mountains, while each island creates local anomalies in the overall wind patterns. Santa Ana winds (steady offshore breezes of several day's duration) occur periodically along the southern California coast.

In Figure 6, the generalized pattern of surface currents in the Santa Barbara Channel is illustrated.

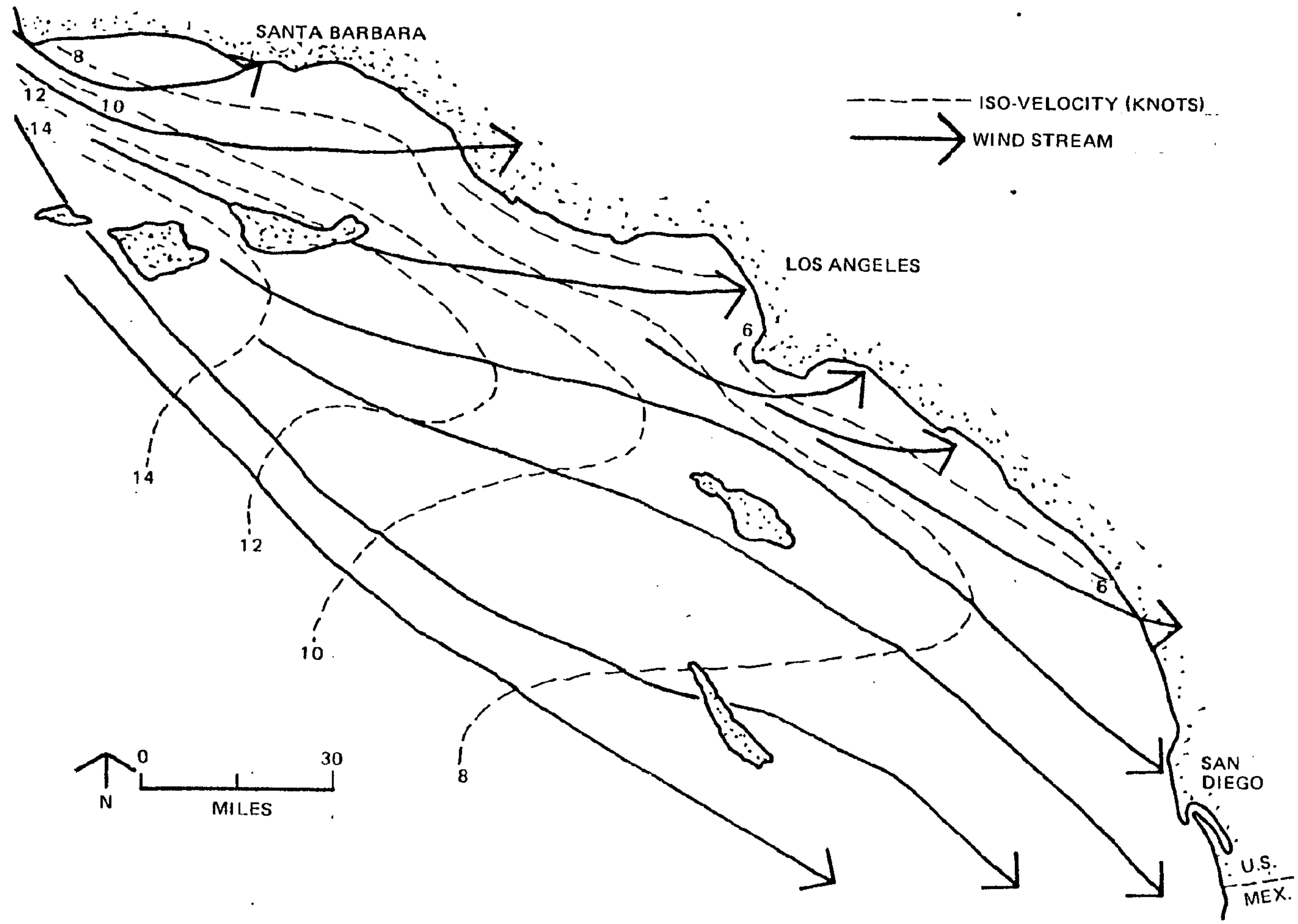


Figure 2. Annual Average Winds In The Southern California Bight.

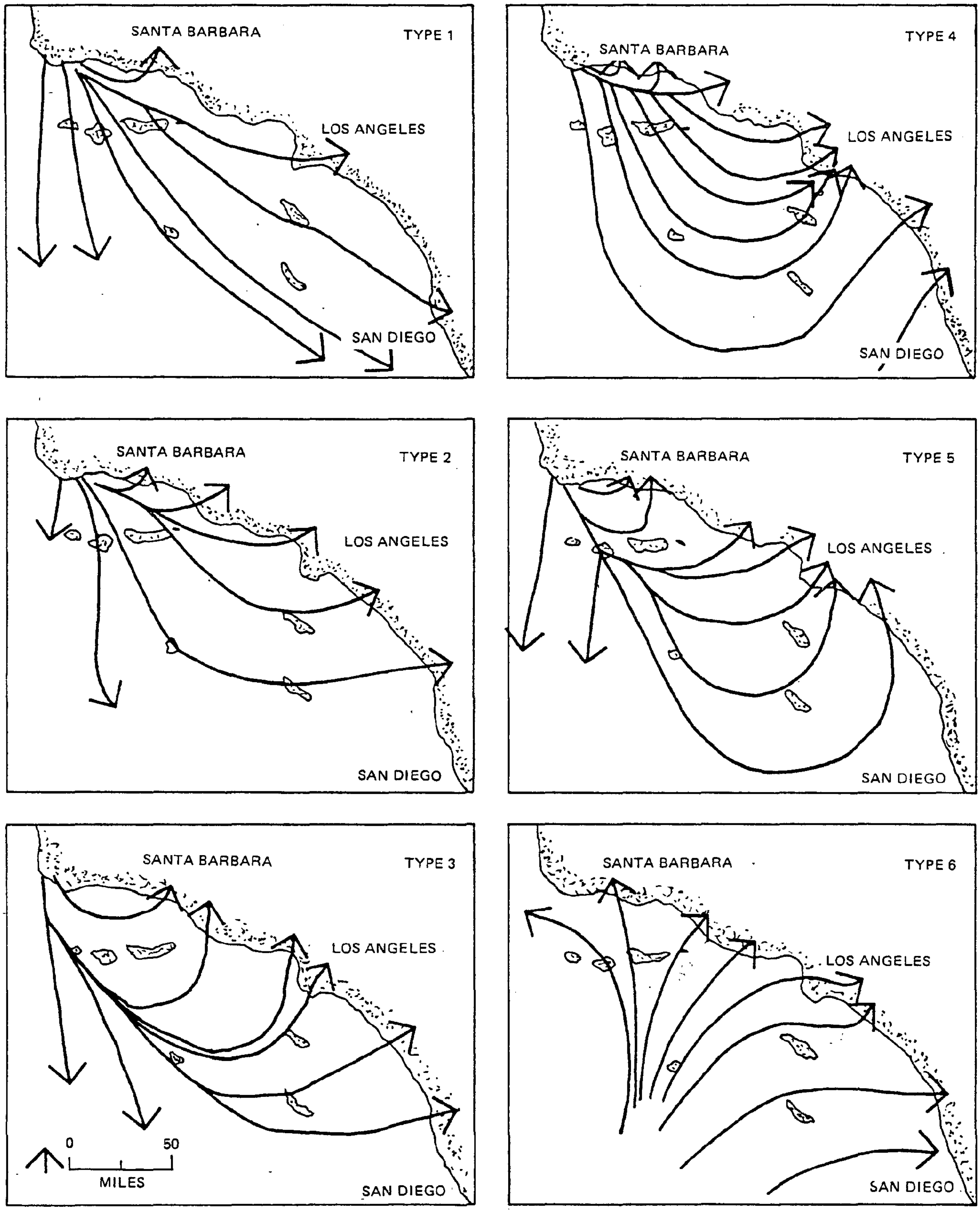
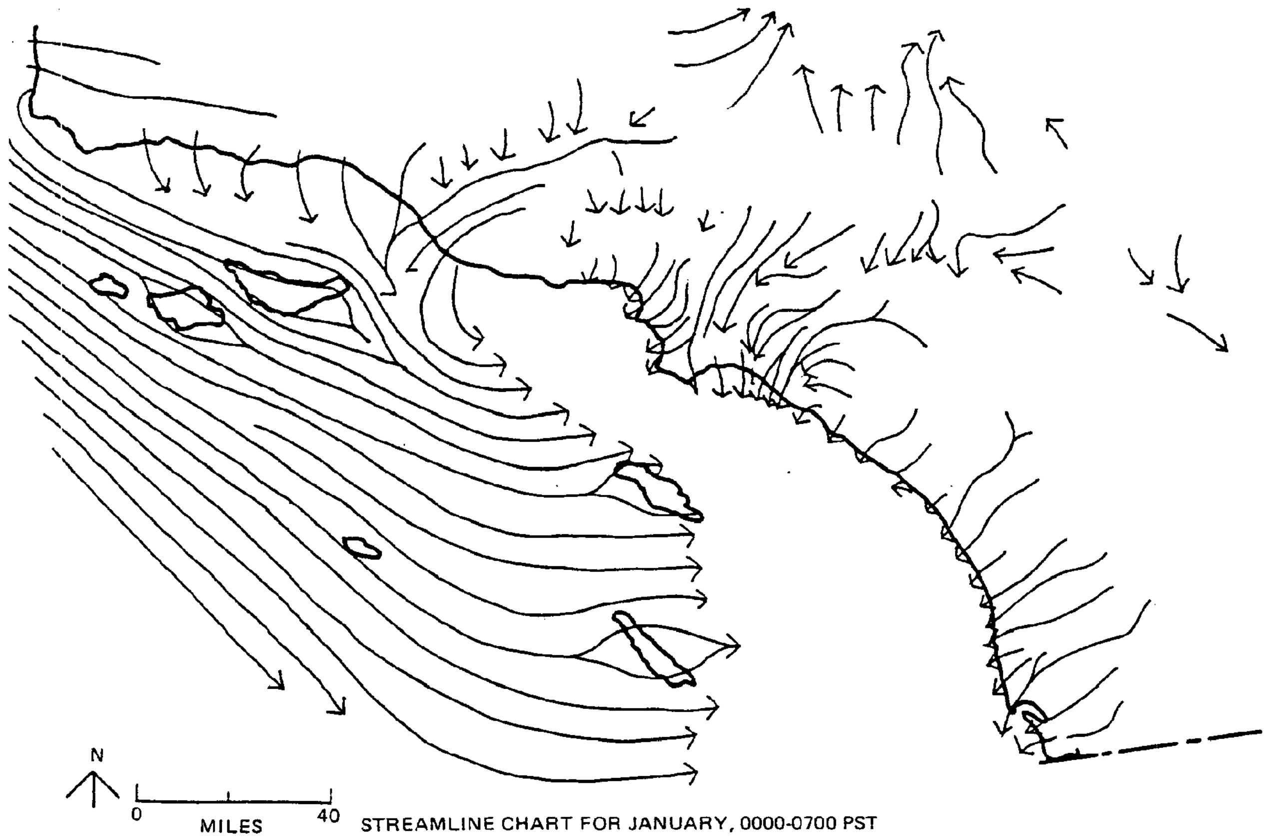
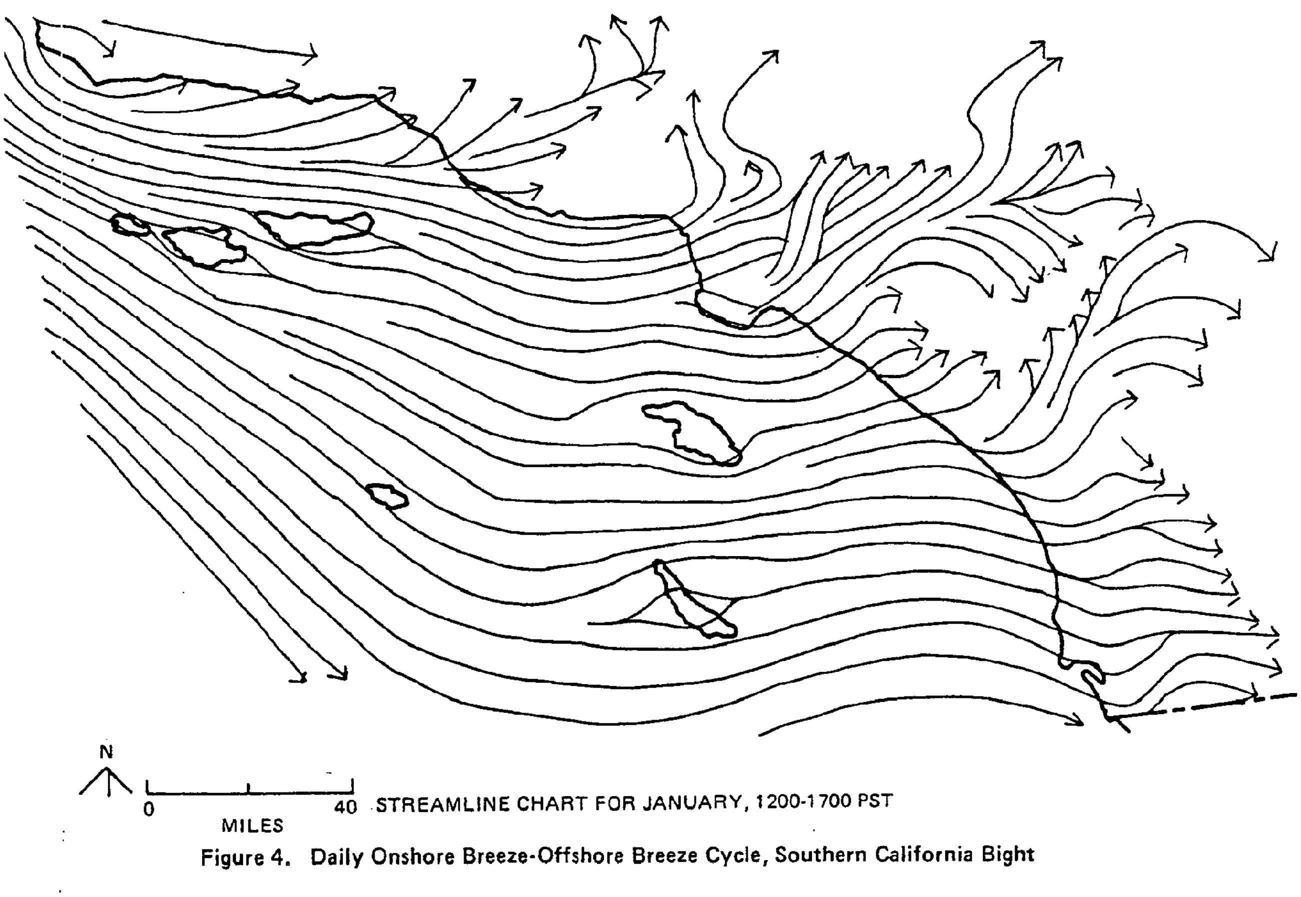


Figure 3. Six Common Wind Patterns in the Southern California Bight

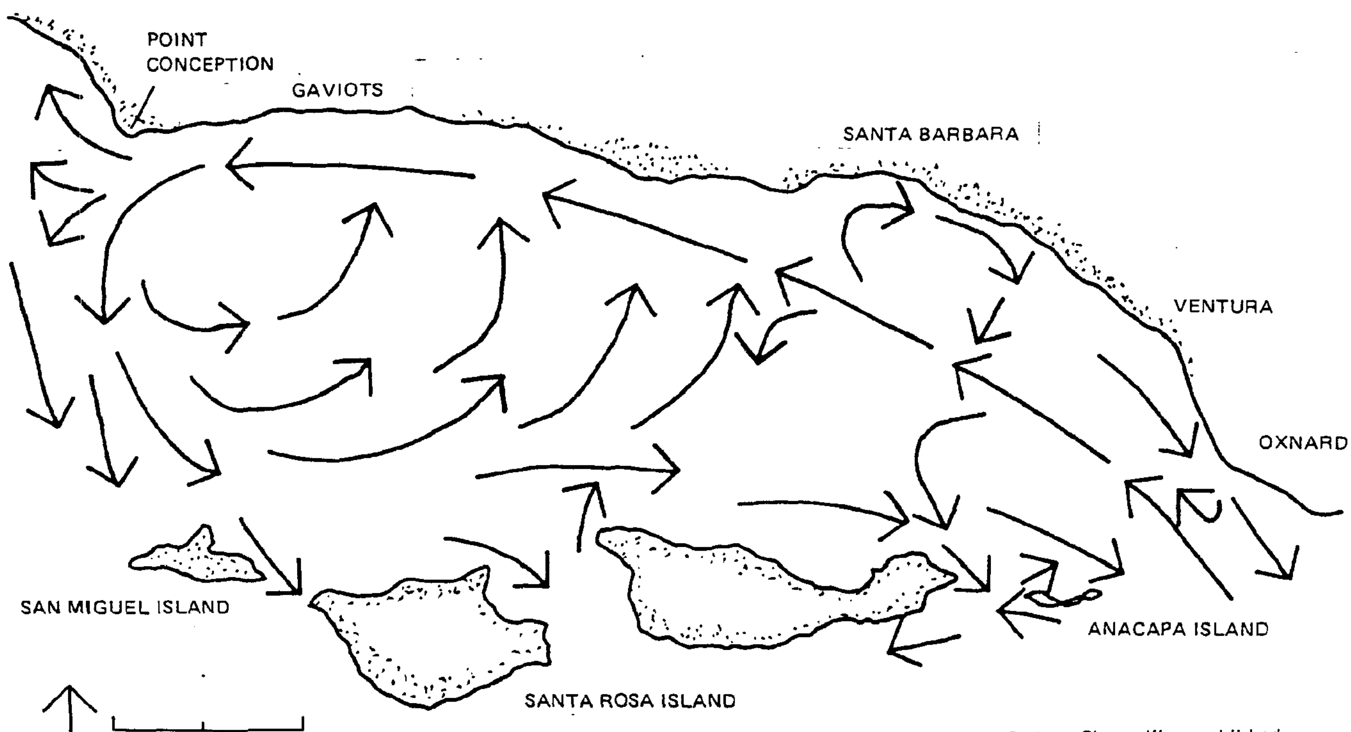


STREAMLINE CHART FOR JANUARY, 0000-0700 PST



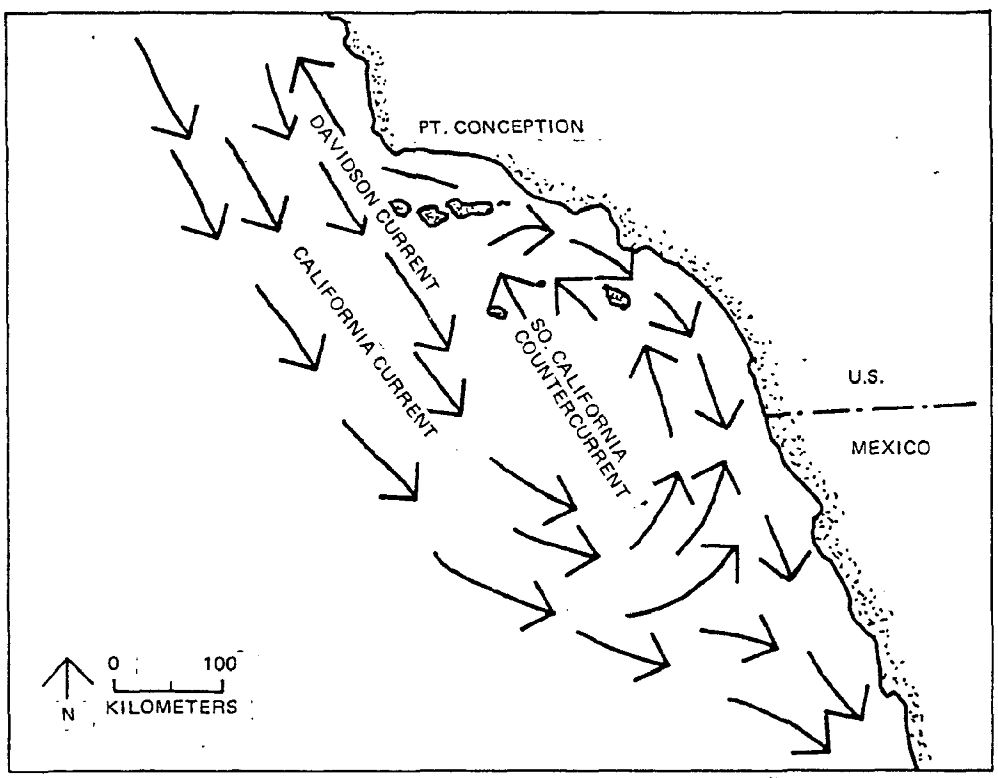
STREAMLINE CHART FOR JANUARY, 1200-1700 PST

Figure 4. Daily Onshore Breeze-Offshore Breeze Cycle, Southern California Bight



Source: Ronald L. Kolpack, "Relationship of Migration of Natural Seep Material in Oceanography of Santa Barbara Channel", unpublished report, August, 1976.

Figure 5. Generalized Pattern of Surface Currents Off Southern California.



Source: United States Department of the Interior, Geological Survey. Final Environmental Statement – Oil and Gas Development in the Santa Barbara Channel Outer Continental Shelf of California, Figure 11 – 19, 1976.

Figure 6. Generalized Pattern of Surface Currents, Santa Barbara Channel

SECTION D-5

EXTRACTS FROM ENVIRONMENTAL IMPACT REPORT/ENVIRONMENTAL ASSESSMENT CHEVRON USA PROPOSED PIPELINE INSTALLATION, SANTA BARBARA CHANNEL PREPARED BY SANTA BARBARA COUNTY, CALIFORNIA COASTAL COMMISSION, U.S. GEOLOGICAL SURVEY, AND U.S. ARMY CORPS OF ENGINEERS; MAY 1979

Introduction

The oceanography of the Santa Barbara Channel is well understood and is extensively reported on in available literature. The surface current structure is complex and unsteady. The offshore islands protect this body of water from the main Pacific, resulting in most sea and swell heights falling below 5 feet. The waters are, in general, quiescent and friendly.

Currents and Circulation

According to current velocity maps published by the Naval Weather Service Command* (1971), the surface currents in the Santa Barbara Channel flow almost parallel to the shoreline in both upcoast and downcoast directions. In summer, surface current speeds range from 0.3 to 0.6 knots, while in winter, a range of 0.5 to 0.7 knots is attained for periods of more than 10 hours.

Current meter records taken by Woodward-Clyde Consultants (1976), over periods of several days, at a position approximately one mile offshore of Point Conception, have shown that nearshore coastal currents are generally dominated by tidal forces. These data indicated that maximum speeds over 1.0 knot were present during almost all tidal phases. At locations farther offshore to depths in excess of 100 feet, however, related studies have indicated no tidally-specific directional reversals, although flow parallel to the general shoreline was still maintained.

Currents moved westerly during November and July, and easterly during February. No monthly effects on current directions were discernable. Maximum speeds were about 0.75 knots with no significant attenuation with depth. Similarly, currents measured at four locations in Santa Barbara Channel by the Exxon Oil Company (USGS, 1973) have shown similar unidirectional flows occurring over unspecified time periods. At Point Conception, maximum surface speeds of 1.45 knots were recorded, and nea near Gaviota, current speeds as fast as 1.7 knots were observed. Offshore from the Naples-Elwood area, maximum surface current speeds of 0.9 knots were measured.

Using drift cards deployed at several locations and recovered at the shoreline, Kolpack (1971) deduced that the surface water circulation patterns in the Santa Barbara Channel consisted essentially of a counterclockwise cell in the western half of the channel and northwesterly flowing current in the eastern part of the channel. The western cell was driven by a current entering the channel from the northwest. Convergence of these currents results in a complex pattern of eddies in the area between Santa Barbara and Santa Cruz Island. Other eddies along the eastern margin of the channel are produced by deflections resulting from current impingement near Santa Barbara and Ventura.

Tides

Channel tides are classified as mixed diurnal and semidiurnal. With semidiurnal tides, water level attains two daily highs and two daily lows; however, in a mixed mode, one of the two daily high water levels is significantly higher than the other (higher high water, HHW) and one of the two daily low water levels is significantly lower than the other (lower low water, LLW). At Santa Barbara, the mean tide range is 3.7 feet, with a mean diurnal range (from mean HHW to mean LLW) of 5.3 feet (NOS, 1974).

Extreme tides occur twice annually, in June or July and in December or January. Termed the solstice tides because of their occurrences near the summer and winter solstices,

*For reference, see the original document.

these extreme tides (approximately −1.5 feet LLW and +7.0 feet HHW at Santa Barbara) are caused by the increased effect of the sun on the diurnal tide as the sun's declination reaches its two annual maxima. At the Santa Barbara Channel, the summer solstice tides reach LLW levels in the pre-dawn hours and HHW levels in early evening, while the winter solstice tides reach their lowest levels in mid-afternoon and their highest levels after dawn.

Waves

The wave protection afforded the Channel by the surrounding terrain is evident in the results of wave measurements and hindcasts. A wave study conducted by National Marine Consultants (1960), as described in a report by the State Lands Commission (1974), reported the results of three consecutive years of wave data hindcast from available wind data for a point near mid-channel. The predominant sea and swell energy occurred from a westerly direction approximately 85 percent of the time. Highest significant wave heights were approximately 19 feet with periods of 12 to 14 seconds. Most sea and swell heights fell below 5 feet. Westerly swell height was less than 5 feet for 78 percent of the time.

The Naval Weather Service Command (1971) has summarized surface wave data in the Santa Barbara Channel for the period 1949-1970. Waves in the central and eastern portion of the channel are generally smaller. The highest frequency of occurrence (15 percent) of large (9-foot) waves occurs in March, and waves are smallest (95 percent of all waves are under 6 feet high) in July and August.

In another study, Marine Advisers, Inc. (1964) reported that the largest significant wave height of 18 feet occurred on two occasions in the channel, each time from a direction of 235°-245°T (January 26-28, 1916; and February 14-17, 1959).

Temperature and Salinity

According to the Naval Weather Service Command (1976), the overall, mean water surface temperature in the Santa Barbara Channel ranges from a low of about 13°C in the January-April timeframe to a high of about 18°C in August or September. On a smaller scale, Kolpack (1971) has documented the wider variation within the channel. For example, in August 1969, a variation from 13°C to 19°C over a span of 10 miles was reported.

During the summer months, a thermocline usually forms at a depth of about 20-40 feet in Santa Barbara Channel. At this level, water temperatures can drop as much as 5°C within several feet of increased depth. In the winter, the thermocline disappears (Allan Hancock Foundation, 1965). Bottom temperatures range from 10°C to 13°C.

Kolpack (1971) has also reported the results of measuring temperature and salinity in Santa Barbara Channel during May, August, and December, 1969, cruises. Surface salinities varied from 33.6 parts per thousand to 33.8 parts per thousand, while the annual surface temperatures varied over a 5°C range, from 14°C to 19°C. Minimum surface salinity values occurred in December, and maximum values in May.

APPENDIX E

STATISTICAL CASUALTIY DATA BASE FOR THE SANTA BARBARA CHANNEL RISK MANAGEMENT PROGRAM

E.1 INTRODUCTION

Casualty data for the Santa Barbara Channel is relatively sparse and does not provide an adequate statistical data base for risk analysis. Not only have there been few reported casualties but also the dynamic state of the channel in terms of oil and gas development with attendant structures renders extrapolations from current data of little value. Although from 15 to 20 vessels will pass through the channel per day during the next 20-year time period, the number of drill ships and production platforms is a source of uncertainty until drilling is carried out under lease sales No. 48 and No. 53. The likely presence of an LNG import terminal at Pt. Conception and its future growth also adds to the uncertainties for future ship-to-ship and ship-to-platform encounters.

The lack of a valid statistical base has led recently (1)* to a probabilistic approach to marine traffic hazard analysis for the Santa Barbara Channel. It is noted, however, that the Ports and Waterways act of 1978 which generated the current vessel access route study is deterministic in regard to vessel accidents. Therefore, a probabilistic risk assessment which leads to a low value of risk will still be unacceptable if the possible accident leads to a high consequence oil spill.

E.2 TYPES OF CASUALTY DATA

The year 1979 was the worst year in history for oil tankers in terms of worldwide accidents. In 1979, more than 776,000 tons of oil were spilled — about 100,000 tons more than in the last three accident-plagued years combined. The year 1980 shows no signs of the lessening in the rate of accidents. The recent Tampa Bay and Galveston channel accidents are good examples. Besides ship-ship and ship-fixed object collisions, there is a significant rise in tankers breaking up under storm induced stresses. In great measure this is a function of ship design and age. As tankers grow older, the incidence of stress crack failures goes up. Besides the standard casualty data, there is incipient casualty data. This is a more sophisticated approach to the determination of future casualties. After the famous SEA WITCH-ESSO BRUSSELS accident in New York Harbor, the Coast Guard began to consider changing the casualty reporting requirements. In 1978, the Coast Guard (2) proposed changing the casualty reporting requirements from a minimum dollar value of damage to a more realistic set of criteria. In addition to dollar value of damage, loss of steering, any occurrence affecting the seaworthiness or efficiency of the vessel, failures of transfer equipment, etc., are now reportable.

Computer On-Line Vessel Data Network

Ship operation safety would be enhanced if local authorities including the Coast Guard had up-to-date information regarding vessels which come to local ports or transverse the confluence region. Within the past few years, a computerized data base for all commercial ships of the world over 1,000 gross tons (MARDATA, Reference 3) has been developed. This data bank, furnished by Lloyds Register of Shipping, contains among other data tanker casualty information. By means of an international time-sharing computer network system, data can be retrieved concerning any ship traversing the Sana Barbara Channel almost instantaneously through the use of a desk-top computer teletype. Currently, the Coast Guard Inspection Division is using this system in conjunction with their own Maritime Safety Information System. The user of this library is able to determine within seconds whether a particular vessel has a higher than normal accident risk and is a potential pollution source. Table E-1 shows a tanker casualty report example. This system is expected to come into widespread use in the next few years.

*References for Appendix E will be found on page E-38.

TABLE E-1. TANKER CASUALTY REPORT EXAMPLE

Yannis M		DWT: 75400, Bulk/Oil (B/O) Flag: GRE Class: LR Motor Ship OWN: Mentor Shipping Co. S.A. (616109), Del. Date: 0168, Ship No. 16805440, Bldr No. 47042, A/B Gotaverken GOT
0369	Standing in Port	Stranded 4 hrs. Ent. Gothenburg loaded crude leakage in ER, Tanks tight, EFFECT: Lightered cargo
0576	Fire and/or Explosion Boilers	Boiler Expl. arriving Beaumont; Loading grain deferred for survey EFFECT: 2 person(s) severely injured
0676	Fire and/or Explosion Boilers	Second Boiler Explosion followed by Engine Room Fire at Beaumont, Texas: Cables and electronic control gear for boilers partially destroyed, Bunker Tank Bulkhead plating heavily distorted. EFFECT: 1 person dead or missing, 1 person severely injured, remained in port for repairs
0876	Fire and/or Explosion Boilers	Had third boiler explosion sailing Mobile: Delayed 16 days repairing Mobile EFFECT: 1 person severely injured, remained in port for repairs
0977	Hit Bottom, Grounded	At Kobe owner requested survey of grounding damage; No date, place or details provided
0178	Weather Damage at Sea	Survey requested at Durban for heavy weather damages: No details given

E.2.1 WORLDWIDE CASUALTY DATA

Casualty data for commercial vessels are compiled on an annual basis by a number of organizations. Primary sources are the Coast Guard and Lloyds Register in London. The Coast Guard compiles statistics about marine accidents that primarily involve the U.S. commercial fleet or have occurred in U.S. waters. For other data, the Coast Guard relies on Lloyds list. In 1978, the Inter-Governmental Marine Consultative Organization (IMCO) in London published a report (4) on serious casualties to ocean-going tankers for the ten-year period 1968 to 1978. This latest published report covers the longest time period and provides the most thorough treatment of serious casualties on a worldwide basis. Table E-2 shows these data for all tankers above 10,000 DWT. Note that a high percentage of tanker accidents occur at sea while in a loaded condition. Figure E-1 shows the distribution of tankship involvement in various failure modes for the years 1968 to 1977. It can be seen that ship breakdown is just as important a factor as collisions and groundings. Table E-3 taken from the Coast Guard tanker casualty file shows non-impact casualties as a function of age. Table E-4 is a normalized version of the data in Table E-3. Figure E-2 shows the plotted data based upon a 20-year and 26-year regression analysis. It is obvious that a strong positive relationship exists between age and breakdowns which could lead to accidents.

At this time, data for years after 1973 are not available on a tabulated basis, but the rate of such failures has continued unabated. Table E-5 displays major tanker casualty oil spills due to collision or grounding over an 11-year period, while Tables E-6 and E-7 carry the data one step further by tabulating the costs associated with major accidents (5). In recent years, a number of accidents have occurred on tankers while unloading. These include the SANSENINA I and the CHEVRON HAWAII. It is important that while these two tankers did not have inerting systems, explosions have occurred on ships so equipped. In these cases, the inert gas systems were not operational or were made ineffective by external events. Table E-8 presents a list of vessels which have been reported to have experienced cargo tank explosions. For example, in the case of the AEGEAN CAPTAIN, a collision introduced air into the tanks. The mere presence of an inerting system is no guarantee that an explosion will not occur under certain circumstances.

TABLE E-2. EXPLOSION/FIRE TANKER INCIDENTS WORLD WIDE DATA 1968-1977 – IMCO

Location	Number	Number per Year	Percent of Total
Worldwide	201	20.1	100
Harbor	(26)	(2.6)	13
Dock	(64)	(6.4)	32
At Sea	(111)	(11.1)	55
Cargo Tank	99	9.9	49
Other	102	10.2	51
CARGO TANK CONDITION			
Loaded	[9]	[0.9]	9
Discharging	[8]	[0.8]	8
Ballast	[26]	[2.6]	26
Other (washing, etc.)	[56]	[5.6]	57

Note: Above data does not include fire/explosion resulting from collision.

TANKER COLLISIONS WORLDWIDE DATA 1968-1977 – IMCO

Location	Number	Number per Year	Percent of Total
Worldwide	134	13.4	100
Harbor	(50)	(5.0)	37
At Sea	(84)	(8.4)	63
CARGO TANK CONDITION			
Loaded	[98]	[9.8]	73
Ballast	[36]	[3.6]	27
Result in Fire	34	3.4	25

( ) Estimated numbers – applies relative frequency of occurrence from Card, Ponce & Snider, 1969-1973 data to 1968-1977 IMCO data.

[ ] Estimated numbers – applies relative frequency of occurrence from Keith & Porricelli, 1969-1970 to 1968-1977 IMCO data.

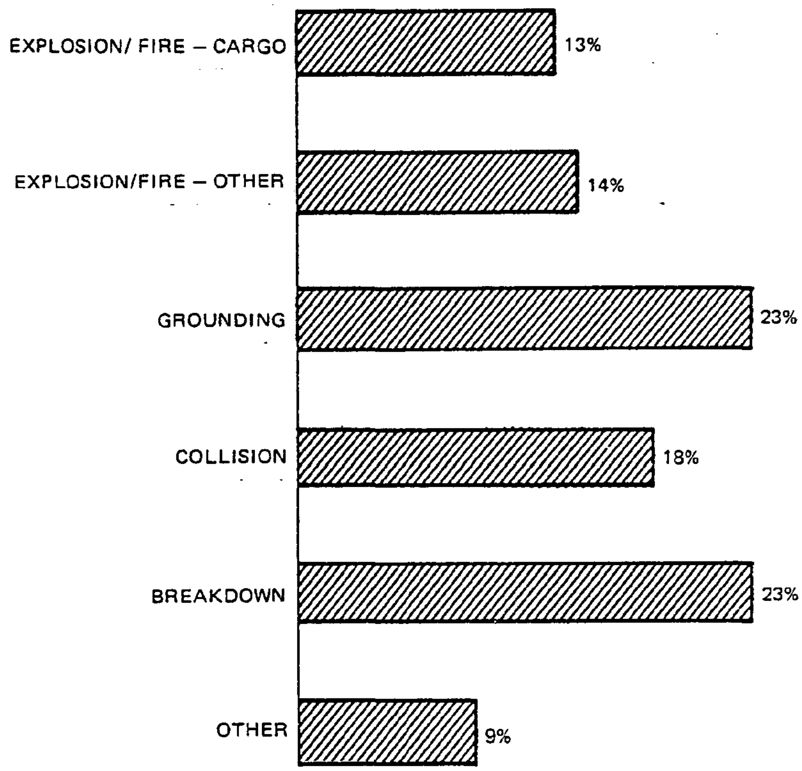


Figure E-1. Distribution of Tankship Involvement, 1963-1977, Tankships over 10,000 Deadweight Tons

E.2.2 U.S. WATERS CASUALTY DATA

A series of tank vessel casualties in U.S. waters during the winter of 1976 to 1977 highlighted the need for improvements in marine safety. As a result of these casualties, the Coast Guard initiated a risk management program. Another result was the passage of the Ports and Waterways Act of 1978 which mandated the installation of a number of safety systems on all tankers, U.S. or foreign, that call at U.S. ports. These systems are to be installed over a period of years. In addition to mandating a number of safety systems, the Act directed that the Coast Guard carry out two studies relevant to marine safety. These are: (1) a vessel access route study for each Coast Guard district and (2) a study of positive vessel traffic monitoring systems. The vessel access route study is underway in the 11th Coast Guard District (Long Beach, California) and should be completed by November 1980. The vessel traffic monitoring system study is being carried out by the Transportation Systems Center, Department of Transportation, Cambridge, Massachusetts and will be completed by October 1980 as required by the Ports and Waterways Act.

E.2.2.1 Transportation Systems Center Casualty Data. In order to develop effective positive vessel traffic monitoring systems, it is essential to understand the factors contributing to tank vessel pollution incidents. A detailed casualty analysis (vessels over 1,000 gross tons) was carried out by the center using the following casualty data sources: (1) Coast Guard merchant vessel casualty reports, (2) Lloyds weekly casualty reports, and (3) MARDATA computerized casualty files. The output of the causative analysis was used to derive preliminary requirements for a vessel traffic management system. Estimates of future casualty trends were based on future traffic projections and past traffic and casualty patterns. Of the 20,047 incidents in the total casualty file for 1972 through 1977, approximately 11 percent involved tank vessels greater than 1,000 tons in U.S. waters. These data are shown in Table E-9.

TABLE E-3. AVERAGE ANNUAL NON-IMPACT TANKER CASUALTIES AND POPULATION, 1969-1973

Age	Structural Failure (STF)	Breakdown (BKD)	Explosion	Fire	Capsizing	STF & BKD	Total	Population
0	1.8	1.4	0.8	1.4	0.0	3.2	5.4	232.0
1	5.0	3.0	1.2	2.4	0.0	8.0	11.6	251.6
2	3.0	2.2	1.2	2.6	0.0	5.2	9.0	218.6
3	4.4	1.8	1.0	1.6	0.0	6.2	8.8	222.4
4	4.2	2.2	1.6	2.2	0.0	6.4	10.2	200.4
5	4.2	2.2	1.2	1.6	0.2	6.4	9.4	192.8
6	3.8	1.2	0.2	1.8	0.2	5.0	7.2	191.0
7	3.6	2.8	1.4	1.6	0.0	6.4	9.4	176.4
8	3.6	2.6	1.0	1.4	0.0	6.2	8.6	187.2
9	4.0	2.0	0.8	2.4	0.2	6.0	9.4	172.2
10	3.4	2.2	0.4	1.6	0.0	5.6	7.6	193.0
11	4.4	5.4	0.2	1.4	0.0	9.8	11.4	199.8
12	8.4	3.4	1.4	2.0	0.0	11.8	15.2	211.2
13	5.6	4.4	1.4	2.0	0.0	10.0	13.4	210.4
14	4.8	5.4	0.8	2.2	0.0	10.2	13.2	197.6
15	6.6	5.4	0.6	3.4	0.2	12.0	16.2	191.0
16	7.4	5.6	1.2	3.0	0.0	13.0	17.2	182.4
17	6.0	3.0	0.8	2.4	0.0	9.0	12.2	157.6
18	5.2	4.8	0.8	1.0	0.0	10.0	11.8	144.0
19	3.6	3.0	0.4	1.8	0.0	6.6	8.8	115.0
20	4.0	2.0	0.6	0.6	0.0	6.0	7.2	87.6
21	2.0	0.8	0.0	0.4	0.0	2.8	3.2	66.0
22	1.4	1.2	0.6	0.0	0.0	2.6	3.2	44.0
23	0.6	0.2	0.2	0.0	0.0	0.8	1.0	38.6
24	1.0	0.8	0.2	0.4	0.0	1.8	2.4	24.8
25	0.4	1.4	0.2	0.2	0.0	1.8	2.2	54.2
26	0.2	1.2	0.0	0.2	0.0	1.4	1.6	39.2
27+	0.6	0.4	N/A	N/A	N/A	1.0	N/A	233.6

TABLE E-4. AVERAGE ANNUAL NORMALIZED NON-IMPACT TANKER CASUALTIES, 1969-1973

Age	Structural Failure STF	Breakdown BKD	STF & BKD	Total Non-Impact
0	0.008	0.006	0.014	0.023
1	0.020	0.012	0.032	0.046
2	0.014	0.010	0.024	0.041
3	0.020	0.008	0.028	0.040
4	0.021	0.011	0.032	0.051
5	0.022	0.011	0.033	0.049
6	0.020	0.006	0.026	0.038
7	0.020	0.016	0.036	0.053
8	0.019	0.014	0.033	0.046
9	0.023	0.012	0.035	0.055
10	0.018	0.011	0.029	0.039
11	0.022	0.027	0.049	0.057
12	0.040	0.016	0.056	0.072
13	0.027	0.021	0.048	0.064
14	0.024	0.027	0.052	0.067
15	0.035	0.028	0.063	0.085
16	0.041	0.031	0.071	0.094
17	0.038	0.019	0.057	0.077
18	0.036	0.033	0.069	0.082
19	0.031	0.026	0.057	0.007
20	0.046	0.023	0.068	0.082
21	0.030	0.012	0.042	0.048
22	0.032	0.027	0.059	0.073
23	0.016	0.005	0.021	0.026
24	0.040	0.032	0.073	0.097
25	0.007	0.026	0.003	0.041
26	0.005	0.031	0.036	0.041
27+	0.003	0.002	0.004	–

NOTE: Normalized casualties equals actual number of casualties in an age group divided by the population in that group.

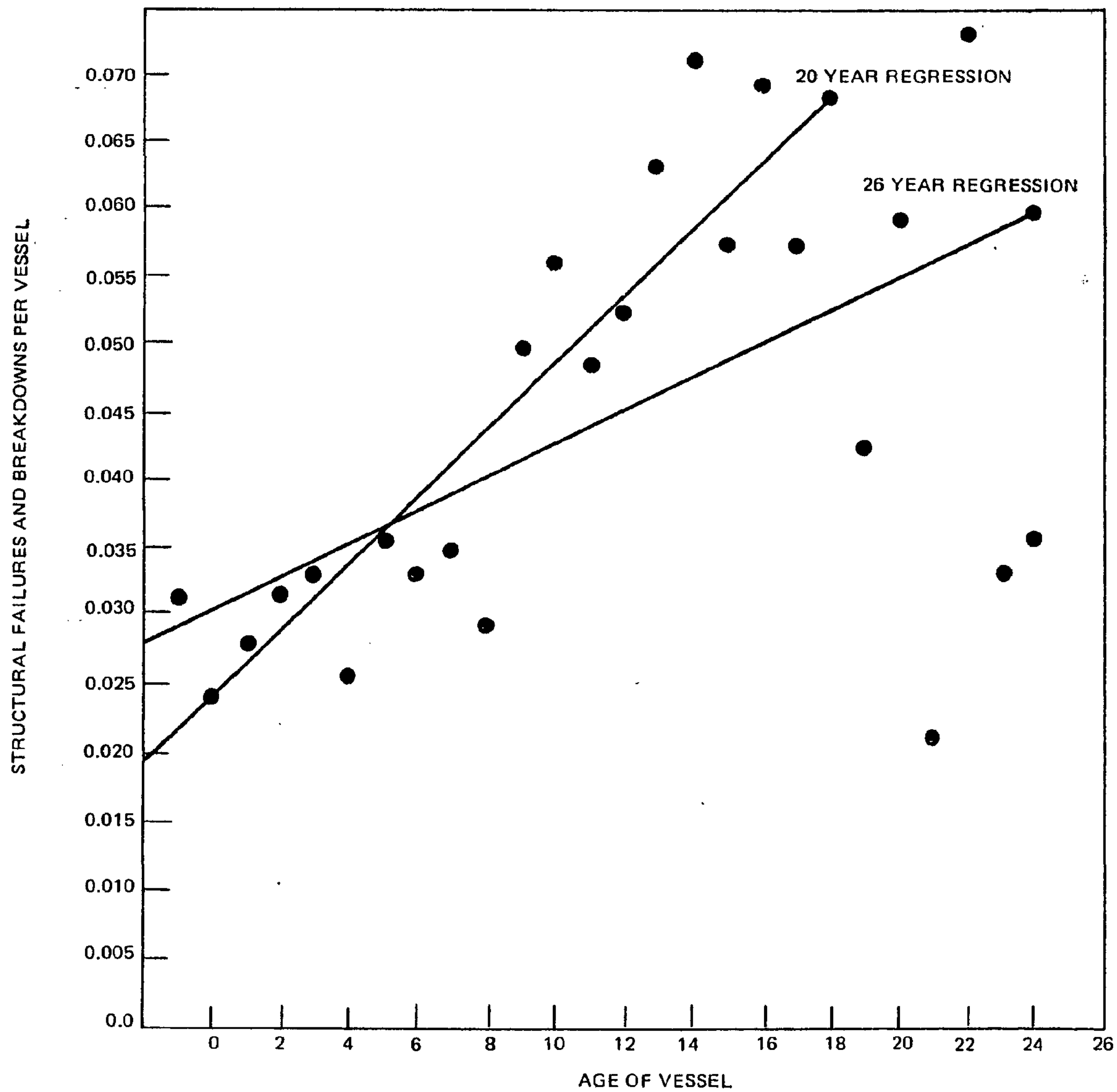


Figure E-2. Structural Failures and Breakdowns per Vessel vs. Age of Vessel, 1969-1973

TABLE E-5. MAJOR TANKER CASUALTY OIL SPILLS IN THE WORLD (1967-1978)

Year	Name of Vessel	Location	Type of Accident	Amount of Oil Spilled (in Long Tons)
1978	Amoco Cadiz	NW Coast of France	Grounding	220,000
1972	Sea Star	West Indian Ocean	Collision	120,300*
1967	Torrey Canyon	SW Coast of England	Grounding	109,500
1974	Metula	Straits of Magellan	Grounding	47,600
1974	Transhuron	SW Coast of India	Grounding	26,600
1976	Argo Merchant	SE Nantucket	Grounding	23,200

*Included in the Tanker Casualty File data base 1969-1973.

Table E-10 lists casualties by time of day and visibility. Figure E-3 is a graphic display for time-of-day casualty figures. As might be expected, the majority of casualties occur at night, but surprisingly, a major share of casualties occur with good or unlimited visibility. Statistical data must be subjected to causal analysis in order to determine the basic causal of casualties and to devise appropriate mitigation measures. Table E-11 identifies the primary causes for 55 groundings included in the TSC extended data base. Of the 55 groundings, 40 involve a navigation error. Ten involved conning errors. Table E-12 shows the primary causes for collisions involving 17 data base casualties. Of the 17 collisions, seven involve lack of agreement as to passing. In three other cases, collision occurred because of poor execution in passing. In four collision cases, vessels lost track of each other. It is interesting to note that in almost all cases, both vessels were aware of each others presence. Figure E-4 is a graphic display by encounter type. Tables E-13, E-14, and E-15 shows selected causative factors for rammings, collisions, and groundings. Note that for rammings, failure to maintain proper lookout accounted for 50 percent of the casualties.

It is important to emphasize that the number of casualties upon which the causal analysis is based is too small to allow any reliable statistical analysis. As has been done by the Transportation Systems Center, it is possible to perform an extensive analysis of the casualty data and derive percentages of casualties with certain combinations of characteristics and causal factors. However, there are problems with this approach because grouping casualties into causal categories ignores secondary factors that may be important in later analysis. This concern is clearly justified if some of the most recent casualties in 1978 and 1979 are considered. The casualties discussed are a matter of historical record. In order to estimate the effectiveness of various vessel traffic monitoring systems, TSC projected casualty scenarios for the 1980s. The objective was to estimate the number of potentially preventable casualties involving tank vessels and offshore platforms if no new VTM techniques were adopted and compare this number with the casualty projection if new VTM methods were adopted. Projections of tanker traffic in U.S. waters (MIT data) are shown in Table E-16. Projections of the number of offshore rigs/platforms that may exist in U.S. waters in the 1980 to 1990 time frame is highly speculative. The basis for the projections was:

1. The number of collisions is assumed to increase as the square of the vessel traffic in U.S. waters.

2. The number of rammings of offshore rigs/platforms is assumed to increase as the product of the number of vessels and the number of offshore platforms in U.S. waters.

Table E-17 shows the casualty projections if no new VTM techniques are adopted. These data are based on the assumption that the same pattern of causative factors which prevailed during the base data period (1972-1977) will continue to occur with the same percentage of tank vessel trips resulting in a casualty. However, as pointed out previously, the Ports and Waterways Act of 1979 mandated

TABLE E-6. COLLISIONS LEADING TO POLLUTION AND KNOWN COSTS INCURRED

Year	Ships Involved	Location	Estimated Spillage of Oil (Tonnes)	Costs Accounted for and Other Notes of Collision	Known Costs (Actual Prices) £000's	Known Costs (1977 Prices) £000's
1970	Efthycosta Esso Ipswich	Bristol Channel	510-800	Clean-up and dispersal costs	16.2-18.9	40.4-47.1
1970	Pacific Glory Allegra	Isle of Wight	5000-6000	Clean-up and dispersal costs (UK only) Collision followed by fire and explosion	200.0-393-5	498.2-980.1
1971	Texaco Caribbean Paracas Brandenburg	Dover Strait	600-610	Clean-up and dispersal costs (UK only) The first two ships collided and the third struck the subsequent wreck	47.4-58.0	108.0-132.0
1971	Hullgate Ida Hoyer	Off Beachy Head, Sussex	610	Clean-up and dispersal costs (UK only)	22.7	51.7
1971	Herulv Guarani	Dover Strait	250-260	Clean-up and dispersal costs (UK only)	17.8	40.5
1975	Olympis Alliance HMS Achilles	Dover Strait	2000-13000	Clean-up and dispersal costs (UK only)	65.0	87.8
1978	Eleni V Roseline	Off Norfolk	1000-2000	General estimate	2000.0	1869.8

TABLE E-7. GROUNDINGS LEADING TO POLLUTION AND KNOWN COSTS INCURRED

Year	Ships Involved	Location	Estimated Spillage of Oil (Tonnes)	Costs Accounted for and Other Notes of Collision	Known Costs (Actual Prices) £000's	Known Costs (1977 Prices) £000's
1967	Torrey Canyon	Scilly Isles	1000-120000	Clean-up and dispersion costs (UK only) Compensation paid to UK and France	7700.0	22500.0
1970	Arrow	Off Nova Scotia	16100-17021	General estimate	116.0	288.9
1970	Ocean Grandeur	Torres Strait, Queensland	1100	Clean-up and oil salvage costs	57.9	144.2
1973	Consco Britannia	Humber Estuary	410	Clean-up and dispersal costs	27.5	53.6
1976	Urquiola	Near La Coruna, Spain	30000-100000	General estimate. Much of the oil was burnt in a fire and explosion following the grounding	2000.0	2318.0
1976	Argo Merchant	Off Massachusetts	25000-16951	Loss of oil salvage equipment	119.0	138.0
1977	Adrian Maersk	Near Hong Kong	400-1000	Compensation paid to 138 fish farmers whose crops were destroyed	558.9	558.9
1978	Amoco Cadiz	Off Brittany	220000	General estimate. Grounding occurred due to steering failure	60000 - 400000	56094 - 373961.110

TABLE E-8. EXPLOSIONS ON VESSELS EQUIPPED WITH INERT GAS SYSTEMS

Vessels	mdwt	Built	Date	Location	Cause
Kriti Sun	121	1974	29/10/75	Singapore, spm	Lightning
Berge Istra	224	1972	30/12/75	South China Sea	Boiler Room most probable cause
Manhattan Duke	81	1976	1/8/77	Venezuela	Hit Dock
Sea Tiger	121	1974	19/4/79	Nederland, TX	Lightning IGS not used
Atlas Titan	209	1969	27/7/79	Portugal	Slop Transfer Air Pump in Tank
Aegean Captain	206	1968	20/7/79	Tobago	Collision
Ioannis Angelicousis	66	1964	16/8/79	Angola	Boiler Room most probable cause

certain safety equipment plus a study of VTM systems. If these are implemented, TSC estimates that groundings will be reduced by 25 percent, collisions by 7 percent, and rammings by 45 percent with an equipment availability of 95 percent. Based on these estimates, the casualty projections are significantly reduced as shown in Table E-18.

E.2.2.2 **Coast Guard Risk Management Program.** The Coast Guard initiated a risk management program in 1977 with the Planning Research Corporation, McLean, Virginia (7). The goal of this program was to have a computerized on-line system in operation by 1982. This project will not reach its goal, as it was terminated in 1979. However, one of the key interim objectives was reached in that a hazard and risk assessment for deep water approach/exits in the Gulf of Mexico was carried out. The LOOP port near New Orleans will begin operations in 1981, while the proposed SEADOCK port near Freeport, Texas looks very doubtful at this time. Figure E-5 shows the LOOP safety area and traffic separation scheme. This region has some analogy to the Santa Barbara Channel. Although there are about 100 times more fixed platforms in the Gulf of Mexico, probability of more significance is the platform population near traffic separation schemes and safety fairways. By this measure, the two regions are likely to be more equal.

In order to carry out a risk assessment for tankers approaching a deep water port, a casualty analysis was performed. The lack of casualty data for deep water ports required the use of surrogate regions for analysis. To apply the surrogate data, a number of assumptions were made:

1. Casualty inducing factors for deep water port transit will not differ significantly from that of current tanker operations in standard ports.

2. Voluntary rules such as use of traffic separation schemes and safety fairways will not necessarily be adhered to by deep water port tankers.

3. The distribution of spill sizes will tend to remain the same despite increases in the size of tankers.

4. The data base used (Coast Guard tanker casualty file) reflects the true oil spill frequency.

Note that the objective of the casualty analysis was in terms of oil spills. Casualty data for this study was obtained from three different data sources. These are: (1) Coast Guard vessel casualty reporting system—available since 1963, (2) Coast Guard pollution incident reporting system—available since 1971, and (3) data obtained from Lloyds Register.

Table E-19 shows the spills in U.S. offshore waters in terms of type of product spilled.

In an attempt to determine both causal and predictive reasons for vessel casualties, vessel spills, and volume spilled, regression analysis was used. Table E-20 shows

TABLE E-9. TANK VESSEL CASUALTIES IN U.S. WATERS – BY NATURE OF CASUALTY (FY 1972 - FY 1977)

	Number of Incidents[2]		
Nature of Casualty	Inland	International	Total
Groundings			
– With damage	248	13	261
– Without damage	431	30	461
Total	679	43	722
Collisions			
– Meeting/crossing/overtaking	97	22	119
– Anchored	107	12	119
– Docking/undocking[1]	41	1	42
– Fog	18	4	22
– Minor bumps, tug and vessel[1]	74	19	93
Total	337	58	395
Rammings			
– Offshore rigs	0	1	1
– Floating or submerged objects	54	10	64
– Ice	16	2	18
– Aids to navigation	60	5	65
– Fixed objects	371	6	377
Total Rammings	501	24	525
Explosions/Fires[1]	69	14	83
Founderings/Capsizings/Floodings[1]	22	10	32
Heavy Weather Damage[1]	6	42	48
Cargo Damage Only[1]	1	0	1
Material Failure			
– Vessel structure[1]	41	18	59
– Machinery/equipment[1]	152	112	264
Other[1]	47	4	51
Total	338	200	538
GRAND TOTAL	1855	325	2180
	-453[1]	-220[1]	-673[1]
	1402	105	1507

NOTES:

(1) Not controllable by Vessel Traffic Management techniques.

(2) Tank vessels > 1000 gross tons.

TABLE E-10. CASUALTIES BY TIME OF DAY AND VISIBILITY

		Visibility (Nautical Miles)					
Nature of Casualty	Time of Day	≤1 (Poor)	1-5 (Fair)	5-10 (Good)	> 10 (Unlimited)	Unknown	Total
Grounding	DAY	4	5	2	4	0	15
	TWI	0	0	2	0	0	2
	NGT	2	3	15	8	2	30
Collision	DAY	3	0	1	0	0	4
	TWI	0	0	0	0	0	0
	NGT	1	0	1	4	0	6
Ramming	DAY	0	0	0	2	0	2
	TWI	0	0	0	0	0	0
	NGT	0	1	3	0	0	4
TOTAL	DAY	7	5	3	6	0	21
	TWI	0	0	2	0	0	2
	NGT	3	4	19	12	2	40

TABLE E-11. CAUSES OF GROUNDINGS

	Primary Cause(s) of Grounding	Number of Groundings
1.	Didn't keep informed of position although navigation aids were available.	8
2.	Determined erroneous position/course although navigation aids were available.	1
3.	Erroneous position. Conning Officer not fully licensed. Didn't use available navigation aids.	1
4.	Didn't keep informed of position, then turned on wrong buoy. Navigation aids were available.	2
5.	Misjudged set, thus didn't know position. On watch over 8 hours. Navigation aids were available.	1
6.	Inaccurate position in poor visibility.	2
7.	Couldn't determine position due to aids to navigation failure. Didn't wait for pilot.	1
8.	Didn't keep informed of position. Gyro failed.	1
9.	Inaccurate position in poor visibility. Radar failed/unreliable.	2
10.	Radar failure.	3
11.	Radar unreliable due to weather conditions.	1
12.	Gyro or gyro repeater error.	2
13.	Misinterpreted lights seen.	1
14.	Water level below normal.	1
15.	Read chart sounds in fathoms instead of feet.	1
16.	Used buoys to navigate. Failed to enter buoy changes on charts.	2
17.	Lacked proper charts for area.	1
18.	Had less detailed chart than needed.	1
19.	Lacked proper charts. Didn't wait for pilot.	1
20.	Informed incorrectly by pilot that buoy was off-station. Used it to navigate.	1
21.	Didn't wait for pilot in safe area. Navigation aids were available.	4
22.	Didn't wait for pilot in safe area. Misjudged set. Navigation aids available.	1
23.	Misjudged set or drift in a maneuver.	6
24.	Bridge unattended, then wrong maneuver.	1
25.	Maneuvered too close to edge of wide passage. Navigation aids were available.	1
26.	Made turn too close to edge of wide passage and barge sheered. Navigation aids available.	1
27.	Uncharted shoal.	5
28.	Inaccurate position in aiding vessel.	1
29.	Anchored in unsafe area.	1

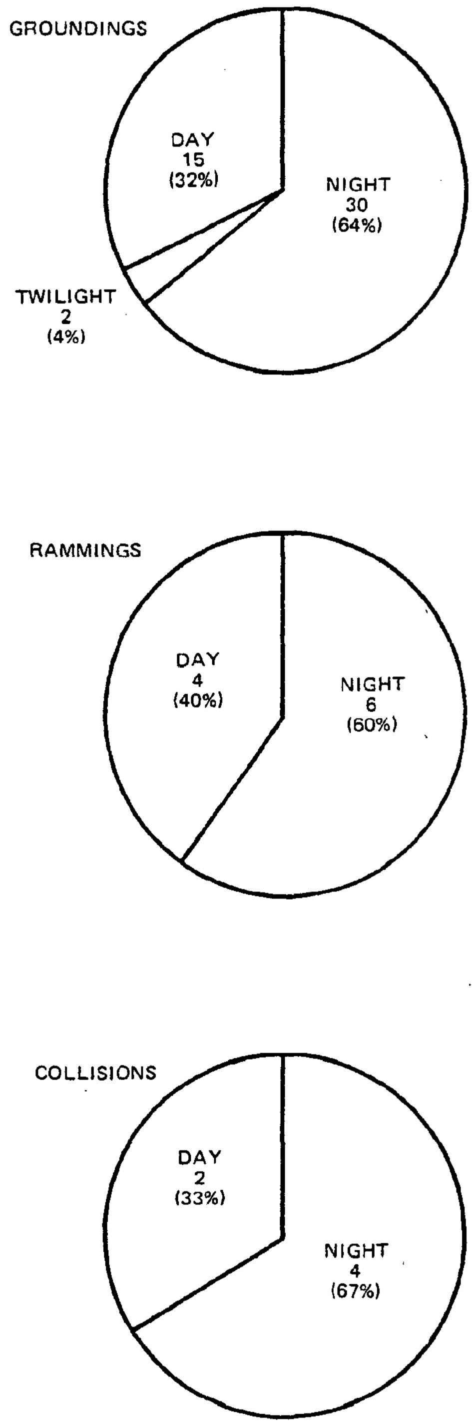


Figure E-3. Time of Day for Casualties

TABLE E-12. CAUSES OF COLLISIONS

	Collision Type	Primary Cause(s) of Collision	Number of Collisions
1.	Meeting	One passed left, one passed right. No communication.	5
2.	Meeting	One passed left, one passed right. Both attempted communication.	1
3.	Meeting	Early radar contact. No radio communication.	1
4.	Meeting	Agreed on passing, but didn't keep right.	1
5.	Crossing	No communication from tug. Tanker thought tug and tow were oil rigs.	1
6.	Crossing	Burdened vessel didn't keep clear.	2
7.	Overtaking	Communication too late. Didn't know where each other was.	1
8.	Overtaking	Failed to maintain proper lookout.	1
9.	Overtaking	Unaware of current while coming alongside.	1
10.	Overtaking	Rudder jammed, didn't signal. Other ship didn't have lookout.	1
11.	Hit Anchored Vessel	Radar failed. Both used fog signals and attempted radio communication.	1
12.	Hit Anchored Vessel	No lookout.	1

TABLE E-13. CAUSATIVE FACTORS FOR RAMMINGS

Causative Factor Involved	Number of Rammings	Percent of Total
Failure to maintain proper lookout.	3	50
Conning error – Poor maneuvering.	2	33
Navigation error – Poor navigation practice.	1	17

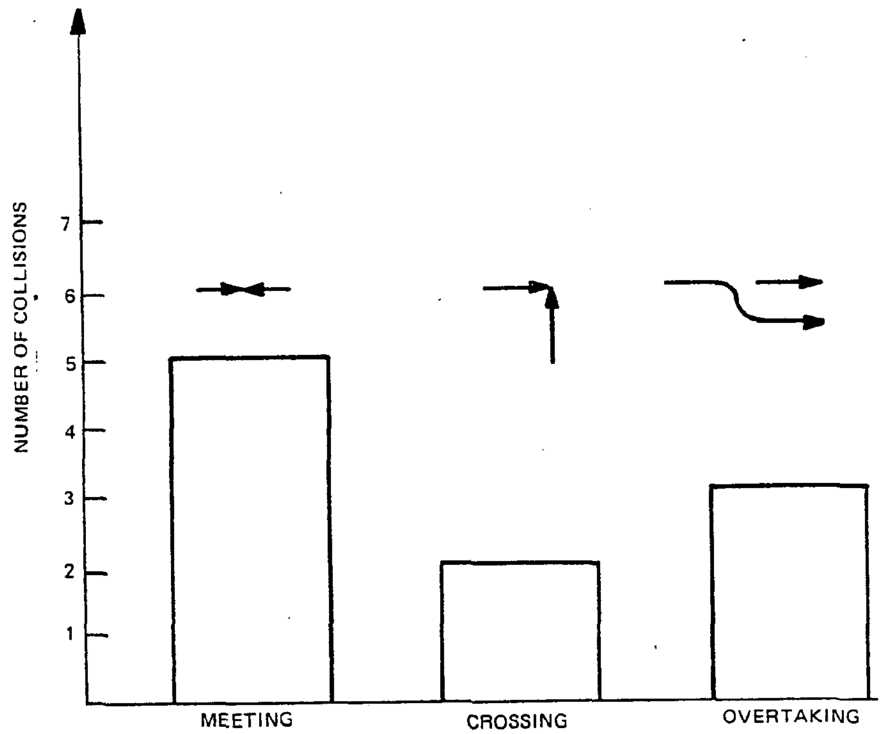


Figure E-4. Collisions by Encounter Types

TABLE E-14. SELECTED CAUSATIVE FACTORS FOR COLLISIONS

Causative Factor	Number of Collisions in Which Factor is Involved	Percent of Total Collisions in Which Factor is Involved
Lack of agreement as to passing.	7	41
Didn't know location of the other vessel.	4	24
Agreed upon or standard passing. Poorly performed.	3	18

NOTE: Some cases involve unique factors not listed above.

TABLE E-15. SELECTED CAUSATIVE FACTORS FOR GROUNDINGS

Causative Factor	Number of Groundings in Which Factor is Involved	Percent of Total Groundings in Which Factor is Involved
Navigation Error (e.g., erroneous position) — all causes	40	72 72
Navigation Error — poor navigation practice	21	38
Navigation Error — inoperable or malfunctioning equipment	9	16
Navigation Error — lack of charts	5	9
Conning Error (i.e., poor maneuvering) — all causes	10	18
Conning Error — misjudged set	6	11
Didn't wait for pilot or didn't wait in safe area	7	13

NOTE: Some cases involve more than one of these factors, and some cases involve unique factors not listed above.

TABLE E-16. TRAFFIC PROJECTIONS — NUMBER OF LOADED TANKER TRIPS PER YEAR

		Year													
Location	Flag	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
East	Foreign	4844	4985	5126	5267	5407	5548	6036	6524	7011	7199	7987	8425	8965	9150
Coast	U.S.	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Gulf	Foreign	2406	2457	2508	2558	2609	2660	2839	3018	3196	3545	3554	3533	3912	4098
Coast	U.S.	2428	2862	2796	2729	2663	2597	3329	4061	4792	5524	6256	6988	6220	8151
West	Foreign	500	473	447	420	394	367	544	720	897	1075	1250	1427	1603	1780
Coast	U.S.	0	147	294	442	589	736	968	1200	1433	1665	1897	2129	2361	2394
Alaska	U.S. (Crude)	0	147	294	442	589	736	827	919	1010	1102	1193	1284	1376	1167
Total		11678	12071	12465	12858	13251	13644	15543	17442	19339	21238	23137	25036	26955	28832

TABLE E-17. CASUALTY PROJECTIONS – CURRENT SYSTEM

	Base Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	10-Year Total
Number of Groundings	17.0	19.0	20.0	21.0	23.0	24.0	26.0	28.0	29.0	31.0	32.0	253.0
Number of Collisions	2.2	2.8	2.9	3.8	4.8	5.9	7.1	8.4	9.8	11.4	13.0	69.9
Number of Rammings	1.0	1.0	1.0	1.2	1.3	1.5	1.7	1.8	2.0	2.2	2.4	16.1

TABLE E-18. CASUALTY PROJECTIONS – BASELINE SYSTEM

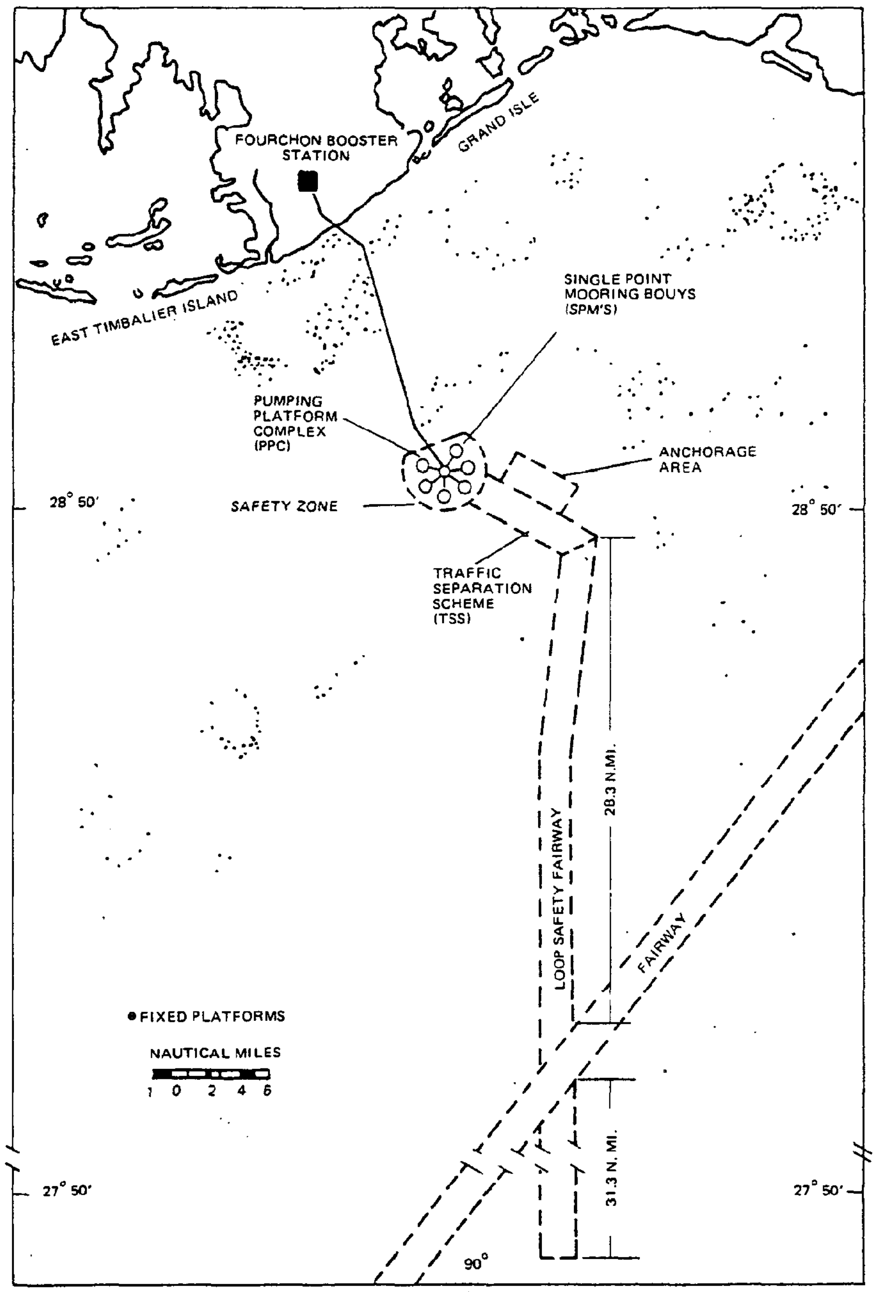
	Base Year	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	10-Year Total
Number of Groundings	17.0	16.0	16.0	17.0	18.0	18.0	20.0	21.0	22.0	24.0	24.0	196.0
Number of Collisions	2.2	2.7	2.7	3.6	4.5	5.5	6.6	7.8	9.1	10.6	12.0	65.1
Number of Rammings	1.0	0.7	0.6	0.7	0.8	0.9	1.0	1.0	1.1	1.3	1.4	9.5

TABLE E-19. SPILLS IN OFFSHORE WATERS OF THE U.S. (FY 1972 – FY 1977)

	Number of Incidents						
		Tank Vessel Cargo				Spills	
Nature of Casualty	Tank Vessel/ Offshore Rig Casualties	Light Oil/ Oil Products	Heavy Oil/ Oil Products	Other	None	Light Oil/ Oil Products	Heavy Oil/ Oil Products
Grounding	47	16	20	3	8	3	4
Collision	10	4	2	3	1	0	0
Ramming	6	0	1	3*	2*	0	1**

*Non-tank vessels

**Spill from tanker – no spills from offshore rigs



SOURCE: U. S. Coast Guard Final Environmental Impact/4(f) Statement. LOOP Deepwater Port License Application, Vol 1. Department of Transportation, 1976.

Figure E-5. Loop Safety Zone, Anchorage Area and Traffic Separation Scheme

TABLE E-20. TANKER CASUALTIES IN SEVEN MAJOR PORT SYSTEMS

	Port System						
Type Casualty	Chesapeake Bay	Delaware Bay	Gulf Coast	Los Angeles	New York	Puget Sound	San Francisco
Collision	7	15	27	5	30	2	5
Ramming	17	30	58	8	41	10	23
Grounding	18	51	80	3	80	3	16
Total Impact	42	96	165	16	151	15	44
Structural Failure	9	17	17	13	7	6	10
Explosion/Fire	4	6	3	1	3	5	3
Capsizing	0	0	1	0	1	0	0
Foundering	0	0	1	0	0	1	1
Flooding	0	0	1	0	0	1	1
Heavy Weather	1	0	0	0	0	1	0
Total Non-Impact	14	23	23	14	11	13	14
Other	2	4	10	0	0	0	1
Grand Total	58	123	198	30	162	28	59

NOTE: Includes only tankers greater than 5,000 Gross Tons.
Source: U.S. Coast Guard's Vessel Casualty Reporting System, 1969-1976.

tanker casualties in seven major port systems. Note that Los Angeles has the minimum number of collisions, groundings, and rammings. Figures E-6, E-7, and E-8 display these data as a function of port calls. Table E-21 compares Gulf of Mexico and the worldwide spill rate by casualty type. Statistical tests were carried out to determine whether there were any significant differences between Gulf and worldwide spill data. The analysis concluded that there was no significant difference as far as location and casualty types were concerned. Table E-22 shows oil spill data from the tanker casualty file as related to location and casualty type. Note the significant number of collisions in the coastal zone as compared to the open sea. This is hardly surprising.

In applying these data to the LOOP deep water port, it was obvious that there were no exact surrogates in the data base for the safety fairway, traffic separation scheme, and the safety zone (see Figure E-5). Oil drilling rigs are banned in the LOOP safety fairway. If the tankers stay within the lanes, rammings should not occur except possibly with floating debris. However, tankers are only advised, not required, to stay within the safety fairways. Experience with existing fairways in the Gulf indicates that tankers often ignore them to follow shorter routes. Therefore, both rammings and collisions were considered for the safety fairways. All types of collisions were considered in the traffic separation scheme segment. Casualty rates for the safety fairway and traffic separation zone were estimated

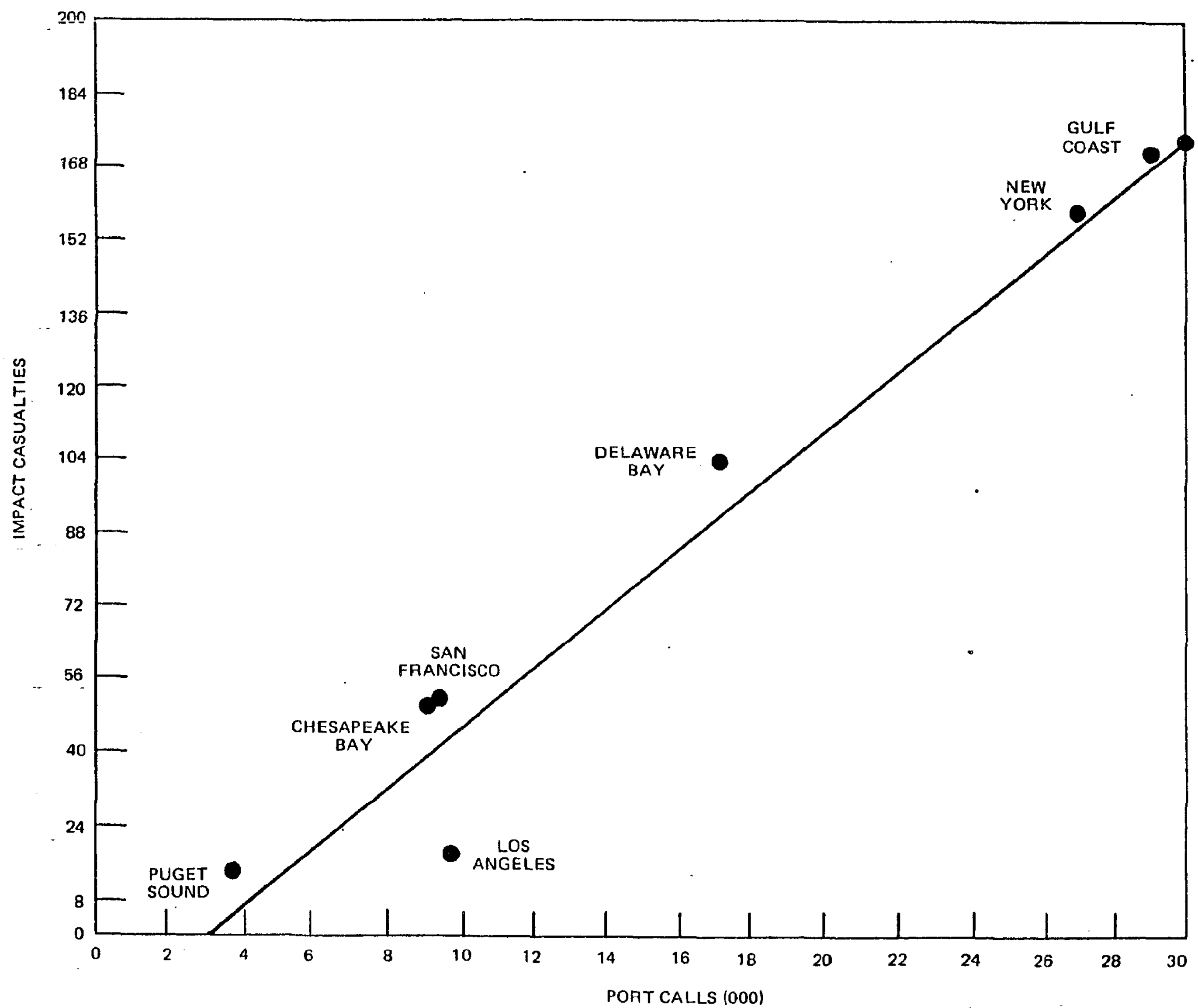


Figure E-6. Tanker (> 5,000 GT) Impact Casualties vs. Port Calls in 7 Major Port Systems 1969-1976

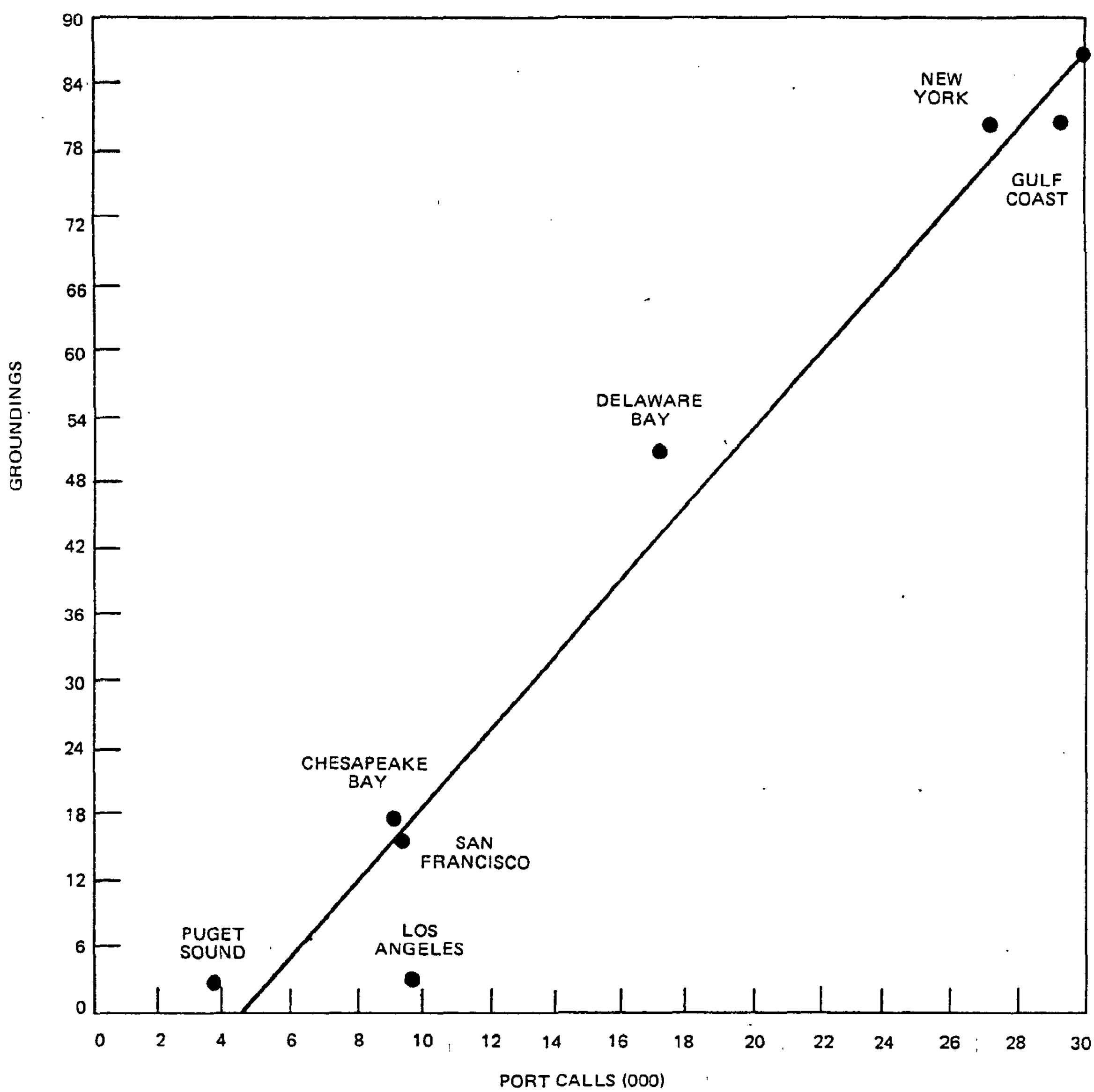


Figure E-7. Tanker (> 5,000 GT) Groundings vs. Port Calls in 7 Major Port Systems 1969-1976

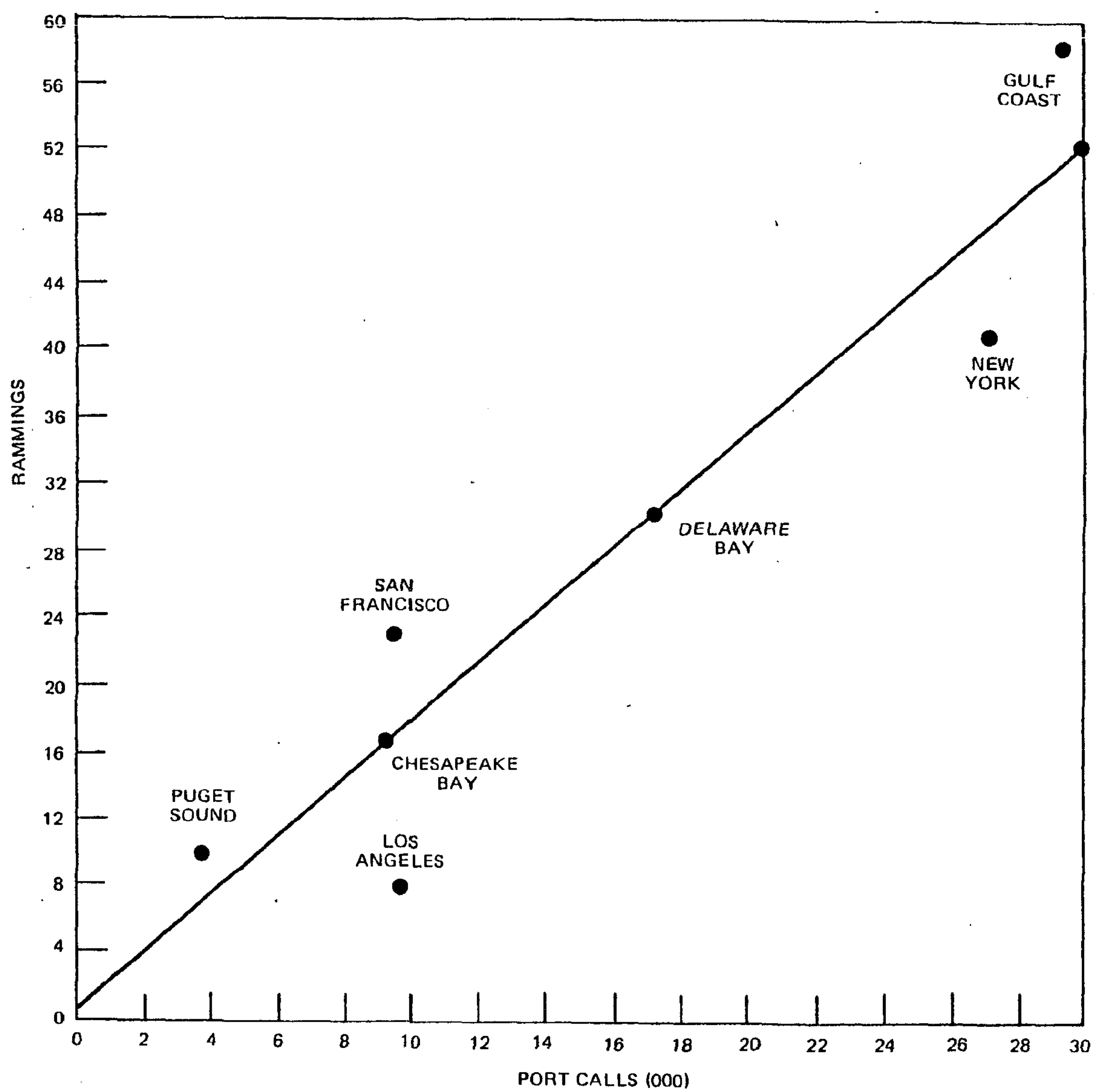


Figure E-8. Tanker (> 5,000 GT) Rammings vs. Port Calls in 7 Major Port Systems 1969-1976

TABLE E-21. COMPARISON OF GULF AND WORLDWIDE OIL SPILL RATE BY CASUALTY TYPE

Oil Spill Incidents	Area: Gulf & Caribbean	Area: World
Collisions	9	190
Rammings	2	90
Groundings	3	148
Breakdowns	2	12
Structural Failures	4	99
Fires	1	26
Explosions	2	41
Capsizing	0	12
TOTAL	23	578

TABLE E-22. OIL SPILL DATA FROM TANKER CASUALTY FILE

	Location Type						
Casualty Type	Coastal	Harbor Entrance	Harbor	Pier	Open Sea	Unknown	Total
Collision	28	13	19	3	5	2	70
Ramming	2	2	8	8	1	1	22
Grounding	27	17	15	1	0	1	61
Total Impact	57	32	42	12	6	4	153
Breakdown	1	1	1	0	0	1	4
Structural Failure	3	1	2	2	34	2	44
Fire	0	0	0	4	2	0	6
Explosion	4	0	0	1	7	0	12
Capsizing	1	0	0	1	1	0	3
Total Non-Impact	9	2	3	8	44	3	69
Total (Impact & Non-Impact)	66	34	45	20	50	7	222

NOTE: Spills are from tankers greater than 20,000 DWT during 1969-1973. One long ton spills and smaller excluded.

by equating these segments with harbor entrances—excluding groundings because of water depths in the LOOP region. Table E-23 summarizes the assignment of surrogates to the transit zones. Casualty frequencies were obtained from Table E-22. The expected number of spills for LOOP by transit zone, casualty type, and time period is shown in Table E-24. These data were obtained by combining historical spill rates with future port calls and tanker days for LOOP. Figure E-9 shows the cumulative probability of total oil spilled during a 30-year period. From all these data, it was estimated that there is a 6 percent probability of a spill at least as large as the Amoco Cadiz spill (220,000 long tons) during the 30-year period. A 25 percent probability of a spill as large as the Torrey Canyon spill (110,000 long tons) exists based on the data analysis. These data represent upper bounds based upon the assumptions in the study. Although 45 percent of the spills are expected to be less than 500 long tons, the likelihood of very large spills is significant.

Potential hazards to tankers transiting the Gulf of Mexico to and from the deep water port region were assessed by several methods. A paper transit was performed using the most likely routes within the Gulf and hazards identified along each segment of the routes. The hazards were then subjectively rated in order of potential danger. Figure E-10 shows the subjective hazards rating for the Straits of Florida. Additional information on hazards was obtained from observations during an actual tanker transit of the Gulf and a visit to the deep water port of Ras Tanura in Saudi Arabia. There is a traffic separation scheme leading to both Ras Tanura and a SPM facility at Juaymah. Continuous surface search radar surveillance is maintained at both Ras Tanura and Juaymah. Vessel traffic is not controlled—only advised. However, non-compliance leads to written complaints to the vessel owners. For the last 15 years there has been no serious accident or massive oil spill. Figure E-11 shows the comparative subjecitive hazard ratings for LOOP, SEADOCK, and Juaymah. Table E-25 lists the hazard rankings for various route segments based on casualty data (Coast Guard casualty file). To augment the data shown in Table E-25, 135 hazard citations gleaned from 148 casualties recorded in the casualty file from 1969 to 1977 were analyzed and the data is shown in Table E-26. Hazard ratings based on the casualty data and subjective ratings based upon actual and paper vessel transits were combined to obtain a composite hazard ranking shown in Table E-27. Note that offshore rigs present a significant hazard in the open Gulf and safety fairways. Table E-28 is a summary of ramming incidents in the Gulf of Mexico involving offshore structures for the 1963 to 1977 time period. Figure E-12 is a map of the Gulf showing location and cause of vessel casualties for the 1969 to 1977 time period.

The study concluded that human factors and heavy weather dominate the accident risk in the Gulf of Mexico. However, fixed offshore structures and floating debris are also significant.

TABLE E-23. SURROGATE TRANSIT ZONES

Transit Zone	TCF Location Type	Casualty Types Excluded	Number of Casualties	Percentage
Straits and Channels	Coastal		57	54
Gulf, Open Sea	Open Sea		6	6
Safety Fairway and Traffic Separation Scheme	Harbor Entrance	Groundings	15	14
Safety Zone	Harbor	Groundings	27	26
TOTAL			105	100
Unknown Location (prorated)			3	
TOTAL			108	

TABLE E-24. EXPECTED NUMBER OF SPILLS FOR LOOP BY TRANSIT ZONE, CASUALTY TYPE, AND TIME PERIOD

Period	Casualty Type	Straits & Channels	Gulf Open Sea	Fairway & TSS	Safety Zone	Total
1980-1984	Impact	0.535	0.055	0.136	0.254	0.98
	Non-Impact	0.007	0.079	0.012	0.032	0.13
	Total	0.052	0.134	0.148	0.286	1.21
1985-1989	Impact	0.720	0.074	0.183	0.341	1.32
	Non-Impact	0.010	0.109	0.016	0.045	0.18
	Total	0.730	0.183	0.199	0.386	1.50
1990-1994	Impact	0.860	0.088	0.219	0.408	1.58
	Non-Impact	0.013	0.133	0.021	0.054	0.22
	Total	0.873	0.221	0.240	0.462	1.80
1995-1999	Impact	0.985	0.101	0.251	0.467	1.80
	Non-Impact	0.015	0.151	0.023	0.062	0.25
	Total	1.000	0.252	0.274	0.529	2.05
2000-2004	Impact	1.060	0.109	0.270	0.503	1.94
	Non-Impact	0.016	0.163	0.025	0.067	0.27
	Total	1.076	0.272	0.295	0.570	2.21
2005-2009	Impact	1.060	0.109	0.270	0.503	1.94
	Non-Impact	0.016	0.163	0.025	0.067	0.27
	Total	1.076	0.272	0.295	0.570	2.21
1980-2009	Impact	5.218	0.535	1.328	2.475	9.56
	Non-Impact	0.076	0.791	0.120	0.324	1.31
	Total	5.294	1.326	1.448	2.779	10.87

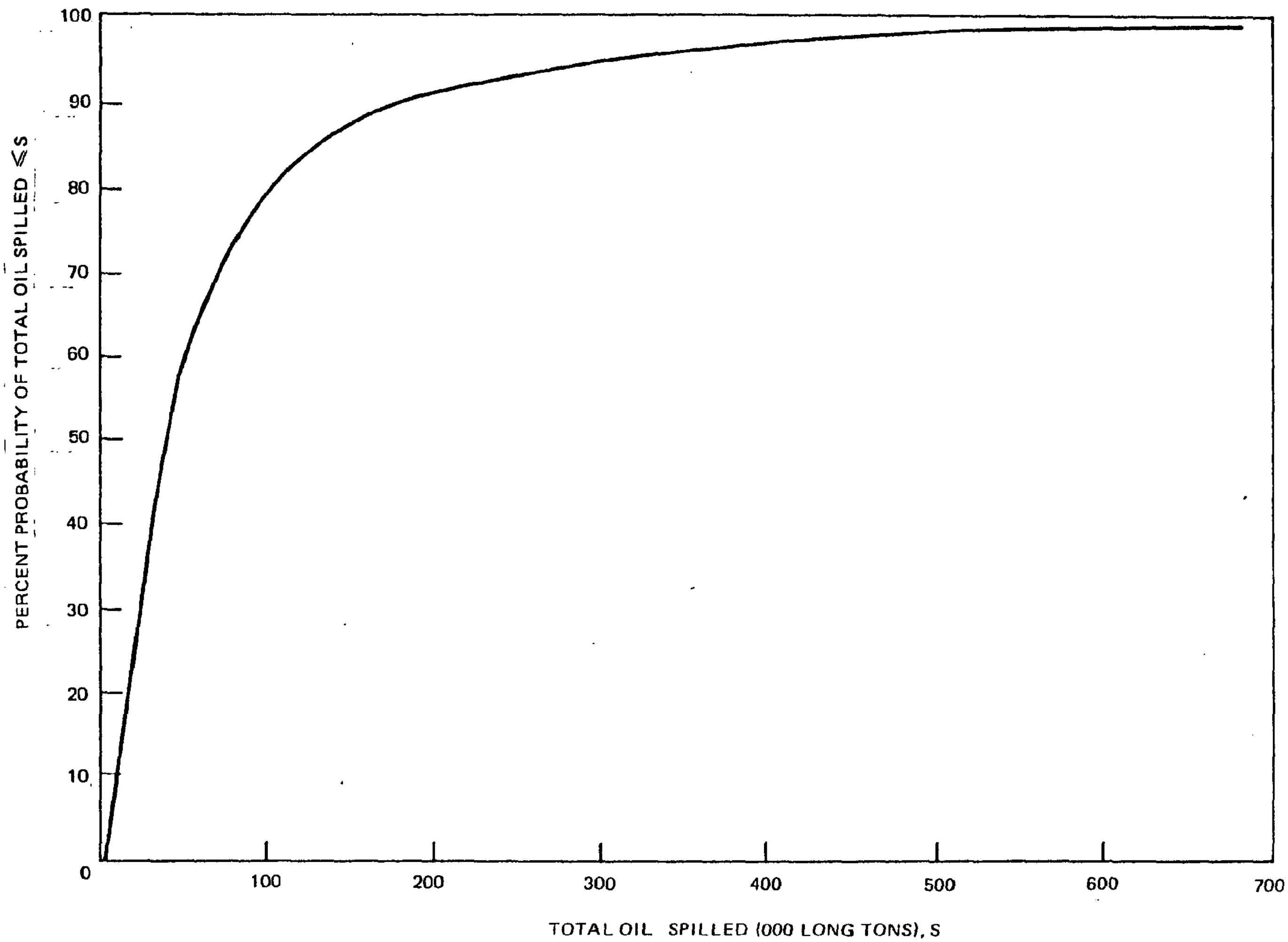


Figure E-9. LOOP: Cumulative Probability of Total Oil Spilled 1980-2009

EXTERNAL HAZARD	STRAITS OF FLORIDA					
	WESTBOUND			EASTBOUND		
	Fort Pierce/ Manilla Shoal Miami/Providence Channel Entrance	Miami/Providence Channel Entrance to Key West/ Nicholas Channel Entrance	Key West/Nicholas Channel Entrance to Dry Tortugas	Dry Tortugas to Key West/Nicholas Channel Entrance	Key West/Nicholas Channel Entrance to Miami/Providence Channel	Miami/Providence Channel Entrance to Ft. Pierce/ Mantilla Shoal
Structures, Vessels, etc.						
Floating debris or submerged objects	3	3	3	3	3	3
Fixed objects—piers,bridges	1	1	1	1	1	1
Offshore rigs	1	1	1	1	1	1
Single Point Moorings	1	1	1	1	1	1
Aids to navigation	2	1	1	1	1	2
Other vessels anchored or moored	3	3	2	1	1	1
Other vessels docking or undocking	1	1	1	1	1	1
Other vessels meeting	3	1	3	3	2	2
Other vessels crossing	5	2	2	5	2	5
Other vessels overtaking	1	1	1	1	1	1
Aids to Navigation						
Reliability	1	1	1	1	1	1
Adequacy	1	1	1	1	1	1
Environmental Weather						
Storms, heavy weather	5	5	5	5	5	5
Adverse weather	2	2	2	2	2	2
Low visibility	2	2	2	2	2	2
Restricted Maneuvering Room						
Channel	2	2	2	2	2	2
Congested area	5	2	5	5	2	5
Unusual Current						
Erratic	1	2	2	1	1	1
Strong current	3	3	2	1	1	1
Depth Less Than Charted						
Charts Erroneous	3	2	2	1	1	1
Area shoaled/silted	5	1	1	1	1	1
Position of hazard doubtful	5	2	2	1	1	3
Bottom and Bank Effect						
Sheer	1	1	1	1	1	1
Suction	1	1	1	1	1	1
Bank Cushion	1	1	1	1	1	1
	59	43	46	43	36	49

HAZARD RATING: Highly harzardous=5; Very hazardous=4; Hazardous=3; Not very hazardous=2; Not hazardous=1; and Unkown=0

Figure E-10. Subjective Hazard Ratings, Straits of Florida

EXTERNAL HAZARD	Gulf of Mexico Transit		Persian Gulf Transit	Safety Fairway (Including "Short Cuts")			Traffic Separation Scheme			DWP Safety Zone		
	Loop	Seadock	Juaymah	Loop	Seadock	Juaymah	Loop	Seadock	Juaymah	Loop	Seadock	Juaymah
Structures,vessels,etc.						None Exists						
Floating debris, or submerged objects	3	3	3	3	3	–	1	1	2	1	1	1
Fixed objects—piers, bridges	1	1	1	1	1	–	1	1	1	1	1	1
Offshore rigs	5	5	5	5	5	–	1	1	1	2	2	1
Single Point Moorings	1	1	1	1	1	–	1	1	1	2	2	2
Aids to navigation	1	1	1	1	1	–	2	2	2	1	1	1
Other vessels anchored or moored	1	1	1	1	1	–	1	1	1	3	3	2
Other vessels docking or undocking	1	1	1	1	1	–	1	1	1	3	3	3
Other vessels meeting	2	2	2	2	2	–	1	1	1	1	1	1
Other vessels crossing	2	2	2	2	2	–	2	2	2	2	2	2
Other vessels overtaking	1	1	1	2	2	–	1	1	1	1	1	1
Aids to Navigation												
Reliability	1	1	1	1	1	–	1	1	1	1	1	1
Adequacy	1	1	1	1	1	–	1	1	1	1	1	1
Environmental Weather												
Storms, heavy weather	5	5	1	5	5	–	5	5	1	5	5	1
Adverse weather	2	2	2	2	2	–	3	3	3	3	3	3
Low visibility	2	2	3	4	5	–	3	3	3	3	3	3
Restricted Maneuvering Room												
Channel	1	1	1	2	2	–	1	1	1	2	2	2
Congested area	1	1	3	2	2	–	1	1	1	2	2	2
Unusual Current												
Erratic	1	1	3	2	2	–	2	2	2	2	2	2
Strong current	1	1	3	1	1	–	2	2	2	2	2	2
Depth Less Than Charted												
Charts Erroneous	1	1	1	1	1	–	1	1	1	1	1	1
Area Shoaled/Silted	1	1	1	1	5	–	1	1	1	1	1	1
Position of Hazard Doubtful	1	1	1	3	3	–	1	1	1	1	1	1
Bottom and Bank Effect												
Sheer	1	1	1	1	1	–	1	1	1	1	1	1
Suction	1	1	1	1	1	–	1	1	1	1	1	1
Bank Cushion	1	1	1	1	1	–	1	1	1	1	1	1
	39	39	44	57	52		37	37	34	44	44	39

HAZARD RATING: Highly hazardous=5; Very hazardous=4; Hazardous=3; Not very hazardous=2; Not hazardous=1; and Unknown=0

Figure E-11. Comparative Subjective Hazard Ratings, LOOP, SEADOCK, and JUAYMAH

TABLE E-25. HAZARD RANKINGS BASED ON CASUALTY DATA

Coastal (Straits and Channels)		Open Gulf (Open Sea)		Fairway and TSS (Harbor Entrance)		Safety Zone (Harbor)	
Depth	5	Weather	5	Restricted Channel	3	Personnel Fault	5
Personnel Fault	4	Debris	2	Personnel Fault	2	Moored Vessels	5
Restricted Channel	3			Low Visibility	2	Congested Area	4
Traffic	3			Anchored Vessels	2	Currents	4
Debris	3			Vessels Docking/Undocking	2	Traffic	4
Weather	2			Congested Area	2	Weather	3
Nav aid-adequacy	2			Traffic	2	Restricted Channel	3
						Fixed Objects	3
						Visibility	2
						Nav aid-adequacy	2
						Debris	2
						Nav aid-raming	2

CODE: 5 = highly hazardous, 4 = very hazardous, 3 = hazardous, 2 = not very hazardous.

E.3 SANTA BARBARA CHANNEL – SOUTHERN CALIFORNIA BIGHT AREA

It was previously pointed out that the statistical data for the Southern California bight region was very sparse. In a presentation given at hearings at Santa Barbara, California in June 1978 (8), the claim was made that 116 ships have sunk in the Santa Barbara area since the early 1700s. Heavy weather was considered to be a major contributing factor. Recent verified losses have included the freighter Chicasau lost when it went aground on Santa Rosa Island in the fog in 1962. In 1968, the freighter Copper State collided head-on with the Navy tanker Cosatot. In 1969, a cruise ship was blown ashore from its anchorage off Port Hueneme and wrecked. In July 1976, a near miss (9) was observed in the northbound traffic lane between a Maersk line container ship and the cargo ship Kyrialoud D. Lemos. More recently, the sport fishing boat Chelan collided with the tanker Sansenina II in the shipping lanes two miles north of Santa Cruz Island is clear weather. Since drilling started in the Santa Barbara Channel, there have been no collisions reported between platforms and ships in Federal waters. The most recent report on casualties from the Mexican border to Point Arguello California has been prepared by the Marine Casualties branch of the Coast Guard in April 1980. These data covering the time period from fiscal 1970 through 1978 are shown in Table E-29.

E.3.1 PROBABILISTIC ASSESSMENTS

In the absence of adequate statistical data, probabilistic methods are often used to assess the risk of ship operations. Relative to the nuclear ship program, the Maritime Administration has sponsored a ship accident study program with George G. Sharp, Inc., of New York (10). Part of the program involved development of a method of calculating the probability of any accident along a specific route. This methodology has been developed jointly with the Babcock

TABLE E-26. VESSUAL CASUALTIES IN GULF OF MEXICO, 1969-1977

Hazard	Number of Hazard Citations							
	Collision	Ramming	Grounding	Explosion Fire	Structural Failure/Breakdown	Other	Total	Percentage
Floating debris/ submerged object		9			1		10	7
Fixed object		4					4	3
Offshore rig		4					4	3
Nav aid-ramming		4					4	3
Other vessel anchored or moored		1					1	1
Traffic		11					11	8
Not otherwise classified		1					1	1
Heavy or adverse weather	3	3		1	6	2	15	11
Low visibility	3	2					5	4
Restricted channel		5	12				17	13
Congested area		1				1	2	1
Currents			8				8	6
Area shoaled			6				6	4
Depth less than charted			7				7	5
Erroneous charts			1				1	1
Personnel fault	10	9	16	3	1		39	29
Total Citations	16	54	50	4	8	3	135	100

TABLE E-27. COMPOSITE HAZARD RANKING

Straits and Channels		Open Gulf		Safety Fairway		Traffic Separation Scheme		Safety Zone	
Personnel fault	4	Weather	5	Weather	3	Weather	3	Personnel fault	5
Weather	4	Offshore rigs	3	Offshore rigs	3	Low visibility	3	Weather	5
Vessel traffic	3	Debris	3	Low visibility	3	Personnel fault	2	Low visibility	3
Debris	3			Debris	3	Vessel traffic	2	Moored vessels	3
Depth	2			Personnel fault	2			Currents	2
Low visibility	2			Vessel traffic	2			Vessel traffic	2
Anchored vessels	2			Depth	2			Offshore rigs	2
Currents	2							SPMs	2
Restricted space	2								

Code: 5 = highly hazardous, 4 = very hazardous, 3 = hazardous, 2 = not very hazardous.

TABLE E-28. SUMMARY OF RAMMING INCIDENTS IN THE GULF OF MEXICO INVOLVING FIXED OFFSHORE STRUCTURES[1] (1963-1977)

	Vessel Size (gross tons)	
	Less than 500	Greater than 500
Total incidents	54	13
Incidents in Gulf of Mexico outside Zone 1 (Shallow Water)	36	10
Estimated range of damage to vessel ($1000)	< 1 - 130	< 1 - 10,000
Estimated range of damage to structure[2] ($1000)	<1 - 1000	5 - 10,000
Incidents resulting in death/serious injury[3]	1	1
Incidents resulting in total loss of vessel	2	1
Incidents resulting in total loss of structure	0	2
Incidents resulting in substantial damage to vessel ($100,000+)	3	3
Incidents resulting in substantial damage to structure ($100,000+)	4	8
Incidents involving vessels supplying or supporting the structure	23	0

(1) Unless otherwise noted, 'fixed structure' includes artificial islands, mobile drilling rigs, and work over rigs.
(2) Artificial islands only.
(3) Same incidents as those resulting in vessel loss.

SOURCE: U.S. Coast Guard

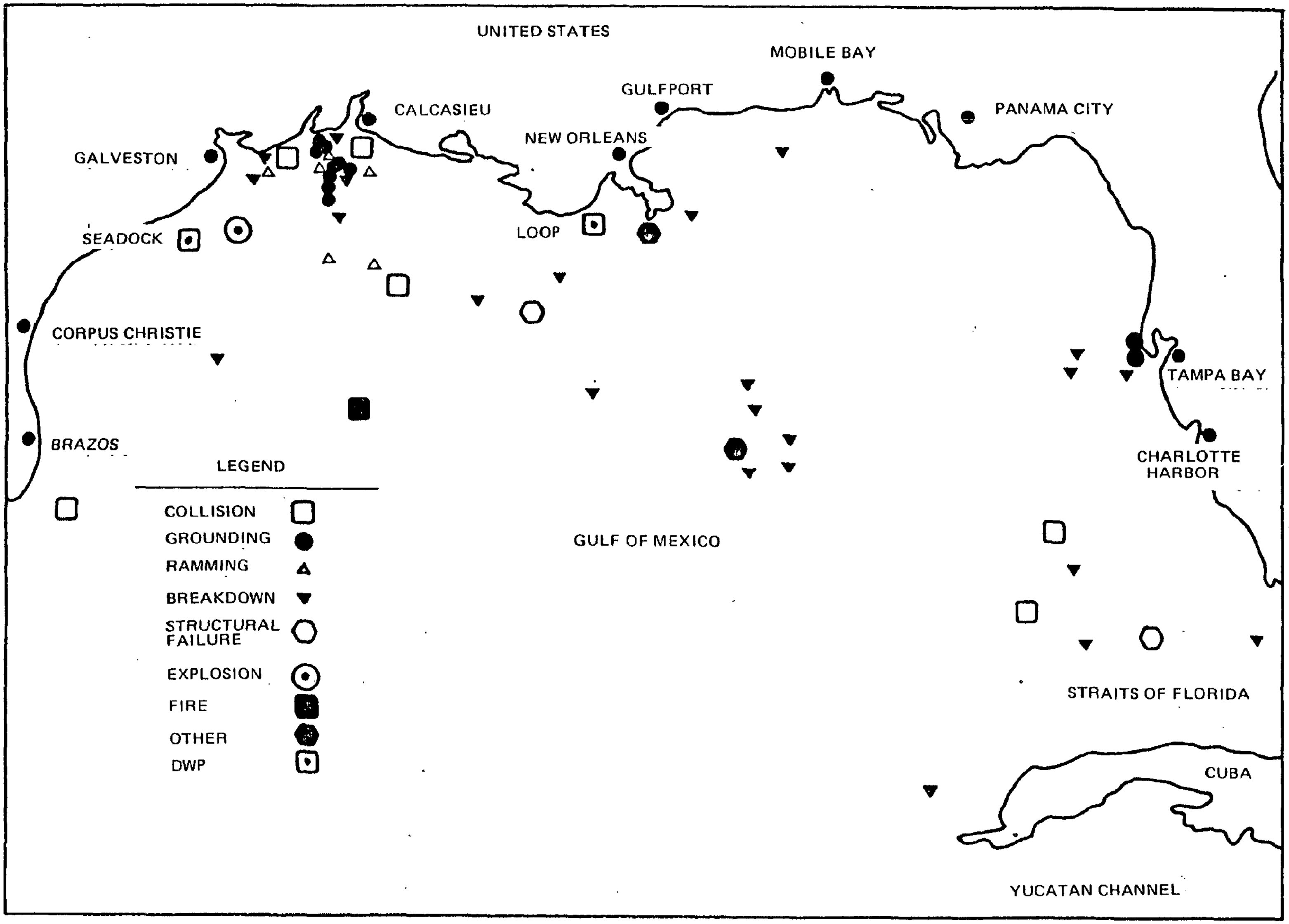


Figure E-12. Vessel Casualties — Cause and Location

TABLE E-29. SHIP COLLISIONS IN SOUTHERN CALIFORNIA BIGHT AREA

Dates	Collision Description	Location
[a] Between 1967-76	2 Collisions between ships	One in Santa Barbara Channel; one off Point Conception
[a] Between 1967-76	1 Grounding	Outside of LA/LB breakwater
[a] Between 1967-76	4 Collisions with pleasure craft (no damage to ship)	San Pedro Bay Channel
[a] Between 1967-76	1 Collision with buoy	San Pedro Bay Channel
[b] December 1976	1 Collision between ships	Port Hueneme
[b] February 1978	1 Collision between fishing craft and ships	Santa Barbara Channel
[c] 1967 to 1978	No collisions between 7 platforms in Federal waters and ships	Santa Barbara Channel

SOURCE: [a] Mc Mullen, J.J. Associates, 1977.
[b] U.S. Coast Guard.
[c] U.S. Geological Survey.

and Wilcox Company. Heller and Pegram (11) recently reported on the development of this model based on regions of potential encounter. Spaans and van der Tak of the Netherlands Maritime Institute (12) have developed a model for calculating a maritime risk criterion number using a "ship domain" concept in which ship traffic is partitioned into ship flows in lanes while in each lane the ships are divided into different danger classes. Ship traffic in the Netherlands, of course, is much greater than in the Santa Barbara Channel. In the Southern California bight area, Science Applications, Inc. (13, 14) has carried out a probabilistic risk assessment for LNG carriers operating into the Little Cojo Bay terminal near Point Conception. This model was based upon a random ship movement stochastic flux mathematical treatment. SAI obtained a value of 7.3×10^{-6} LNG ship collisions per year. Reese et al. (15) estimated the probability of an LNG tanker collision transiting across the Santa Barbara Channel as 5×10^{-6} per year. Wright et al. (1) in late 1979 carried out a marine traffic hazard analysis for the Santa Barbara Channel in reference to Union Oil drilling activities about three miles from Point Conception. The analysis was based upon Mac Duff's study of traffic in the Dover Straits. Probability of a collision with another vessel or drill ship was considered to be the product of a causation probability and a geometric probability. For the Santa Barbara Channel, Wright estimated that the probability of a collision given an encounter between vessels was approximately 1×10^{-5} collisions per encounter. The probability of damage to a transiting vessel operating in the Santa Barbara Channel in the vicinity of the drill ship was estimated as 5×10^{-6} per transit for northbound ships and 2.5×10^{-6} for southbound ships (Public hearing Santa Barbara, California, March 1, 1980).

In considering the merits of probabilistic safety analysis, it is important to note that the Coast Guard is on public record that such an approach is not employed to set maritime safety procedures. This is made clear by the deterministic requirements of the Ports and Waterways Act of 1978.

E.3.2 BUREAU OF LAND MANAGEMENT ASSESSMENT

As part of the environmental impact statement for lease sale no. 48 (offshore Southern California), the Bureau of Land Management, U.S. Department of Interior, carried out an analysis of potential collisions with offshore structures (16). Since there are insufficient ship/platform collision records in the Southern California bight region, BLM used the collision record in the Gulf of Mexico to estimate the number of collisions for lease sale no. 48 and no. 48 combined with existing Federal leases. Table E-30 displays the record of ship collisions in the bight area. Note the scarcity of data. Table E-30 gives data on ship/platform collisions in the Gulf of Mexico. This table is considerably out of date in light of ramming accidents in the Gulf of Mexico in recent years. Tables E-31 and E-32 give the estimated collisions between ships and platforms and accidental deaths and injuries for lease sale no. 48 and combined with other Federal leases.

Steinberg (17), president of the Pacific Merchant Shipping Association, recently commented on the BLM derivation of estimates of Santa Barbara Channel platform collisions from Gulf of Mexico data. He noted that such extrapolations are tenuous at best.

E.4 OFFSHORE OIL PLATFORM CASUALTIES

In addition to the viewpoint of vessel casualties discussed above, there have been a number of offshore rig mishaps over the twenty-four year period 1955-1979. Table E-33 summarizes rig casualties over that period, worldwide. These should be considered as indicators of the type and relative frequency of occurrence of rig mishaps.

Although this table indicates a collision frequency of only about one per year, there have been a number of recent incidents in the Gulf of Mexico. On November 28, 1979, the Greek ship Skymnos rammed an oil platform on the edge of the vessel safety fairway ten miles off the Galveston entrance, with moderate damage to both platform and ship. On February 26, 1980, the USNS tank vessel Sealift Indian Ocean collided with an oil platform also on the edge of a vessel fairway 100 miles from the Galveston entrance with over $2 million damage to platform and vessel. On April 16, 1980, the Chilean motor vessel Lago Hualaihue rammed platform DXY B1 outside the fairways, ten miles offshore Galveston near Bolivar Peninsula with very extensive damage to both rig and vessel. All of these collisions occurred in darkness during the early morning hours (17).

TABLE E-30. COLLISION BETWEEN SHIPS AND PLATFORMS IN GULF OF MEXICO

Date	Number of Collisions Between Ships and Platforms	Ship Size Gross Tons	Location of Collisions	Personal Accidents		Damage in Dollars	
				Injuries	Deaths	Platform	Ship
Between July 1962 and June 1973	8	> 1,000	3 less than 5 miles from shipping fairways and anchor areas	0	0	3.2×10^6	87,000
	7	100-605	[a]	[a]			
					0	102,000	426,000
	15	< 100					
Aug. 1975	1	[a]	Between British Oil Tanker and an unmanned platform under construction caused large oil spill	[a]	6	[a]	[a]

SOURCE: FES Sale No. 43.

[a]Not indicated in the source.

TABLE E-31. ESTIMATED COLLISION BETWEEN SHIPS AND PLATFORMS FOR SALE NO. 48 AND COMBINED

Items	No. of Platforms	No. of Years	Total No. of Collisions
Gulf of Mexico	1,180	11	30
Sale No. 48	31	14	1.0[a]
Combined Sale No. 48 and existing Federal leases	86	14	2.8[a]

SOURCE: FES Sale No. 48.

[a]Estimates.

TABLE E-32. ESTIMATED ACCIDENTAL DEATHS AND INJURIES FOR SALE NO. 48 AND COMBINED

Items	No. of Platforms	No. of Years	Estimated Total Deaths	Estimated Total Injuries
Gulf of Mexico	1,330	9	62	2,890/yr[a]
Sale No. 48	31	14	2.3[a]	943[a]
Combined Sale No. 48 and existing Federal leases	86	14	6.2[a]	2,616[a]

SOURCE: FES Sale No. 48.

[a]Estimated.

TABLE E-33. OFFSHORE RIG CASUALTIES 1955–MID-1979 NUMBER OF CASUALTIES (REFERENCE 18)

Type of Casualty	Catastrophic; Loss of Rig	Major Accident — Damage over $1M	Minor Accident — Damage under $1M
Blowout/fire	11	7	3
Storm induced	10	8	18
Moving/preparing to move	11	15	3
Drilling	3	3	0
Collision	0	2	21
Other/not designated	4	3	6
Total Cost*	$249M	$110M	$ 9M

*Dollars as of year of occurrence.

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APPENDIX F
SCENARIO DESCRIPTIONS AND DEBRIEFING QUESTIONNAIRE

This Appendix contains the following materials:

- Scenario Descriptions, each using an actual example of a test subject's run including the ground track of all other traffic ships.
- Instruction to Subjects, provided to each master before experimental runs were begun, including ship specific and general navigation/environmental information.
- Blank Questionnaire, used to debrief test subjects at the conclusion of their simulator activities.

SCENARIO DESCRIPTIONS

CONDITION 1 – Figures F-1 and F-2

Segment A

Ownship (O/S) starts the transit northbound in TSS four miles below the Port Hueneme Access Fairway. No platforms are present in proximity to the Traffic Lanes and no other vessels are encountered other than a container vessel southbound in the lanes. Segment ends when ownship reaches the dog-leg axis line.

Segment B

Ownship position is reset to dog-leg axis line in the center of the northbound lane. Direction of transit in the lane is northbound and no platforms or obstructions are present in close proximity to the Traffic Lanes. No other vessels are encountered with the exception of a container vessel which is in the southbound lane. The segment ends approximately four and a half miles beyond the dog-leg axis.

CONDITION 2 – Figures F-3 and F-4

Segment A

Ownship starts the transit northboundin the TSS four miles below the Port Hueneme Access Fairway. No platforms are present in proximity to the Traffic Lanes. A container vessel is outbound in the Port Hueneme Access Fairway and she will turn into the Northbound Lane of the TSS after ownship passes. A Naval destroyer crosses the Separation Zone from the Southbound Lane and passes ahead of ownship into the Access Fairway. A tugboat is outbound from Port Hueneme and crosses the Northbound Lane about 3 miles ahead of ownship. Two fishing vessels are operating just outside the lanes and in the Separation Zone and serve only to provide additional realistic radar contacts. The segments ends when ownship reaches the dog-leg axis.

Segment B

Ownship position is reset to dog-leg axis line in the center of the Northbound Lane. The vessel is proceeding northbound and a drilling vessel is encountered, positioned on the south boundary of the lane approximately three miles from the dog-leg axis. No other vessels are encountered other than a freighter proceeding south in the opposite lane. The segment ends when ownship is four and a half miles from the axis.

CONDITION 3 – Figures F-5 and F-6

Segment A

Ownship starts the transit northbound in the TSS four miles below the Port Hueneme Access Fairway. A production platform is sited in the Separation Zone opposite the Access Fairway. The container vessel and destroyer are both maneuvering identically to the vessels in Condition 2. Other smaller craft such as a fishing boat and tug are operating in and about the Traffic Lanes but do not interact with ownship. The segment ends when ownship reaches the dog-leg axis.

Segment B

Ownship position is reset on the dog-leg axis in the center of the Northbound Lane. The drilling vessel is positioned three miles from the axis and approximately 500 meters inside the Separation Zone at the edge of a "buffer zone."

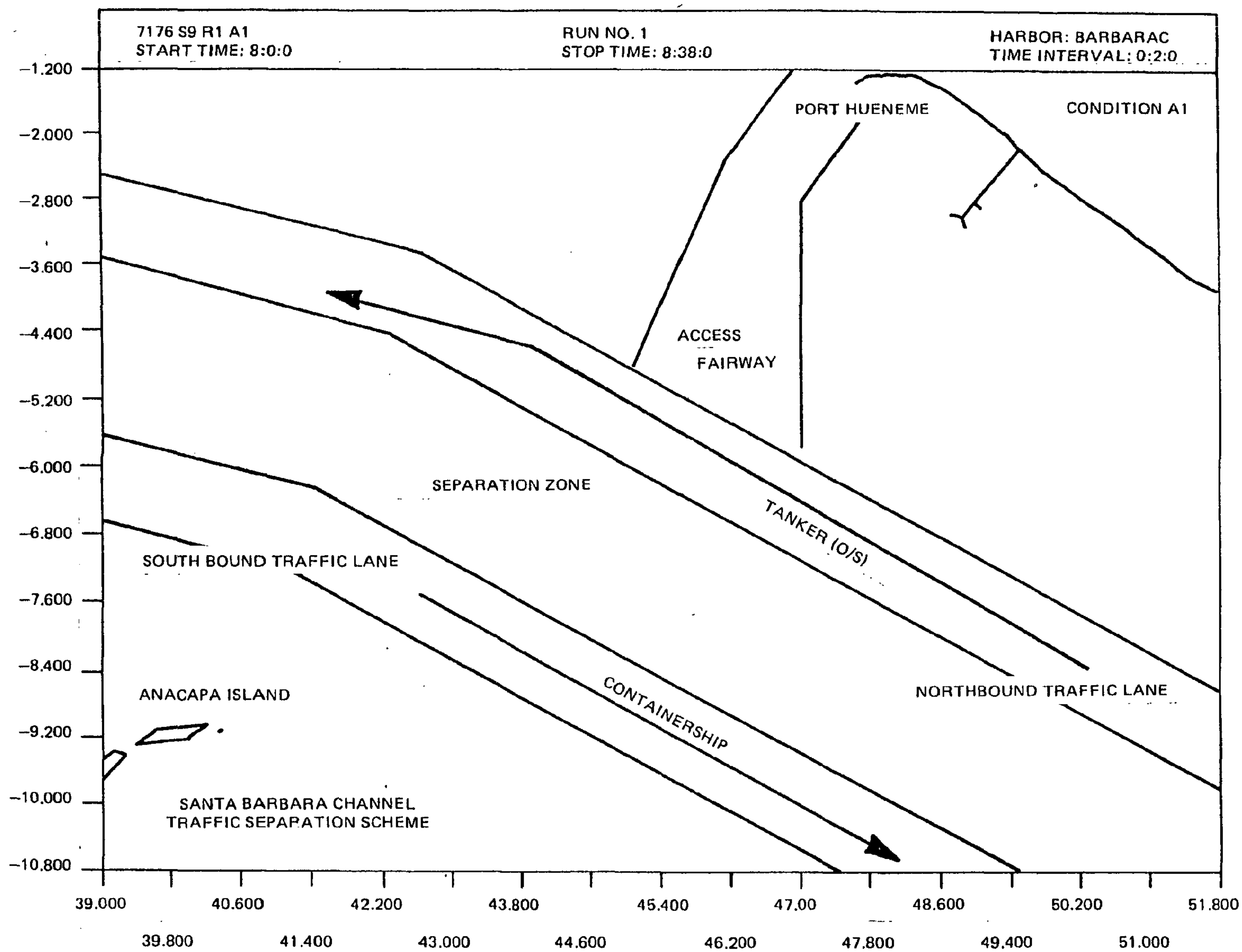


Figure F-1. Scenario A1

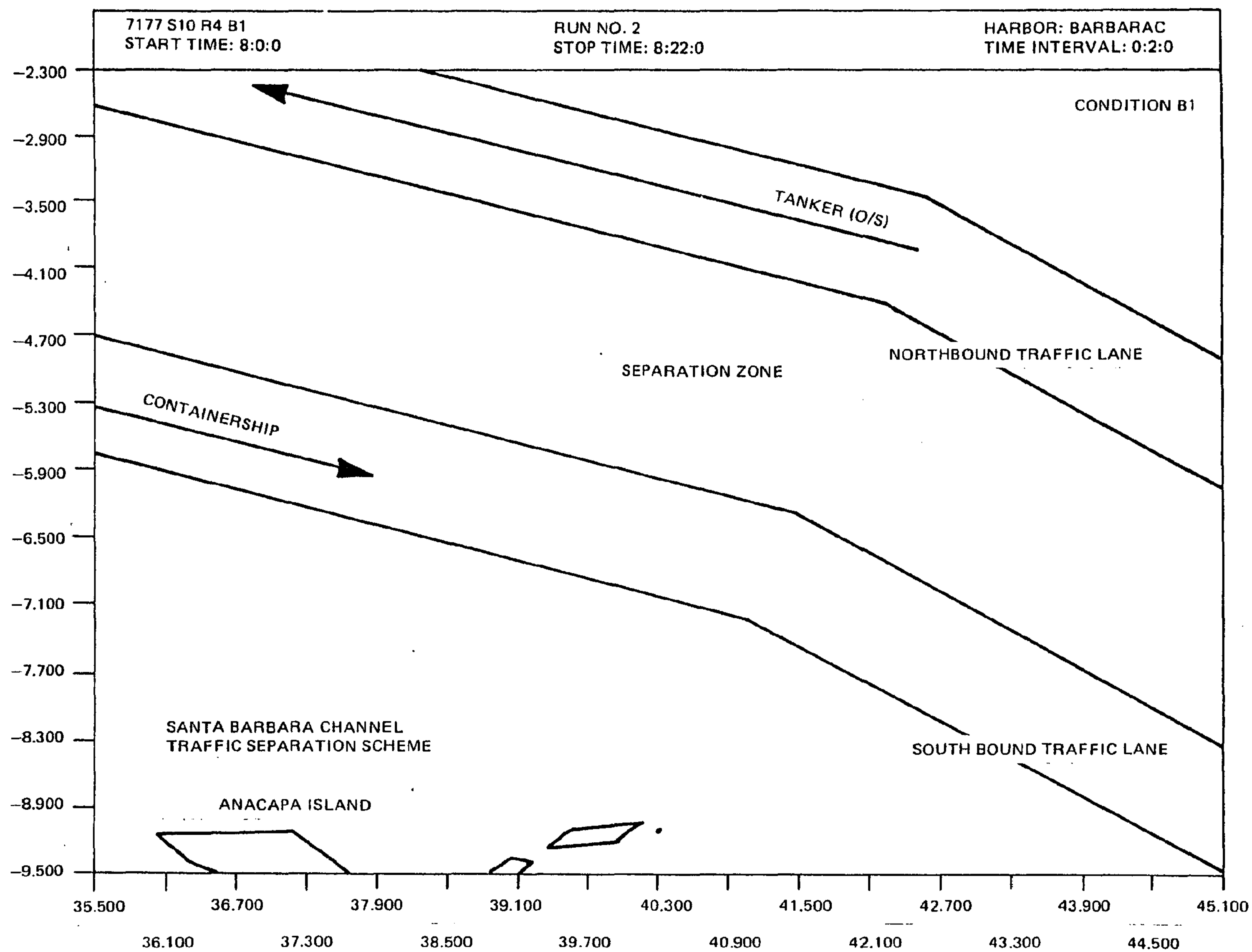


Figure F-2. Scenario B1

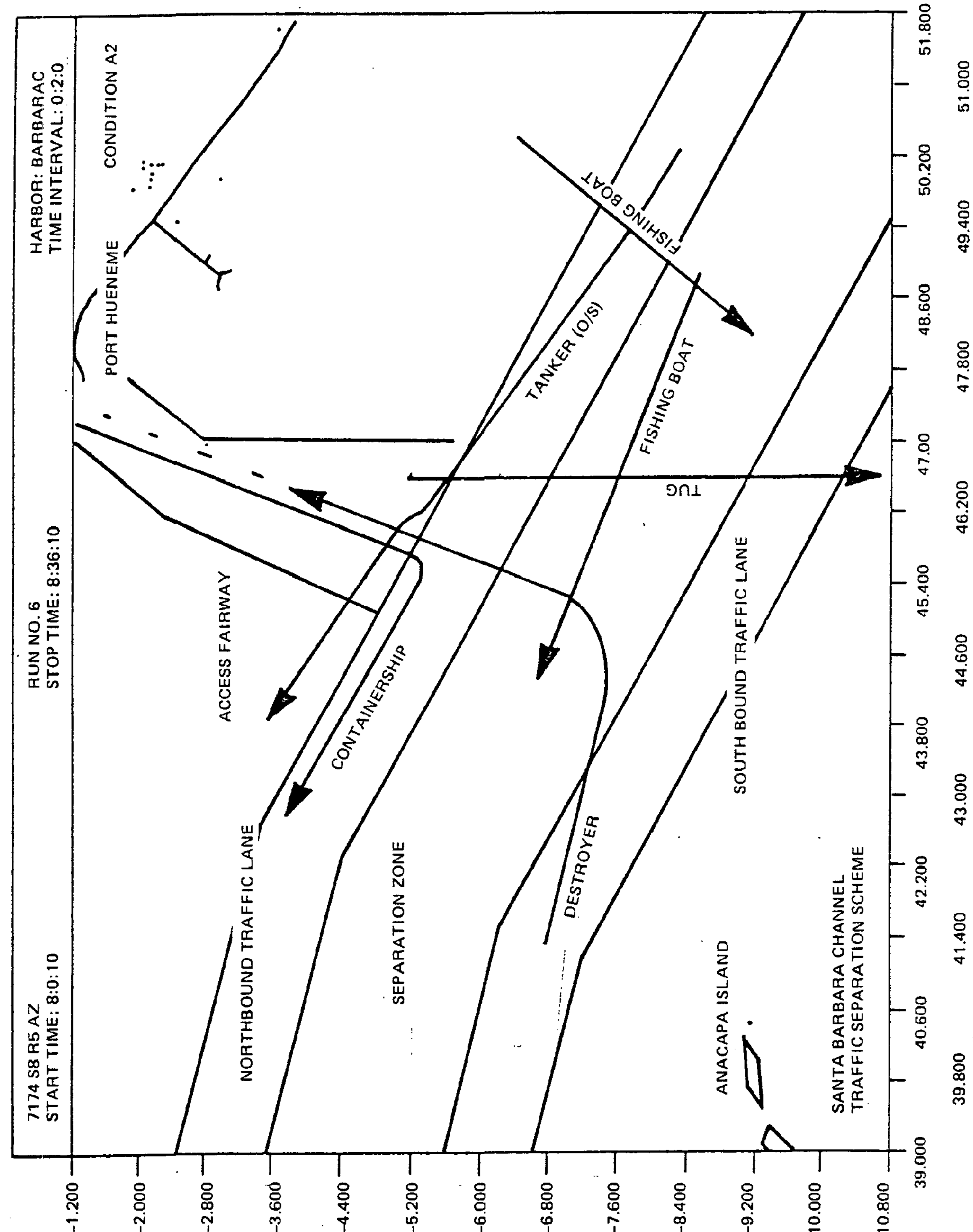


Figure F-3. Scenario A2

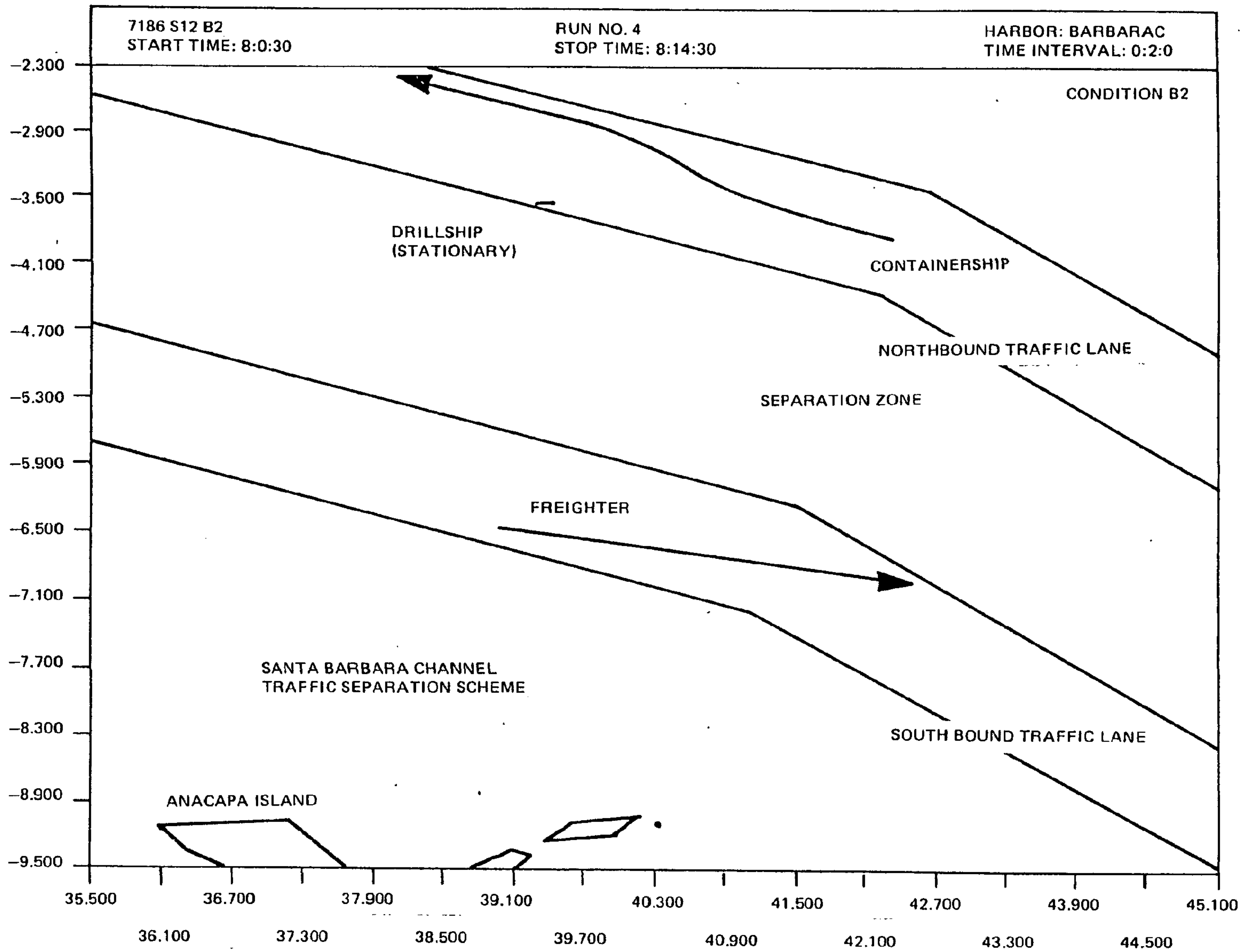


Figure F-4. Scenario B2

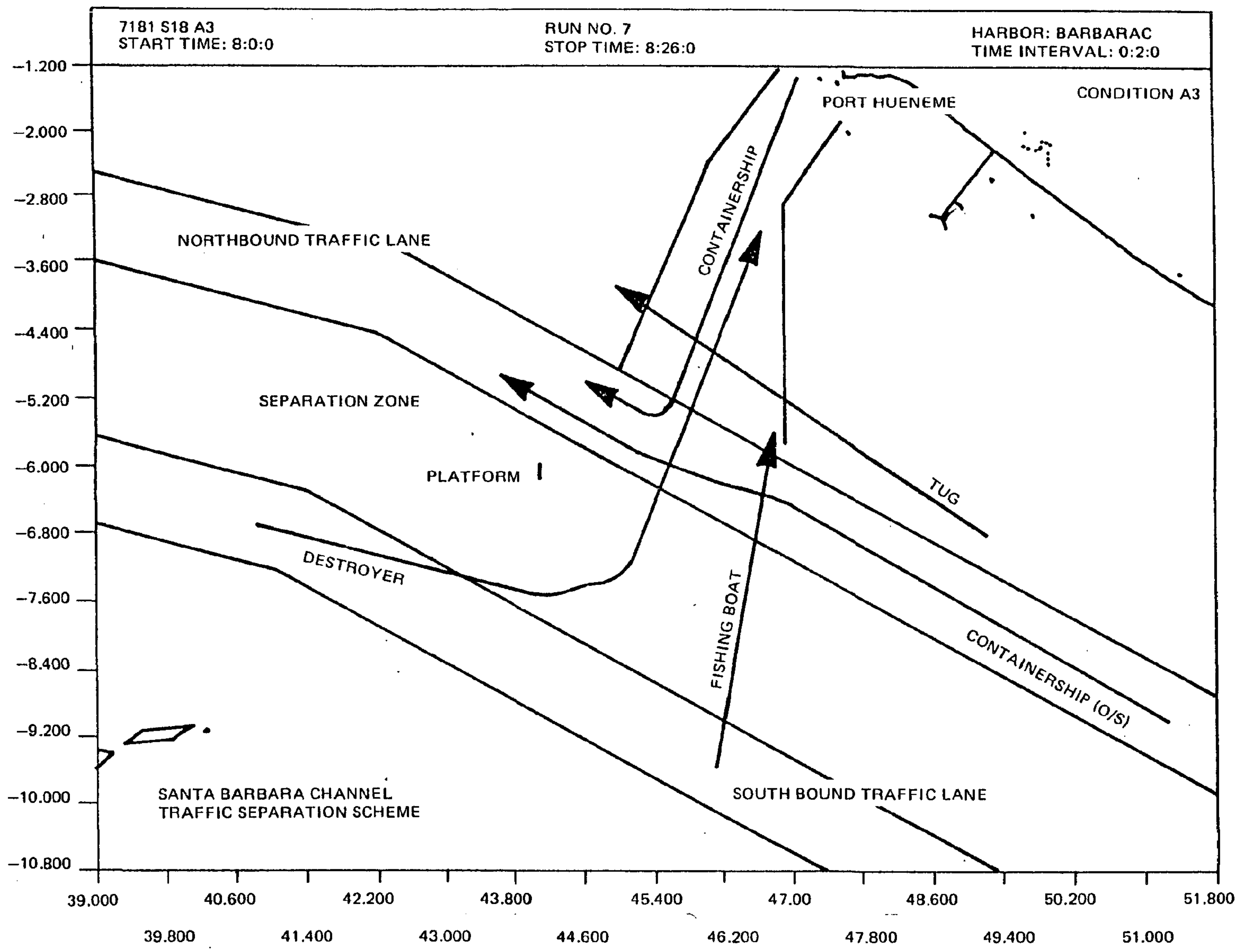


Figure F-5. Scenario A3

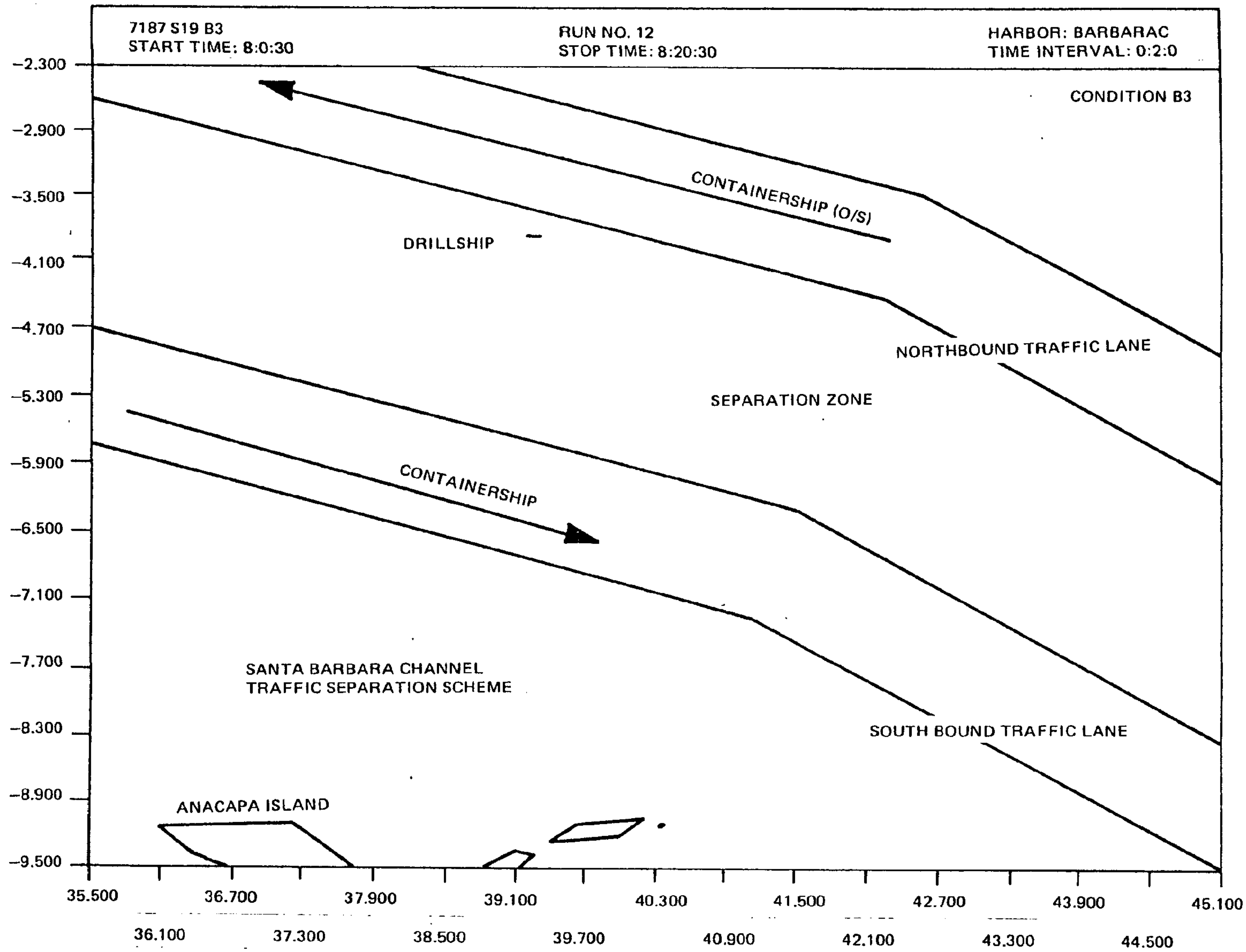


Figure F-6. Scenario B3

Only one other vessel is encountered: a containership is proceeding south in the Southbound Lane but does not interact with ownship. The segment ends four and a half miles from the dog-leg axis.

CONDITION 4 – Figures F-7 and F-8

Segment A

Ownship starts the transit northbound in the TSS four miles below the Port Hueneme Access Fairway. A production platform is sited in the Separation Zone opposite the Access Fairway. The container vessel and destroyer from Conditions 2 and 3 are present and maneuvering as before. Additionally, several resource recovery support vessels are operating to and from the platforms and may be found crossing the Traffic Lanes in close proximity to ownship. These include a crew boat and a supply boat. The segment ends when ownship reaches the dog-leg axis.

Segment B

Ownship is repositioned in the center of the lane on the axis, and is northbound. The drilling vessel is positioned just on the southern lane boundary and several small support vessels are operating in the vicinity. A crew boat accelerates from one of the platforms well outside the Traffic Lanes and proceeds to cross the Northbound Lane to approach the drill ship. The segment ends four and a half miles from the dog-leg axis.

The remainder of the descriptions cover Conditions 5 through 9 and all take place in Segment B. Visibility is one-half nautical mile in all conditions.

CONDITION 5 – Figure F-9

As in the remaining scenarios, ownship is positioned in the center of the northbound traffic lane on the dog-leg axis. In this instance a "gated" configuration is formed by the location of a drill ship three miles down the lane from the dog-leg axis and positioned on the south boundary between the lane and the Separation Zone. Directly opposite the drill ship across the northbound lane is a fixed platform sited on the north boundary. "Chaff" traffic in the vicinity includes a fishing vessel crossing out of the northbound lane into the Separation Zone. Such chaff traffic does not interact with or impede ownship. The scenario ends when ownship has passed through the gate.

CONDITION 6 – Figure F-10

Ownship once again is positioned on the dog-leg axis in the center of the northbound lane. A staggered gate configuration consisting of the drill ship and a fixed platform straddles the northbound lane. The stationary drill ship is positioned on the south boundary a distance of three nautical miles from the dog-leg axis. The platform is located across the lane on the north boundary with a separation distance (along the traffic lane) of one nautical mile from a point directly across from the drill ship (perpendicular to the direction of traffic flow).

A tanker is proceeding southeast in the southbound traffic lane and a small crew boat gets underway and proceeds out of the Separazation Zone. The scenario ends when ownship has transited the traffic lane beyond the platform.

CONDITION 7 – Figure F-11

Ownship's initial parameters are the same as in the previous conditions. The gated configuration is similar to that depicted in Condition 5 with the exception that both the drill ship and the platform are each removed away from the northbound lane by a distance of 500 m. This "buffer zone" between the obstruction and the lane edge effectively increases the cross-lane separation distance between the obstructions by 1000 m.

A container vessel is proceeding in the northbound traffic lane in the same direction as, and about three and a half miles ahead of, ownship. A supply boat is headed south across the Separaztion Zone.

CONDITION 8 – Figure F-12

The alternate configuration presented here (all other parameters remaining the same as previously described) is a staggered gate with a drill ship and platform as the opposing obstructions similar to Condition 6. The drill ship and fixed platform are located on the south and north boundaries of the northbound lane, respectively. The drilling vessel is sited three nautical miles from the dog-leg axis, and the platform is located two nautical miles farther down the lane as measured from a point across the lane (perpendicular to the direction of traffic flow) from the drill ship. The scenario ends when ownship is approximately a mile beyond the drill ship in the traffic lane.

A fishing boat and a tug are operating in the Separation Zone as chaff traffic.

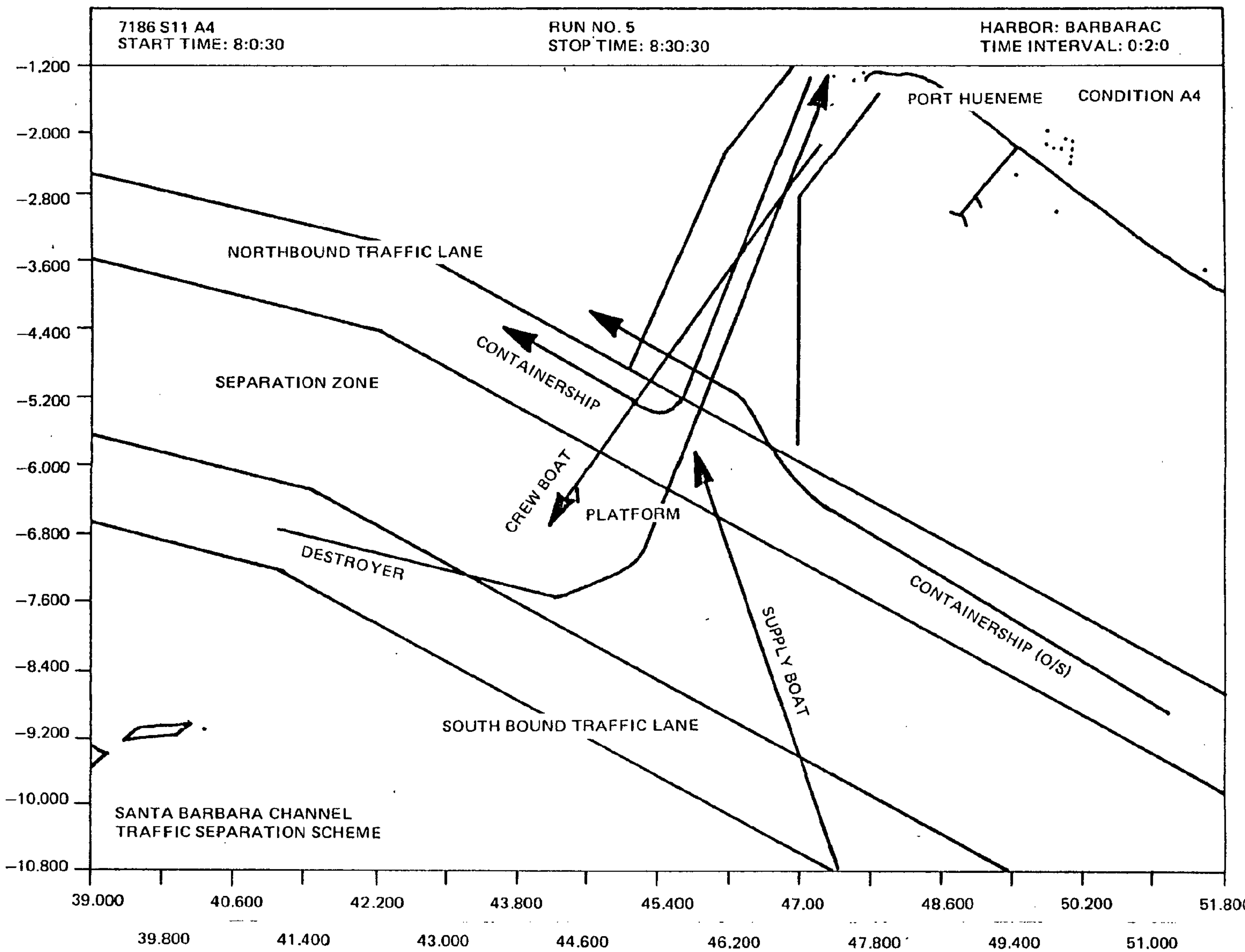


Figure F-7. Scenario A4

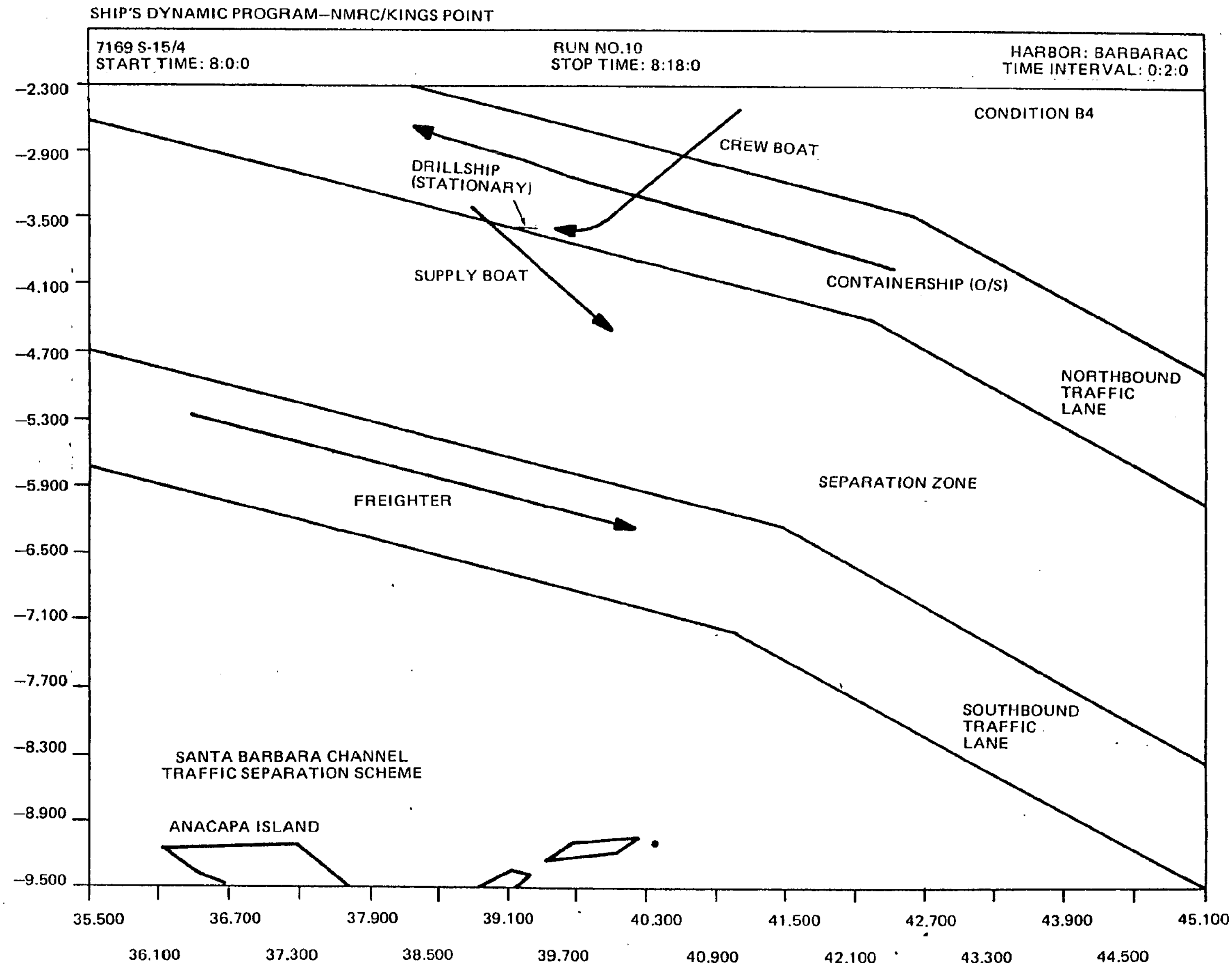


Figure F-8. Scenario B4

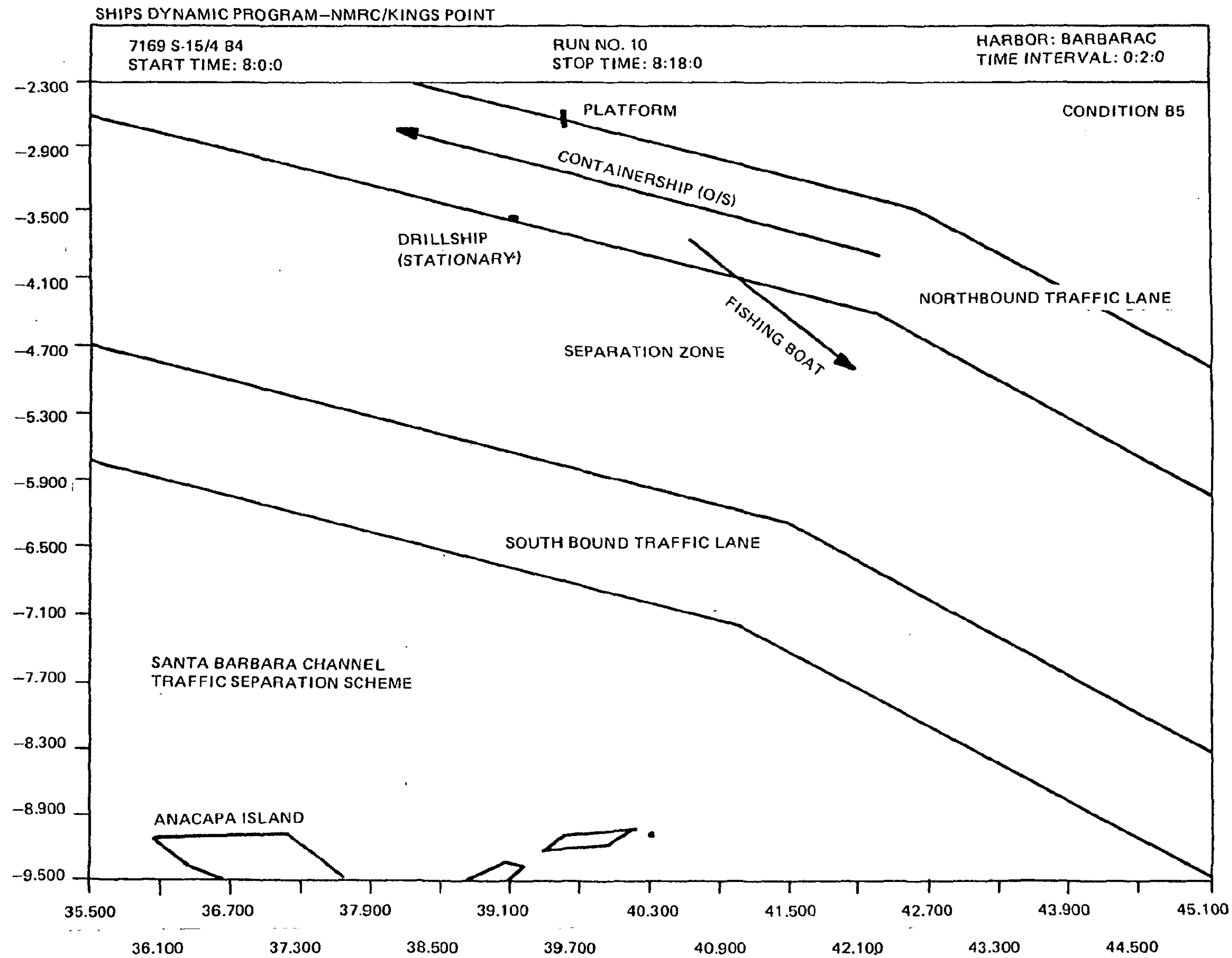


Figure F-9. Scenario B5

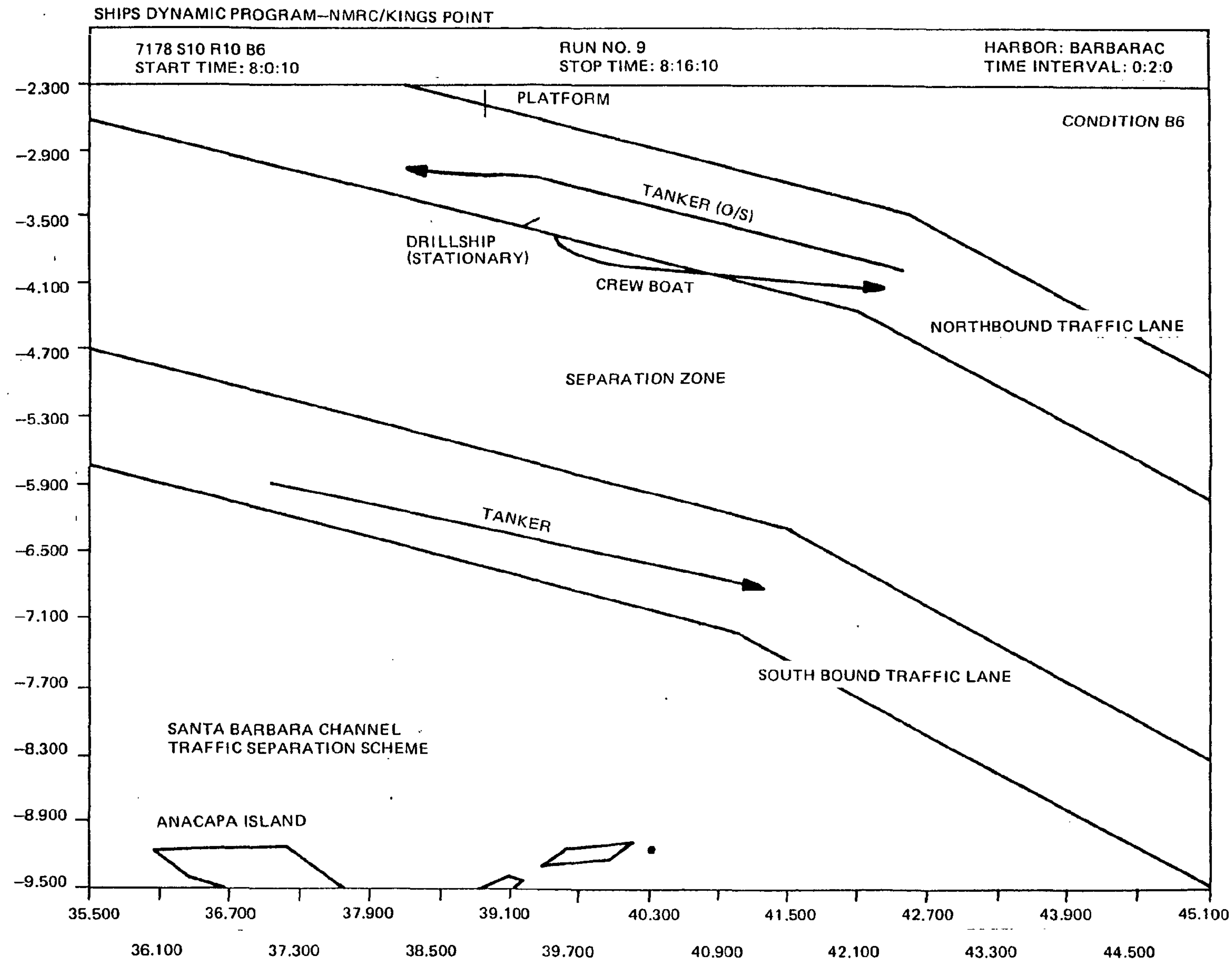


Figure F-10. Scenario B6

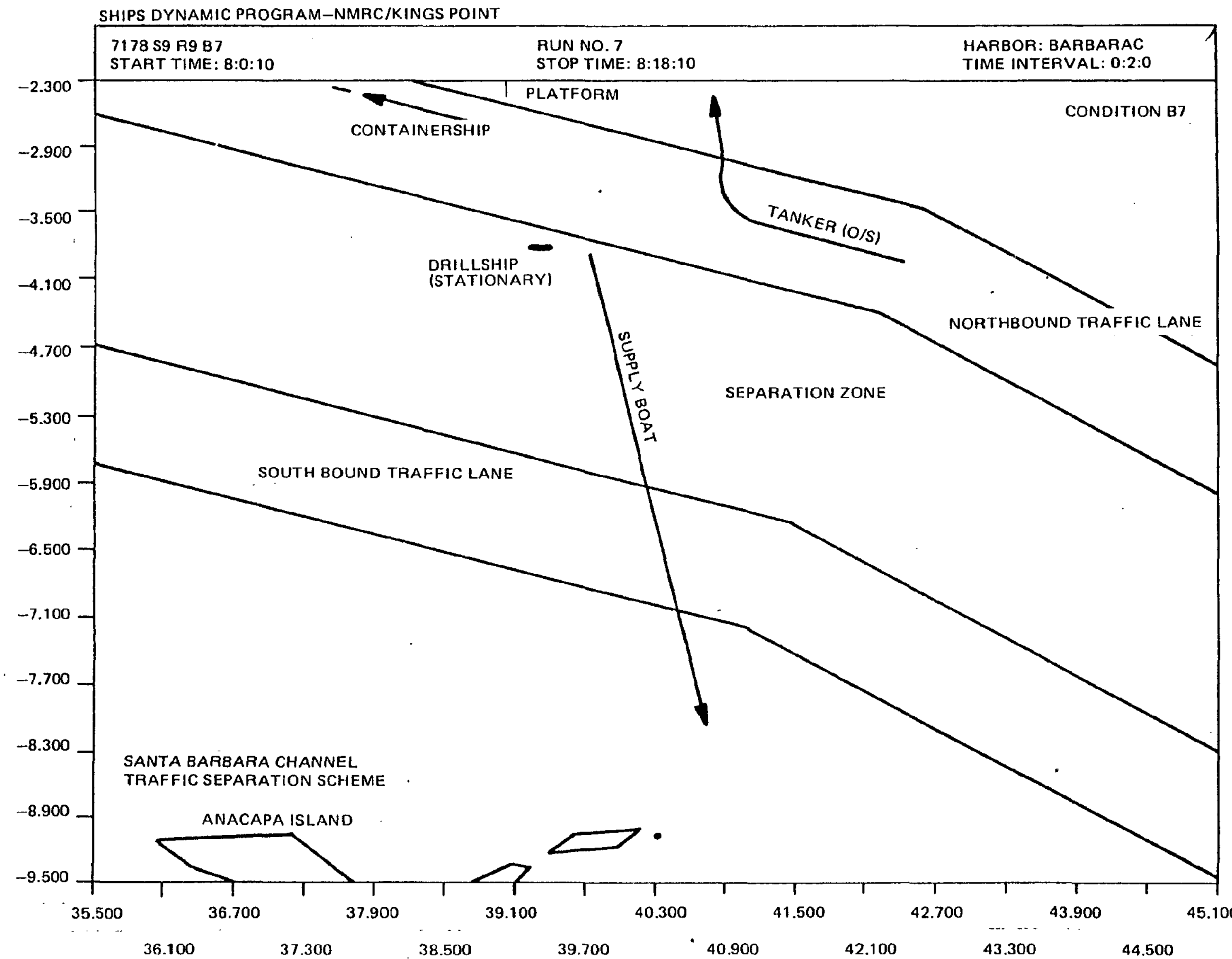


Figure F-11. Scenario B7

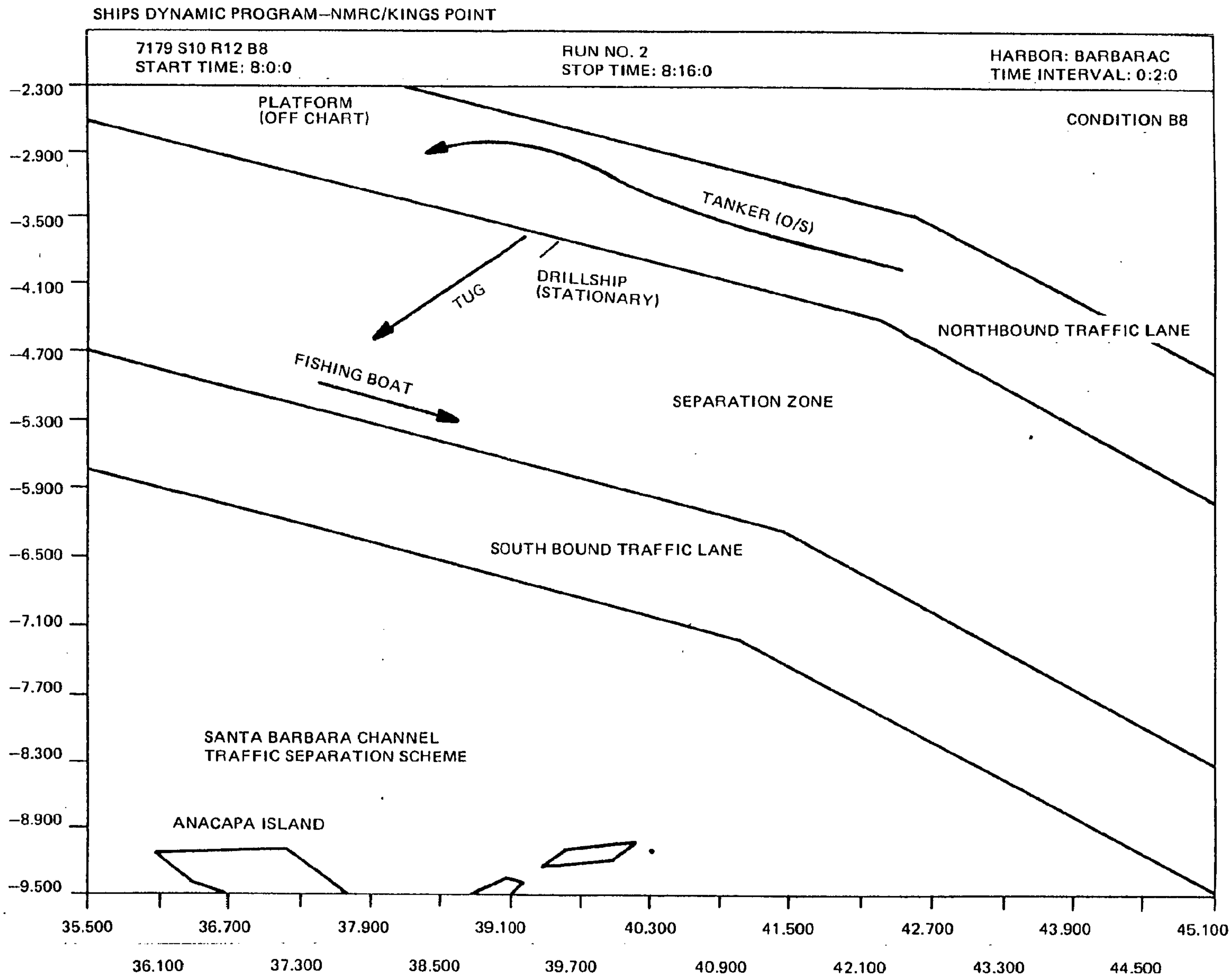


Figure F-12. Scenario B8

CONDITION 9 – Figure F-13

In this final scenario ownship again is positioned at the dog-leg in lane center and proceeds northwest in the northbound traffic lane. The configuration depicted is identical to that in Condition B7 for the gated obstructions (drill ship and fixed platform). In this instance a "rogue vessel" (tug and barge unit) is crossing the northbound traffic lane in an improper manner and generally opposing the prescribed traffic flow. The vessel is proceeding so as to cross ahead of ownship at about a half mile distance and presents a potential collision situation. The scenario ends when ownship has passed beyond the gated configuration, or leaves the traffic lane.

SANBAR II

INSTRUCTIONS TO MASTERS

Welcome to CAORF and thank you for participating in the Santa Barbara Channel Experiment. You have been selected on the basis of your experience in serving as master of containerships. You will, after a brief familiarization run, be asked to navigate a loaded container vessel through segments of the Santa Barbara Channel on the coast of California. The scenarios which make up the series of runs simulate the eastern portion of the Channel in the vicinity of Port Hueneme, and various projections of traffic and offshore oil production at points in time within the next decade.

Prior to the eight experimental runs, you will be conducted on a short familiarization run through some area of the Channel by one of the CAORF Operations personnel. This transit is not so much to acquaint you with the area in which the experiment takes place as it is to allow you an opportunity to get aclimated to CAORF's visual scene and the location and operation of the bridge equipment. Please feel free to ask any questions you may have regarding their operation at this time, however we will not be able to answer any questions regarding the purpose of the experiment until you have completed your runs.

During the experimental runs in which you will have the conn, you will be assisted by the officer of the watch who will be instructed by you as to his duties before commencement of the runs. A qualified helmsman will also man the wheel.

So that each of you will have an equal opportunity to complete the Channel transits without prior knowledge as to scenario content, we ask that you do not discuss the scenarios with any of the other test subjects.

OWNSHIP CHARACTERISTICS – C/V EVERSTAR

* Type: Containership
* Displacement: 22,635 tons
* LOA: 504.0'
* LBP: 468.7'
* Beam: 78.7'
* Draft: 30.5' Even Keel
* Propulsion: geared steam turbine – 17,500 shp
* Single Screw: 4 blade propeller dia. 19.0'; pitch 18.5'
* Bridge height of eye/location: 77' above waterline 250' forward of stern
* Maximum rudder: 35° Port or Starboard

BRIDGE EQUIPMENT

- Steering stand with gyro repeater
- Overhead 3-face rudder angle indicator
- Bulkhead mounted gyro repeater
- Rate of turn indicator
- Engine order repeater
- 2 RPM indicators
- Engine order telegraph
- Speed log (through the water)
- Digital clock
- VHF radio telephone
- Manual whistle control
- Automatic whistle timer control
- Sound powered phone
- Digital depth sounder
- Relative wind indicators
- Loran-C receiver
- 3 cm and 10 cm radars
- Course recorder
- 2 Bridge wing gyro repeaters with pelorus mounted
- Chart table, chart and plotting tools

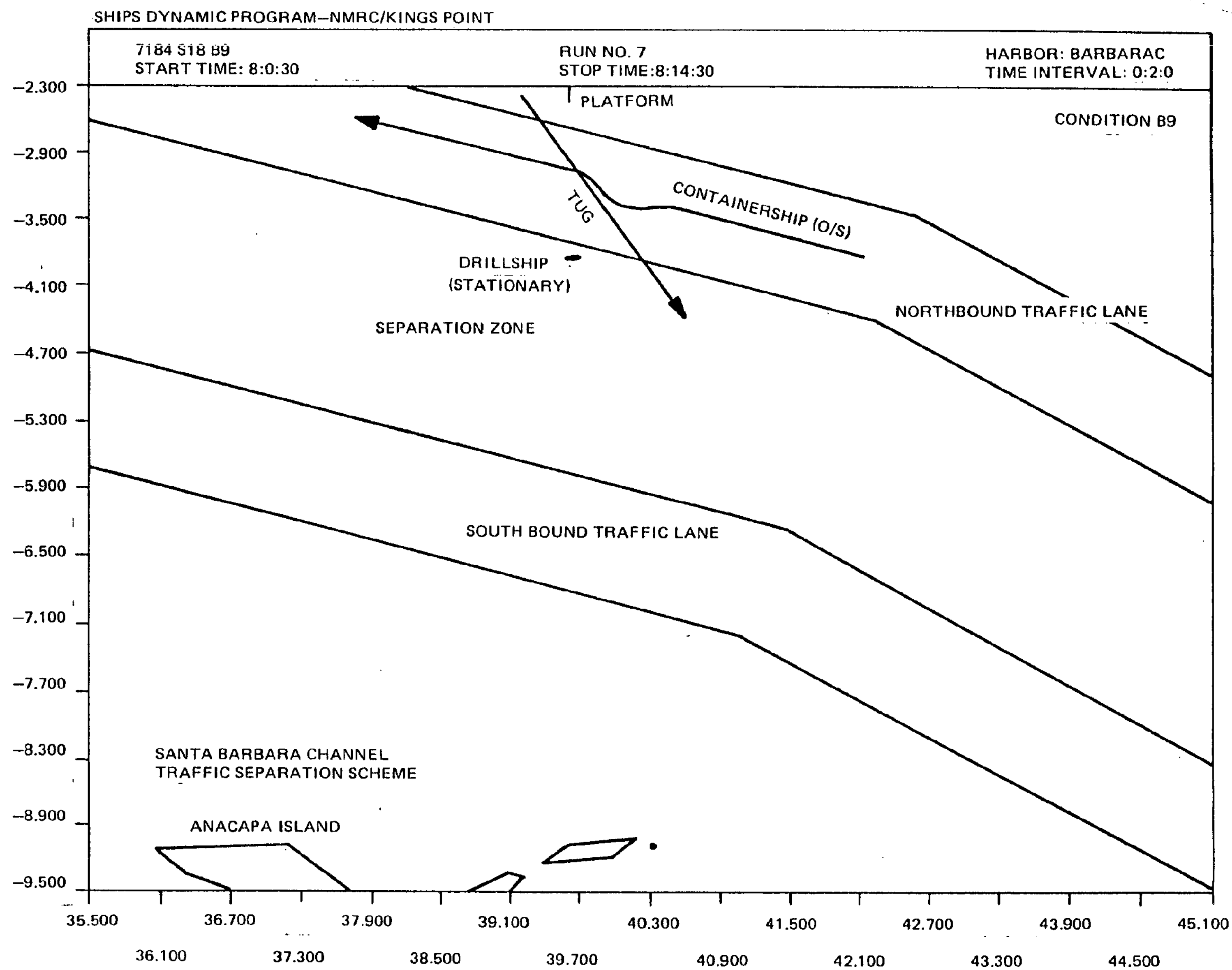


Figure F-13. Scenario B9

INITIAL EXPERIMENTAL CONDITIONS

Segment A

Ownship position:	Center of north bound traffic lane as plotted on chart N.O. 18720
	Lat.
	Long.
Heading:	300°T
Speed:	19.3 knots @ 120 RPM
Wind:	Westerly at about 15 knots
Current:	Setting East at about half a knot
Visibility:	3 miles or less in haze
Time of Day:	Day

Segment B

Ownship postion:	Center of north bound traffic lane as plotted on chart N.O. 18720
	Lat.
	Long.
Heading:	285°T
Speed:	19.3 knots @ 120 RPM
Wind:	Westerly at about 15 knots
Current:	Setting East at about half a knot
Visibility:	Approximately 0.5 mile in fog
Time of day:	Day

In each case you should make the northbound transit in the Santa Barbara Channel as you would in the real-world following your normal procedures.

SANBAR II

INSTRUCTIONS TO MASTERS

Welcome to CAORF and thank you for participating in the Santa Barbara Channel Experiment. You have been selected on the basis of your experience in serving as master of large tankers. You will, after a brief familiarization run, be asked to navigate a loaded 80,000 DWT tanker through segments of the Santa Barbara Channel on the coast of California. The scenarios which make up the series of runs simulate the eastern portion of the Channel in the vicinity of Port Hueneme, and various projections of traffic and offshore oil production at points in time within the next decade.

Prior to the eight experimental runs, you will be conducted on a short familiarization run through some area of the Channel by one of the CAORF Operations personnel. This transit is not so much to acquaint you with the area in which the experiment takes place as it is to allow you an opportunity to get aclimated to CAORF's visual scene and the location and operation of the bridge equipment. Please feel free to ask any questions you may have regarding their operation at this time, however we will not be able to answer any questions regarding the purpose of the experiment until you have completed your runs.

During the experimental runs in which you will have the conn, you will be assisted by the officer of the watch who will be instructed by you as to his duties before commencement of the runs. A qualified helmsman will also man the wheel.

So that each of you will have an equal opportunity to complete the Channel transits without prior knowledge as to scenario content, we ask that you do not discuss the scenarios with any of the other test subjects.

OWNSHIP CHARACTERISTICS – S/T CAPELLA

* Type: 80,000 DWT tankr with house aft
* Load Condition: Fully loaded
* LOA: 800'
* LBP: 763'
* Beam: 125'
* Draft: 39' 11" Even Keel
* Propulsion: geared steam turbine – 23,000 shp
* Single Screw: 5 blade propeller dia. 23'; pitch 19'
* Distance to Wheel house: Aft bulkhead to bow 675' Forward bulkhead to stern 139'
* Bridge height of eye: 60' above deck
* Maximum rudder: 35° Port or Starboard

BRIDGE EQUIPMENT

- Steering stand with gyro repeater
- Overhead 3-face rudder angle indicator
- Bulkhead mounted gyro repeater
- Rate of turn indicator
- Engine order repeater
- 2 RPM indicators
- Engine order telegraph
- Speed log (through the water)
- Digital clock
- VHF radio telephone
- Manual whistle control
- Automatic whistle timer control
- Sound powered phone
- Digital depth sounder
- Relative wind indicators
- Loran-C receiver
- 3 cm and 10 cm radars
- Course recorder
- 2 Bridge wing gyro repeaters with pelorus mounted
- Chart table, chart and plotting tools

INITIAL EXPERIMENTAL CONDITIONS

Segment A

Ownship position:	Center of north bound traffic lane as plotted on chart N.O. 18720
	Lat.
	Long.
Heading:	300°T
Speed:	15.5 knots @ 107 RPM
Wind:	Westerly at about 15 knots
Current:	Setting East at about half a knot
Visibility:	3 miles or less in haze
Time of Day:	Day

Segment B

Ownship postion:	Center of north bound traffic lane as plotted on chart N.O. 18720
	Lat.
	Long.
Heading:	285°T
Speed:	15.5 knots @ 107 RPM
Wind:	Westerly at about 15 knots
Current:	Setting East at about half a knot
Visibility:	Approximately 0.5 mile in fog
Time of day:	Day

In each case you should make the northbound transit in the Santa Barbara Channel as you would in the real-world following your normal procedures.

SANBAR I

DEBRIEF QUESTIONNAIRE

Your candid answers to the following questions are solicited so that we might gain insights to be used in designing future scenarios for simulation. Your answers will not be associated with your name at any time, or in any writings.

1. Have you transitted areas of high offshore platform density previously? Where?

2. If offshore production platforms are sited in close proximity to normal traffic lanes or recommended fairways, what do you consider to be a safe passing distance for them?

3. What factors might influence your decision to alter your intended track so as to open the distance between your vessel and a platform or stationary drilling rig? (List multiple answers in order of their priority, first priority being at the top of the list.)

4. Do you recall any instances where you objected to or preferred not to follow a recommended (but not compulsory) Traffic Separation Scheme or fairway? If yes, what factors influenced your decision?

5. Do you feel that a Separation Zone between Traffic Lanes is a "no-man's land" that should never be entered by vessels using the lanes in the normal direction of transit and under normal operating conditions (other than emergency)?

6. If, while proceeding in a lane of a Traffic Separation Scheme, you encountered an obstruction for which you would have to leave the Traffic Lane to pass at a safe distance, would you be more likely to enter the Separation Zone or pass out of the lane to starboard (assuming ample sea room was available to either side of the Traffic Lane)?

7. How do you feel, in general, about the siting of production platforms or stationary drilling vessels in the Separation Zone or a Traffic Separation Scheme? Would your opinion be altered if their positions were accurately known (either printed on local charts or available through local Notices to Mariners)?

8. What is your opinion of permitting stationary drilling vessels to operate within a recommended Traffic Lane? Would your opinion be altered if the vessel's position were known in advance?

9. When you are transitting a recommended Traffic Lane or fairway does your criteria for an acceptable CPA to vessels crossing the lanes differ from acceptable CAP's to crossing traffic in an open sea situation (no lanes)?

10. Approximately what range at CPA is acceptable to you in the open sea (crossing situation)? If different (question 9) what range at CPA is acceptable when transitting a recommended Traffic Lane?

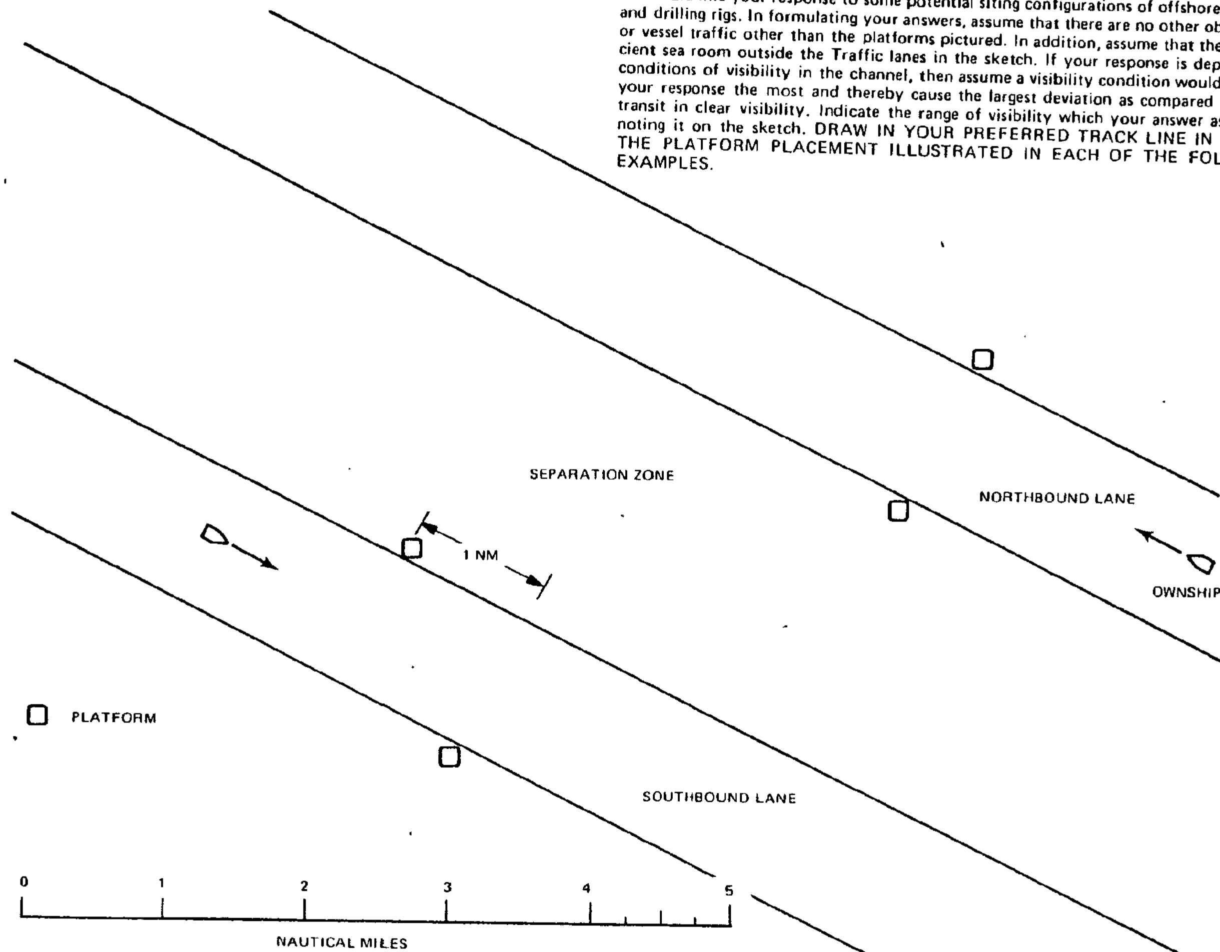
11. Are there other factors which affect your criteria for acceptable range at CPA, such as weather, visibility, size or speed of other vessels? If yes, explain how these factors would change your criteria?

12. Are you aware of the proposal to begin drilling in or near the Santa Barbara traffic lanes?

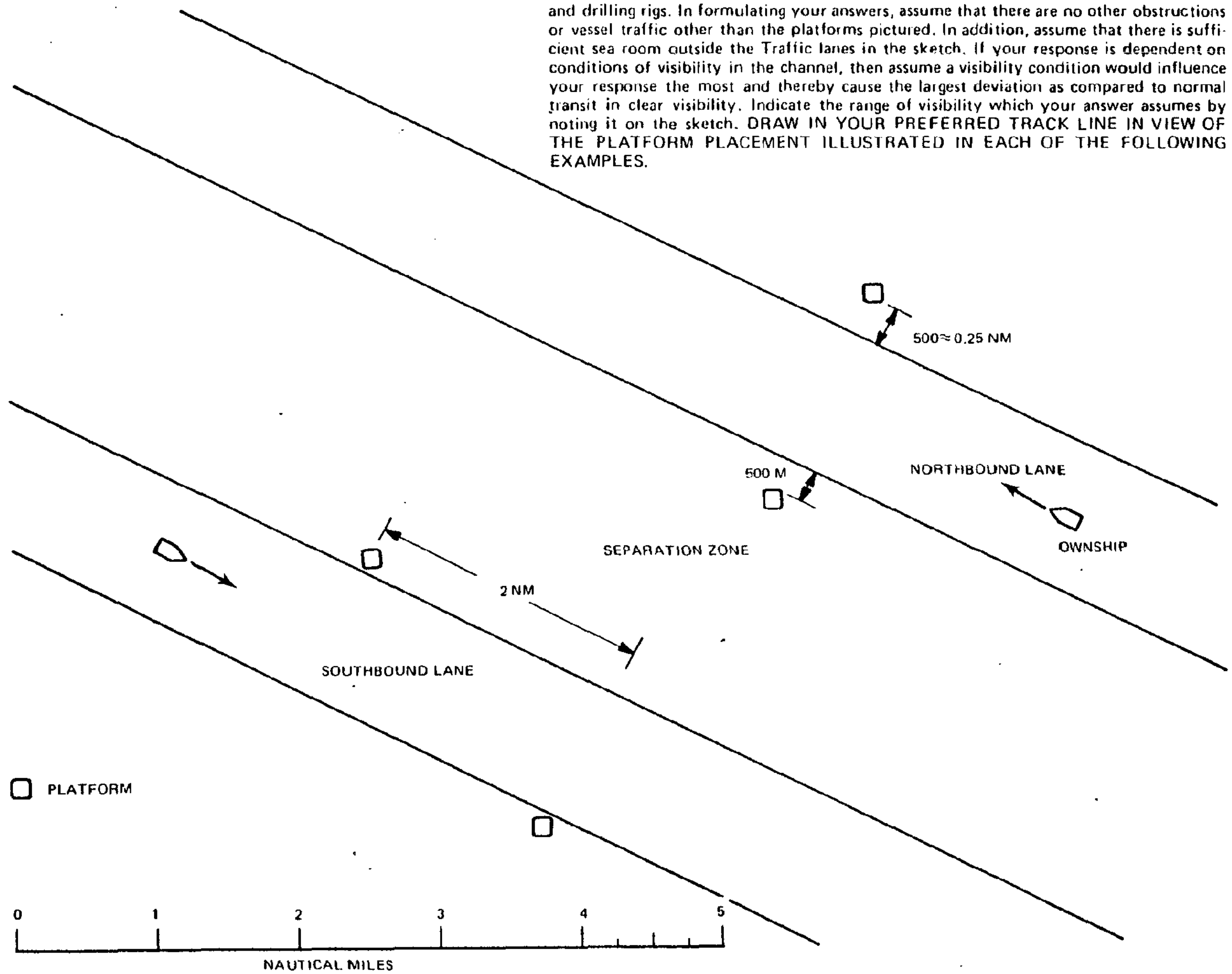
13. Would you be opposed or in favor of such activity?

14. Have you ever voiced an opinion on this matter in the past? If so, could you briefly restate it here?

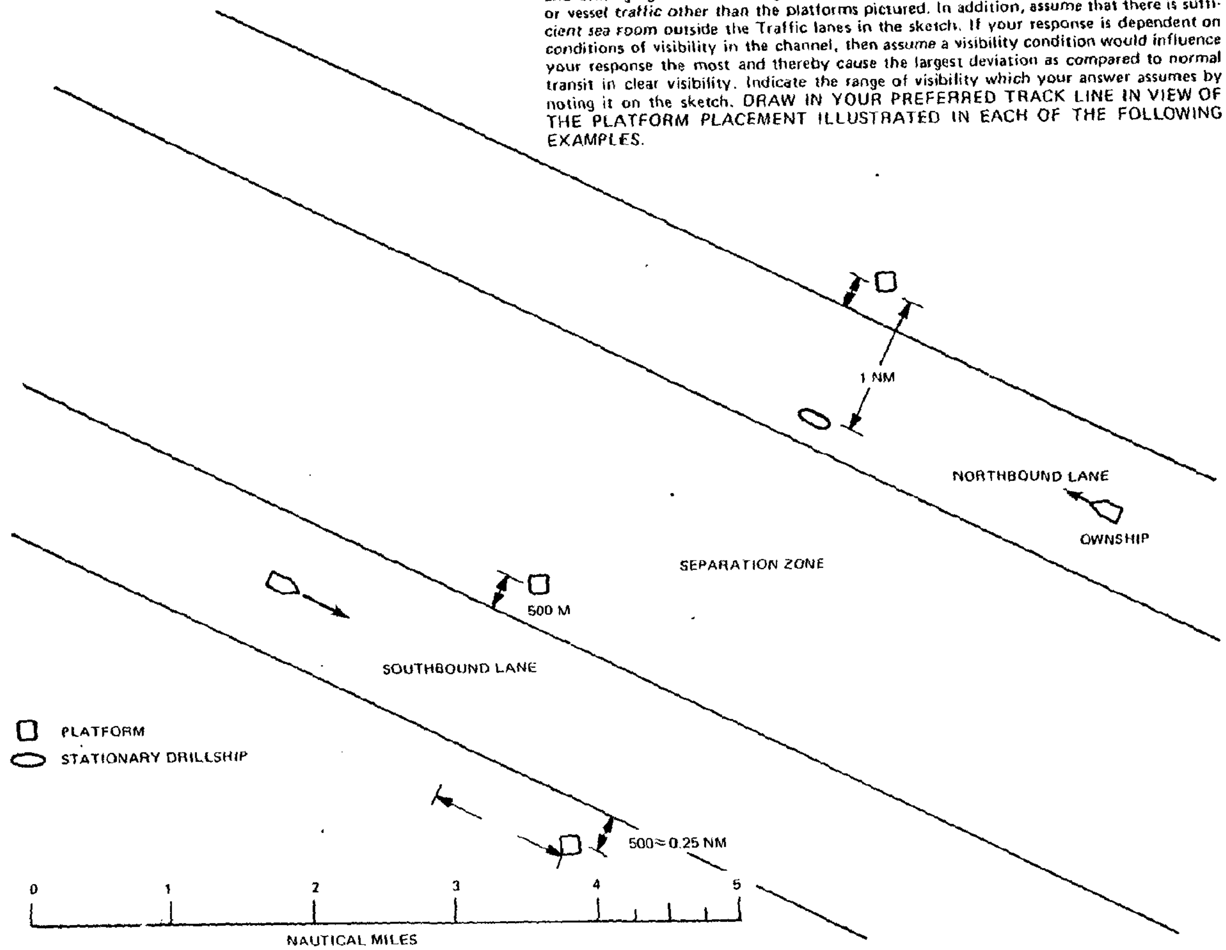
We would like your response to some potential siting configurations of offshore platforms and drilling rigs. In formulating your answers, assume that there are no other obstructions or vessel traffic other than the platforms pictured. In addition, assume that there is sufficient sea room outside the Traffic lanes in the sketch. If your response is dependent on conditions of visibility in the channel, then assume a visibility condition would influence your response the most and thereby cause the largest deviation as compared to normal transit in clear visibility. Indicate the range of visibility which your answer assumes by noting it on the sketch. DRAW IN YOUR PREFERRED TRACK LINE IN VIEW OF THE PLATFORM PLACEMENT ILLUSTRATED IN EACH OF THE FOLLOWING EXAMPLES.



We would like your response to some potential siting configurations of offshore platforms and drilling rigs. In formulating your answers, assume that there are no other obstructions or vessel traffic other than the platforms pictured. In addition, assume that there is sufficient sea room outside the Traffic lanes in the sketch. If your response is dependent on conditions of visibility in the channel, then assume a visibility condition would influence your response the most and thereby cause the largest deviation as compared to normal transit in clear visibility. Indicate the range of visibility which your answer assumes by noting it on the sketch. DRAW IN YOUR PREFERRED TRACK LINE IN VIEW OF THE PLATFORM PLACEMENT ILLUSTRATED IN EACH OF THE FOLLOWING EXAMPLES.



We would like your response to *some* potential *siting* configurations of offshore platforms and drilling rigs. *In formulating your answers*, assume that there are *no* other obstructions or vessel *traffic other* than the platforms pictured. In addition, assume that there is sufficient *sea room* outside the Traffic lanes in the sketch. If your response is dependent on conditions of visibility in the channel, then *assume* a visibility condition would influence your response the most and thereby cause the largest deviation as compared to normal transit in clear visibility. Indicate the range of visibility which your answer assumes by noting it on the sketch. DRAW IN YOUR PREFERRED TRACK LINE IN VIEW OF THE PLATFORM PLACEMENT ILLUSTRATED IN EACH OF THE FOLLOWING EXAMPLES.



APPENDIX G

THE COMPUTER AIDED OPERATIONS RESEARCH FACILITY (CAORF)

G.1 DESCRIPTION OF CAORF

CAORF is a sophisticated ship-maneuvering simulator operated by the U.S. Maritime Administration for controlled research into man-ship-environment problems. Controlled experiments, which might require several vessels, cannot be performed readily in the real world and would certainly be ruled out for testing situations that involved potential danger. Such experiments can be performed safely and easily at CAORF. A simplified cutaway of the simulator building is shown in Figure G-1 and the relationships among the major subsystems are illustrated in Figure G-2.

All actions called for by the watch officer on the bridge are fed through a central computer that alters the visual scene and all bridge displays and repeaters in accordance with the calculated dynamic response of ownship and the environmental situation being simulated. CAORF has the capability of simulating any ship, port, or area in the world. The major subsystems are:

- **Wheelhouse,** which contains all the equipment and controls needed by the test subject watch officer to maneuver ownship through a scenario, and includes propulsion and steering controls, navigational equipment, and communication gear

- **Central Data Processor,** which computes the motion of ownship in accordance with its known characteristics, models the behavior of all other traffic ships, and drives the appropriate bridge indicators

- **Image Generator,** which constructs the computer-generated visual image of the surrounding environment and traffic ships that is projected onto a cylindrical screen for visual realism

- **Radar Signal Generator,** which synthesizes video signals to stimulate the bridge radars and collision avoidance system for the display of traffic ships and surrounding environment

- **Control Station,** from which the experiment can be monitored and (if desired) traffic ships and environment can be controlled

- **Human Factors Monitoring Station,** from which unobtrusive observation and video recording of test subject behavior can be carried out by experimental psychologists.

G.2 SIMULATED BRIDGE

The simulated bridge consists of a wheelhouse 20 feet (6.1 m) wide and 14 feet (4.3 m) deep. The equipment on the CAORF bridge is similar to that normally available in the merchant fleet and responds with realistically duplicated time delays and accuracy. The arrangement is based on contemporary bridge design. It includes:

- **Steering Controls and Displays** – a gyropilot helm unit with standard steering modes, rate of turn indicator, rudder angle/rudder order indicators, and gyro repeaters

- **Propulsion Controls and Displays** – an engine control panel (capable of simulating bridge or engine room control) containing a combined engine order telegraph/throttle, an rpm indicator and a switch for selecting the operating mode, such as finished with engine, warm up, maneuvering and sea speed

- **Thruster Controls and Display** – bow and stern thrusters and their respective indicators and status lights

- **Navigation Systems** – two radars capable of both relative and true motion presentations, plus a collision avoidance system. Capability exists for future additions such as a digital fathometer, Radio Direction Finder, and Loran C and Omega systems

- **Communications** – simulated VHF/SSB radio, docking loudspeaker (talkback) system, sound powered phones and ship's whistle

- **Wind Indicators** – indicate true speed and direction of simulated wind.

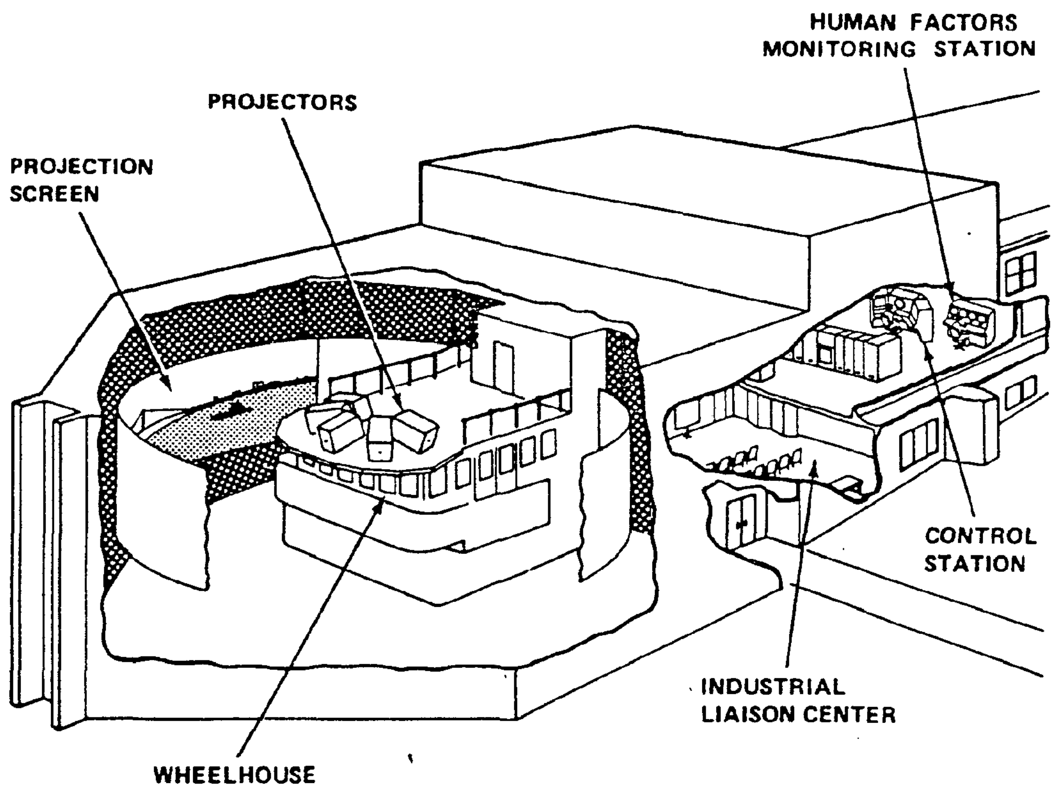


Figure G-1. Cutaway of CAORF Building

G.3 OWNSHIP SIMULATION

Any ship can be simulated at CAORF. The computerized equations of motion are adapted to the ship by changing specific coefficients, among which are hydrodynamic, inertial, propulsion, thruster, rudder, aerodynamic, etc. Wind and currents realistically affect ship motion according to draft (loaded or ballasted) and relative speed and direction. Ownship's computer model was validated by comparing various simulated maneuvers (e.g., zig-zag, turning circle, spiral, crash stop, and acceleration tests) with actual sea trial data.

G.4 IMAGE GENERATION

The visual scene is generated at CAORF to a degree of realism sufficient for valid simulation. The scene includes all the man-made structures and natural components of the surrounding scene that mariners familiar with the geographical area deem necessary as cues for navigation. Thus, bridges, buoys, lighthouses, tall buildings, mountains, glaciers, piers, coastlines, and islands would be depicted in the scene. In addition, the closest traffic ships and the forebody of ownship appear. All elements in the scene appear to move in response to ownship's maneuvers. The sky is depicted without clouds and the water without waves.

For enhanced realism the scene is projected in full color. The perspective is set for the actual bridge height above waterline for the simualted ship. Shadowing can be varied according to the position of the sun at different times of day.

Environmental conditions also affect the scene. The lighting can be varied continuously from full sun to moonless night. At night, lights can be seen on traffic vessels, buoys, piers, and other points ashore. Visibility in day or night can be reduced to simulate any degree of fog or haze.

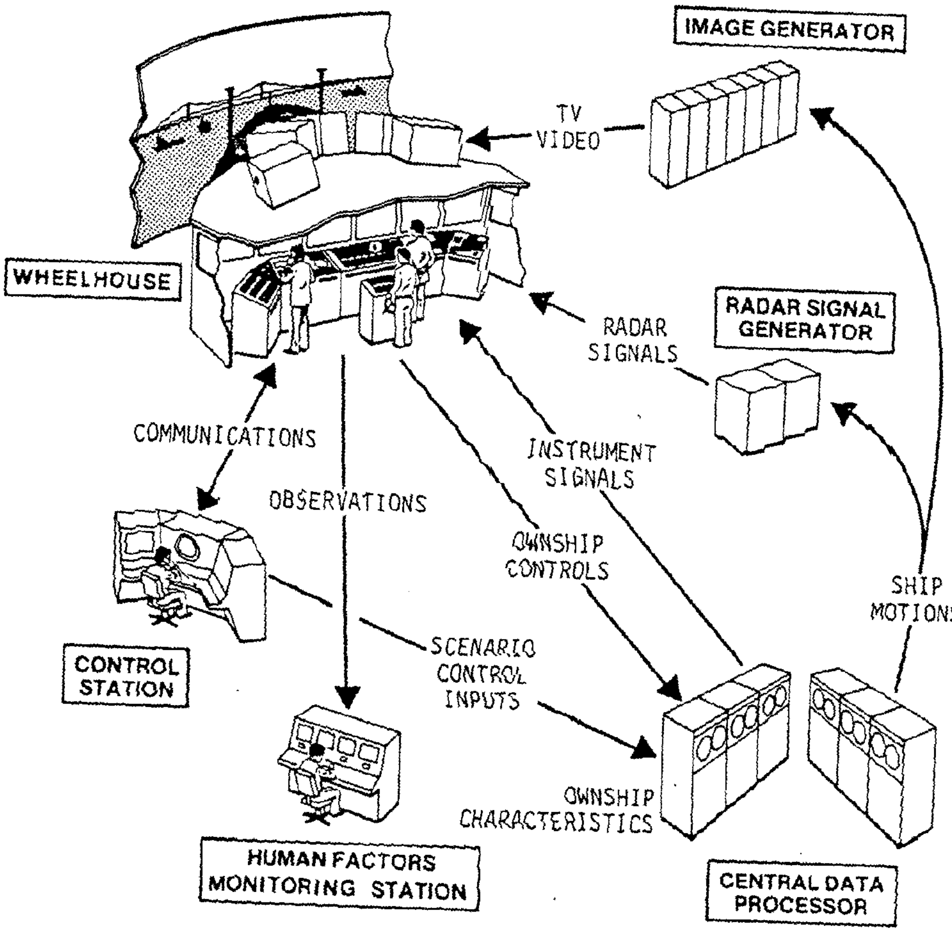


Figure G-2. Major CAORF Subsystems

G.5 RADAR SIGNAL GENERATION

The Radar Signal Generator produces real-time video signals for driving the two radar PPIs. The items displayed are synchronized with the visual scene and include navigation aids, ships, shorelines and other topographical features with appropriate target shadowing, clutter, range attenuation, and receiver noise. The radar gaming area, which covers an area of 150 by 200 miles, extends beyond the visual gaming area, which is 50 by 100 miles. Within the radar gaming area, as many as 40 moving traffic ships can be displayed. The radar signal generator also drives the collision avoidance system, which can be slaved to either of the master PPIs.

G.6 CONTROL STATION

The Control Station is the central location from which the simulator experiment is controlled and monitored. An experiment can be initiated anywhere within the visual gaming area with any ship traffic configuration. The Control Station enables the researchers to interface with the watch-standing crew on the bridge, to simulate malfunctions, and to control the operating mode of the simulator. The Control Station is also capable of controlling motions of traffic ships and tugs in the gaming area and simulating telephone, intercom, radio (VHF, SSB) and whistle contact with the CAORF bridge crew.

G.7 HUMAN FACTORS MONITORING STATION

The Human Factors Monitoring Station is designed to allow collection of data on crew behavior. Monitoring data is provided by five closed-circuit TV cameras and four microphones strategically located throughout the wheelhouse to record all activities, comments and commands.

APPENDIX H

EXISTING AND POTENTIALLY APPLICABLE RISK MANAGEMENT MITIGATION MEASURES

H.1 INTRODUCTION-MITIGATION TECHNIQUES

In a recent critique of the Coast Guard vessel safety program, the General Accounting Office (23, 24) pointed out that the number of serious marine accidents is growing. For example, in 1977 there were 2,330 collisions, rammings, and groundings with losses totalling more than 89 million dollars. Figures for 1978 and 1979 are higher. Among the recommendations made in the GAO reports were: (1) improved inspection of U.S. vessels, (2) increased boarding and examination of foreign vessels, (3) licensing of merchant marine personnel, and (4) the promotion of international marine safety. These are some of the key elements in a system approach to marine safety, but are not a complete program in themselves. For some years, the Coast Guard has carried out a variety of research and development programs often in association with other agencies such as the Maritime Administration (MarAd) and the Department of Energy to improve marine (and port) safety. However, until recently reliance has still been mainly on rules and regulations. With the rash of marine accidents in the winter of 1976-77, pressure increased for a more forceful and deterministic approach to marine safety. Further, several states (Alaska and Washington) began to press for improved vessel safety. All of this culminated in the landmark Port and Tanker Safety Act of 1978 (P.L. 95-474). This act mandated certain design and equipment improvements to all vessels calling on U.S. ports. Included were cargo tank inerting systems, dual radars, and most recently (25) collision avoidance aids, even though the average cost per ship installation was $70,000 to obtain an estimated reduction of collisions and groundings of only 10 percent. The act also requested the U.S. Coast Guard to carry out a vessel port access route study for all districts and a positive vessel track monitoring study. The vessel access route study for the Southern California area (11th U.S. Coast Guard District) is due by the end of 1980, while the monitoring system study is due to be delivered to Congress in October 1980. The key element of this latter study is the idea of monitoring ship movements from shore, independent of any actions taken on the vessel. This approach is analogous to aircraft traffic control. Although the legal ramifications have not been completely worked out, the trend towards mandatory vessel traffic control systems is accelerating. For example, recent attempts to cut the budgets for the New York and New Orleans Vessel Traffic System (VTS) were thwarted by local, state, and Congressional protests. In the accident-prone Houston ship channel, the VTS was made mandatory in August 1980.

In the area of international marine safety, significant progress has been made by the Coast Guard working with the International Maritime Consultative Organization (IMCO) in London. (IMCO is the world organization which sets the rules of the sea.) The European Community, spurred by the Amco Cadiz and other major accidents in recent years, has recently adopted a draft that sets standards for construction, equipment, and crew of vessels and provides enforcement powers. These standards will be implemented within 18 months.

As far as emergency response systems are concerned, joint programs are underway with MarAd and NASA. These include the Puget Sound organizational effort and hardware development at the Marshall Space Flight Center.

H.2 SANTA BARBARA CHANNEL RISK MITIGATION REQUIREMENTS

A major accident in the Santa Barbara channel with significant environmental impact is unacceptable to the public and might affect resource recovery for many years in a manner similar to the 1969 spill. Earlier sections in this report have discussed the projected vessel traffic, the projected offshore oil-related development and construction, the climatological conditions in the Channel, and the statistical data base of maritime casualties. Therefore, it is essential that system safety analysis be applied to the Channel with major emphasis on preventing the significant accident. For example, although the level of traffic considered by itself could probably not justify a high level VTS system, consideration of all the risk elements might make the Channel a candidate for such a system. The Prince William Sound in Alaska has such a system with even less traffic, and the Chesapeake Bay in Maryland is under evaluation because of recent ship casualties. It would be unfortunate if the Channel became a candidate for a VTS only after a major casualty. The cost of that casualty would likely far exceed the cost and operation of a modern cost-effective VTS.

H.3 APPLICABLE RISK MANAGEMENT TECHNIQUES

H.3.1 EXISTING RISK MANAGEMENT

H.3.1.1 Organization and Planning. Often the focus in a risk management program is on regulations and hardware. However, of key importance is the development of a risk management organization for the Santa Barbara Channel. Such an organization should include the U.S. Coast Guard, U.S. Geological Survey, State of California, County of Santa Barbara, and local cities. In Washington state, some effort along this line has recently been initiated by the Department of Transportation with the Puget Sound Council on Governments. The focus of this program (26) is mainly on emergency response to hazardous spill accidents. It does, however, provide a framework for a more comprehensive program. Efforts in this direction have been successfully implemented in Europe and Japan.

In the Santa Barbara Channel, the existing organization and planning for response to a casualty and an actual or threatened oil spill lies in two major areas, governmental and industry. The governmental response planning is further divided into Federal and State.

The Federal spill contingency plans begin with the National Response Team, and include the Regional Response Team at a regional level and the local planning of the local On-Scene Coordinator (OSC). The primary physical response capability by the Federal government is the U.S. Coast Guard's three Strike Teams. For the Santa Barbara Channel, the Coast Guard Pacific Strike Team, headquartered at Hamilton Air Force Base (near San Francisco) would provide the first on-scene Federal oil contaiment and recovery hardware and personnel.

The State plans provide for organizatioal response by a number of State Agencies such as the Department of Fish and Game, Regional Water Quality Control Boards, Office of Emergency Services, and others.

At the industry level, a very large amount of planning and equipment for oil spill response is available within the oil industry and also by virtue of spill response cooperatives established to protect the coastal areas.

Industry response, hardware, and capabilities may be divided into three categories. These are:

- on-scene equipment;
- spill response cooperative equipment and resources, and existing contingency plans;
- contractor equipment and resources.

a. **On-Scene Equipment**

For exploratory drilling activities in the Santa Barbara Channel, the California Coastal Commission in conjunction with the USGS require a certain minimum of equipment and preparation at the drill site. This includes at least 1,500 feet of spill containment boom and a boat capable of deploying it. The boat must be within 15 minutes of the site. Further, some type of skimming or pickup device must be on site, as well as certain dispersants and sorbent material. These on-site requirements have been developed by the Coastal Commission and USGS over a period of time, and are exercised via surprise drills called from time to time.

The on-scene equipment may be viewed as the "first-level" response to a spill incident at the operation.

b. **Spill Response Cooperative and Contingency Plans**

There are three spill response cooperatives in Southern California. The Southern California Petroleum Contingency Organization (SC-PCO), which is operated jointly with Clean Coastal Waters (CCW), has equipment staged in San Pedro and on Catalina Island, and is prepared to respond in the area from Point Dume to the Mexican border. SC-PCO is set up to respond to offshore spills, while the CCW element is prepared to combat spills in the harbor areas.

The third area cooperative, and the one specifically organized to respond to spills in the area which includes the Santa Barbara Channel, is Clean Seas, headquartered in Goleta. Clean Seas is a cooperative organization of fifteen oil companies, and maintains a large inventory of spill containment and cleanup equipment, both prestaged at points along the coast and stored at its main yard at Carpinteria. The prestaged inventory is located at eight points from Estero Bay to Ventura, and is mostly stored in large semi-trailers for rapid movement to a spill scene.

The Clean Seas equipment includes at least four miles of containment boom, skimmers of various capabilities and capacities, and storage systems of various sizes including a large barge based in Ventura harbor. Some of the containment boom is prepacked in boats for fast deployment. A complete inventory, including locations, capability and capacities, and deployment plans are contained in the Clean Seas Oil Spill Cleanup Manual (27).

In addition to the equipment and planning to contain and pick up oil spilled at the site of a casualty, Clean Seas has equipment and detailed plans for defense of sensitive or otherwise important shoreline areas such as harbors and marinas. Plans and prepositioned attachment points, pilings, etc., have been established by Clean Seas for the placement of primary, secondary, and diversionary booms as necessary. Detailed maps of the area potentially impacted by a spill from the proposed drilling operations are included in the Clean Seas manual. These maps and their associated text describe sensitve areas, general shoreline descriptive data, access routes, biological data, property ownership and control with points of contact, seasonal influences, potential disposal sites, and many other factors necessary and/or useful in planning pollution defense and cleanup.

Finally, the local planning by the cooperative includes use of outside contractors and services for provision of manpower and equipment. Areas are covered such as beach cleanup, helicopter surveillance, crane services, trucking, welding, boat usage, diving, towing, earth moving and hauling, vacuum truck operation, and other special services. Contractors in most of these support areas are under contract to Clean Seas as a matter of policy.

c. Contractors

There are three primary oil spill response contractors in Southern California, possessing a vast amount of equipment of many types, i.e., Crowley Environmental Services, IT Services, and Crosby and Overton. While they are equipped primarily to handle oil spills in sheltered waters, each has some capability to respond in the offshore area of the proposed drilling operations. This capability can be augmented by hiring of equipment from others and/or by making use of offshore equipment held by the cooperatives. Crowley's parent company has a fleet of tugs, barges, and salvage craft at its disposal. These contractors can be set into action by direction of the Federal On Scene Coordinator, by the Cooperatives, or by the spiller itself.

H.3.1.2 Tank Ship Risk Mitigation

a. Background

During the winter of 1976/1977, several tanker casualties occurred in or near U.S. waters which demonstrated the need for a global effort to improve both the level of safety and degree of pollution prevention from oil tankers. This series of casualties resulted in great public concern within the United States regarding the risks associated with the marine transportation of oil. Public demand for the Federal Government to take additional steps to improve tanker safety and pollution prevention were evident.

Both the Executive Branch of the Federal Government and the Congress responded to these demands. An Interagency Oil Pollution Task Force was established to review the problem and make recommendations. As a result, on March 17, 1977, President Carter announced a series of desired Federal Government actions to deal with the problem of marine oil pollution caused by oil tankers.

These Presidential Initiatives included a diverse but interrelated group of measures designed to reduce the risks associated with the marine transportation of oil. These measures, both international and domestic in nature and scope, were aimed toward achieving a number of objectives, including reform of ship construction and equipment standards for all U.S. oil tankers of 20,000 DWT and above and foreign oil tankers of 20,000 DWT and above that enter U.S. ports.

Specifically, the Secretary of Transportation was directed to develop new rules within 60 days which would include:

- Double bottoms on all new tankers.
- Segregated ballast on all tankers (SBT).
- Inert gas systems on all tankers (IGS).
- Backup radar and collision avoidance equipment on all tankers.
- Improved steering gear standards for all tankers.

In response to these Presidential Initiatives, the Coast Guard published proposed rules in the May 16, 1977 issue of the Federal Register to incorporate the recommended changes to tanker construction and equipment standards. At the same time, as part of the Presidential Initiaves, the

United States proposed changes to the international standards for tanker construction and equipment and the international system for inspection and certification of tankers. These proposals, together with various alternatives, were considered at the IMCO-sponsored Tanker Safety and Pollution Prevention (TSPP) Conference. The Coast Guard decided to wait until the TSPP Conference was concluded before taking any further action on the regulatory proposals made on May 16, 1977.

The TSPP Conference adopted two very important instruments that contained internationally-agreed upon standards to reduce pollution from and improve the safety of tank vessels:

The Protocol of 1978 Relating to the International Convention for the Safety of Life at Sea, 1974 (SOLAS Protocol) which amended and added requirements to the Convention for the Safety of Life at Sea (SOLAS 74). In view of the fact that eleven administrations had already ratified SOLAS 74, it was decided at IMCO to make the SOLAS Protocol a separate instrument for ratification.

The Protocol of 1978 Relating to the International Convention for the Prevention of Pollution from Ships, 1973 (MARPOL Protocol) which amended and incorporated requirements of the Convention for the Prevention of Pollution from Ships (MARPOL 73). Only three administrations had ratified MARPOL 73; therefore, the MARPOL Protocol was combined with its parent Convention, MARPOL 73, for ratification as one single instrument called the MARPOL Protocol.

These two instruments, the SOLAS and MARPOL Protocols, contained new standards for SBT, Clean Ballast Tanks (CBT), Crude Oil Washing (COW), IGS, improved steering gear standards, and dual radar for tank vessels. These standards adopted by the TSPP Conference are at least equivalent to and in some instances are more stringent than the Presidential Initiatives.

In the spring of 1978, the Coast Guard began work in developing regulatory amendments which would withdraw the proposed rules for double bottoms, SBT, IGS, and improved steering gear standards published in the Federal Register of May 16, 1977 and in their place, substitute the related standards developed at the TSPP Conference. The standards developed at the TSPP Conference for dual radar were the same as those proposed on May 16 and were, therefore, issued as final rules on July 24, 1978.

On October 17, 1978 the Port and Tanker Safety Act of 1978 (PTSA, PL 95-474) became law and mandated, as a minimum, the tanker construction and equipment standards developed at the TSPP Conference. The PTSA became new authority for issuing the regulations which implement the TSPP standards. The implementation dates contained in the PTSA are the same as those recommended in Resolutions One and Two of the TSPP Conference. In addition, the PTSA mandates additional construction standards which were not developed at the TSPP Conference. These include requirements for existing tank vessels 20-40,000 DWT and for tank vessels that transfer oil from the Outer Continental Shelf (OCS).

The U.S. Coast Guard issued new proposed regulations for SBT, CBT, COW, IGS, and improved steering gear standards on February 12, 1978 and, at the same time, withdrew the proposals for double bottoms, SBT, IGS, and improved steering gear standards which were published on May 16, 1977. Interested parties were given 60 days to submit comments concerning this action to the U.S. Coast Guard. A number of changes were made to the detailed requirements for COW and CBT based on the comments received. This rulemaking action was a perfect example of how the U.S. Coast Guard and industry can work together to produce well-written technical requirements. Interim final rules for SBT, CBT, and COW and final rules for IGS and improved steering gear standards were published on November 19, 1979. Final rules for SBT, CBT, and COW were issued on June 30, 1980 with only a few minor editorial modifications.

b. Overview

Section 5 of the PTSA contains the standards applicable to tank vessels. These include:

1. SBT/CBT/COW
2. Inert gas systems
3. Improved steering gear systems
4. Navigation equipment
5. Requirements for tank vessels in OCS trade
6. Requirements for existing tank vessels 20-40,000 DWT
7. Specific trade exemptions
8. Personnel standards
9. Lightering operations.

As of this date, regulations addressing all of these subjects have not been issued. Regulations for some of these standards have been issued as final rules, others have been issued as proposed rules, and still others have yet to be issued.

The U.S. Coast Guard goal is to implement these standards and their interpretations in a policy that is consistent with those agreed to internationally at IMCO. Work regarding interpretations has been conducted, and is continuing at IMCO with U.S. Coast Guard participation. To assist the industry with the interpretations of the U.S. Coast Guard regulations that were issued on November 19, 1979, a draft regulatory guide has been prepared.

With regard to ratification of the MARPOL and SOLAS Protocols, both were submitted to the Senate in January 1979 for advice and consent. The House of Representatives has recently held hearings on implementing legislation for the MARPOL Protocol.

On July 2, 1980, the U.S. Senate, by a vote of 90 to 0, passed a resolution giving its advice and consent to ratification of the SOLAS and MARPOL Protocols. The U.S. can, therefore, be expected to deposit instruments of ratification of these documents with IMCO in the near future.

Several of the applicable areas listed above are discussed in detail in the following subsections.

SEGREGATED BALLAST TANKS, DEDICATED CLEAN BALLAST TANKS, AND CRUDE OIL WASHING SYSTEMS

The U.S. Coast Guard has established four regulatory projects to implement the requirements for segregated ballast tanks (SBT), dedicated clean ballast tanks (CBT), and crude oil washing (COW) systems mandated by the PTSA. A new tank vessel is one that is contracted for after June 1, 1979, has the keel laid after January 1, 1980, or is delivered after June 1, 1982.

(1) The first project applies to new crude oil carriers of 20,000 DWT and above, new product carriers of 30,000 DWT and above, and existing crude oil and product carriers of 40,000 DWT and above. Proposed rules were published on February 12, 1979 and interim final rules were published on November 19, 1979 in 33 CFR 157. This project implements paragraphs A, B, D, and G of subsection 7 of Section 5 of the PTSA. The specific requirements that these vessels must meet are as follows:

- New crude oil carrier of 20,000 DWT or above—protectively located SBT and a COW system upon delivery.
- New product carrier of 30,000 DWT or above—protectively located SBT upon delivery.
- Existing product carrier of 40,000 DWT or above—SBT or CBT by June 1, 1981.
- Existing crude oil carrier of 40,000 DWT or above—SBT, CBT, or COW by June 1, 1981; then, SBT or COW by June 1, 1983 for vessels 70,000 DWT or more, and June 1, 1985 for vessels 40,000 DWT or more but less than 70,000 DWT.

These regulations are consistent with the standards developed at the IMCO sponsored Tanker Safety and Pollution Prevention Conference in February 1978. A draft regulatory guide was prepared by the U.S. Coast Guard to assist with the implementation and interpretation of these regulations and those regulations for inert gas systems and steering gear standards which were also published as final rules on November 19, 1979.

Interim final rules were issued because of changes to the assignment of responsibility for various operating requirements. Final rules were issued on June 30, 1980 with only a few editorial modifications.

(2) The second project applies to tank vessels engaged in the transfer of oil from the Outer Continental Shelf (OCS). Paragraph M of subsection 7 of Section 5 of the PTSA requires any tank vessel that transfers oil from the OCS to be equipped with SBT, CBT, or special ballast arrangements. Proposed regulations were issued in the Federal Register in 33 CFR 157 on May 1, 1980. The comment period was open until June 16, 1980. Final rules are expected to be issued by the fall of 1980.

(3) The third project implements paragraph N of subsection 7 of Section 5 of the PTSA which provides existing U.S. tank vessels with an exemption from the requirements of SBT, CBT, or COW if shore-based reception facilities are determined to be the preferred method of handling dirty ballast mixtures. Proposed rules were issued in the Federal Register in 33 CFR 157 on May 22, 1980. The comment period was open until July 7, 1980. Final rules are expected to be issued in the fall of 1980.

(4) The fourth project applies to existing tank vessels between 20,000 and 40,000 DWT. Paragraphs E and H of subsection 7 of Section 5 of the PTSA require an existing crude oil carrier of 20,000-40,000 DWT to be equipped with SBT or COW and an existing product carrier of 20,000-40,000 DWT to be equipped with SBT or CBT by January 1, 1986 or when the vessel is 15 years of age, whichever occurs later. The U.S. Coast Guard is currently

working on a cost benefit analysis for these requirements which is expected to be completed by the end of summer 1980.

STEERING GEAR

Recent casualties have highlighted the need for improved steering gear standards. These include:

- SEA WITCH/ESSO BRUSSELS collision in New York harbor.
- SITALA collision with moored barges in New Orleans.
- MARINE FLORIDIAN collision with the Benjamin Harrison bridge in Hopewell, Virginia.
- AMOCO CADIZ off the coast of France.

These accidents dramatically underline what can occur when there is a steering gear failure in a critical maneuvering situation or when steering gear capability cannot be recovered within a reasonable period of time. The current philosophy to improve this situation leans more toward duplication of components, which is being reflected in the latest national and international regulations.

International Regulations

SOLAS 74, Regulations 29 and 30 of Chapter II-1, Machinery and Electrical Regulations are not very extensive. They lean more toward passenger vessels than cargo vessels.

IMCO Resolution A.325(IX), Recommendations for Machinery and Electrical Installations, was developed in 1975 by the Ship Design and Equipment Subcommittee and included much more extensive requirements for cargo vessels. Many of these requirements were the basis of the TSPP Conference requirements.

The requirements of the 1978 TSPP Conference were very similar to A.325, but also included retrofit standards for existing tank vessels for the first time.

National Regulations

Steering gear requirements have been included in 46 CFR 58.25 (marine engineering) and 46 CFR 111 and 113 (electrical engineering) with very little change since 1963.

November 19, 1979 Federal Register made the first substantial amendments and additions to steering gear requirements which were included in 33 CFR Part 164.

Current and Future Action

Proposed electrical regulations were issued on March 3, 1980. The major items of this proposed action include amendments to 46 CFR 111.93 which basically implement Resolution A.325 for all U.S. vessels and the amendments to 46 CFR 113 which propose a steering failure alarm when rudder control is lost.

Docket opened for the issuance of proposed rules implementing Regulation 19 developed at the TSPP Conference requiring tests and drills to be conducted on U.S. and foreign vessels other than tankers. Proposed rules are expected to be issued by late 1980.

IMCO is preparing a revision to Resolution A.325 as a result of the AMOCO CADIZ accident. Standards developed at TSPP Conference would not have prevented the AMOCO CADIZ accident; therefore, additional amendments have been established, primarily aimed at improving the hydraulic systems of the steering gear. The major amendment would require recovery from a steering gear failure in 45 seconds on all new tankers of 10,000 gross tons and above. A U.S. Coast Guard regulatory project will be established to parallel these international requirements when they are approved.

NAVIGATION EQUIPMENT

The requirements for navigation equipment are contained in paragraph J of subsection 7 of Section 5 of the PTSA. These requirements are applicable to vessels of 10,000 gross tons or above and include:

- Dual radar system
- Electronic relative motion analyzer
- Electronic position fixing device
- Adequate communications equipment
- Sonic depth finder
- Gyrocompass
- Up-to-date charts.

The requirements for adequate communication equipment, a sonic depth finder, a gyrocompass, and up-to-date charts are not new. They have been required by previous legislative and regulatory action, therefore, additional regulatory projects for these items will not be necessary.

The requirements for dual radar were published in the Federal Register on July 24, 1978 and were amended on May 7, 1979 to include the standards for dual radar mandated by the PTSA. These include short-range and long-range capabilities and true north features. With regard to short-range and long-range capabilities, a separate "S" and separate "X" band radar are not required. With regard to the true north features, a display that is stabilized in azimuth is required. These standards are required on tank vessels as of June 1, 1979.

The regulations for electronic position fixing devices were published in the Federal Register as final rules on May 31, 1979. These regulations require Loran-C, a hybrid satellite system, or an equivalent system acceptable to the Commandant. This equipment is required on tank vessels of 10,000 gross tons or more by June 1, 1979 and on tank vessels of 1,600 gross tons butt less than 10,000 gross tons by June 1, 1982. All the specific requirements are contained in the regulations but there are two major points to mention:

(1) A Loran-C receiver installed after May 31, 1979 must be Type I or II meeting Part 2 of the Radio Technical Commission for Marine Services (RTCM) Paper 12-78/DO-100 dated December 20, 1977. A Loran-C receiver installed on or before May 31, 1979 that is not Type I or II must be replaced by a Type I or II receiver by June 1, 1982.

(2) A hybrid satellite system must have, among other things, a continual tracking integrated complimentary system. If a hybrid satellite system is installed before June 1, 1982, the continual tracking integrated complimentary system is not required until June 1, 1985. A U.S. Coast Guard study of vessel collisions will be conducted to determine if the requirement for a continual tracking integrated complimentary system is unnecessary. If the study reveals that such equipment is not necessary, a regulatory project will be initiated to make the proper modifications to the regulations. Until that time, the continual tracking integrated complimentary system is required.

Proposed regulations for electronic relative motion analyzers (ERMA) were published in the Federal Register on February 21, 1980. This equipment has also been referred to as "collision avoidance aids" (CAA), or by IMCO as "automatic radar plotting aids" (ARPA). This proposal adopts the IMCO ARPA standard except that the Maritime Administration (MarAd) standard for both visual and audible operational warnings would be required. A copy of both the IMCO and MarAd standards are contained as Appendices to the proposed regulations. The comment period for this proposal closed on April 7, 1980 and the U.S. Coast Guard is in the process of evaluating the comments received and developing final rules. As mandated by the PTSA, ERMA is required by July 1, 1982. Final rules are scheduled to be issued by July 1980 to provide industry with a two-year lead time.

Any additional navigation equipment requirements developed by IMCO will be implemented by the U.S. Coast Guard in future regulatory projects. All of the navigation equipment requirements addressed here are codified in 33 CFR 164.

PERSONNEL AND MANNING STANDARDS

On July 7, 1978, the International Conference on Training and Certification of Seafarers adopted the International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers (STWC-78). This Convention established international standards for the qualification and training of seafarers. It also established minimum watchkeeping standards. The STWC Convention was forwarded to the Department of State on April 9, 1979 to initiate the necessary action to obtain advice and consent of the U.S. Senate to ratification.

The PTSA mandates qualification and training standards forr personnel serving on foreign tank vessels. The U.S. Coast Guard published an interim final rule on April 7, 1980 which contains interim procedures for evaluating tank vessel personnel licensing and certification programs of foreign countries. The USCG is presently in the process of evaluating the materials received from foreign countries; however, there are many problems associated with the evaluation process, some of which are discussed in the interim final rule. It is doubtful that any determination will be made in the near future, but until a determination is made and issued to the public, foreign vessels will be allowed to continue operating in U.S. waters.

At the present there are no detailed international requirements pertaining to manning levels. SOLAS 74, which became effective on May 25, 1980, contains requirements for a vessel to carry a radio officer, but otherwise leaves to each administration the responsibility to ensure that ships of their nationality are sufficiently and efficiently manned from the point of view of safety of life at sea. The International Convention on Standards of Training, Certification, and Watchkeeping for Seafarers prescribes qualifications for vessel personnel but does not prescribe manning levels.

The Subcommittee on Standards of Traning and Watchkeeping at its 11th, 12th, and 13th sessions did consider the manning issue; however, they have rejected the concept of international manning scales. Instead they have formulated basic principles to determine safe manning.

The PTSA requires that manning levels be established for foreign tank vessels when operating in U.S. navigable waters or ports. Minimum manning levels are presently being developed and should be published as a notice of proposed rulemaking in the summer of 1980. Since this rule is presently in the developmental stage, it is premature to attempt to discuss it in detail. Once the rule is issued, public comments or questions can be submitted to the public docket and addressed during the preparation of final rules.

H.3.2 POTENTIAL RISK MANAGEMENT MEASURES

H.3.2.1 Casualty Data Base. As discussed in Chapter 5 (Statistical Data Base for Risk Analysis) a computerized data base for all commercial ships over 1,000 tons has been developed.

This data bank contains not only information about ship characteristics and accident records but also specifics about berthing practices, ownership, level of crew training, etc. The bank could be expanded to include mandatory reporting of incidents that do not necessarily lead to significant accidents. This procedure was recommended by the National Academy of Sciences in its report on the safety aspects of LNG transportation. By means of the international timesharing computer network, data could be retrieved almost instantly by the risk management organization through use of a desktop intertype. Eventually, through a satellite such as Marisat, real-time characteristics of a ship passing through the Channel could be monitored. A similar file for all drill ships and production platforms in the channel could also be kept.

H.3.2.2 Vessel Speed Control. A simple but effective approach to reducing the effects of a collision is to institute vessel speed control where indicated. For the Channel, the most applicable region would be the West end. Compliance with such a regulation would be monitored by means of VTS.

H.3.2.3 Simulator Research and Training. For the determination of appropriate separation distances between shipping lanes and drill-ship/platforms, the exercise of CAORF ship bridge simulator research scenarios is indicated. CAORF has been used for similar areas including Prince William Sound and Puget Sound. In addition to studying ship-ship and ship-platform scenarios, CAORF can play an important role in evaluating the man-navaid interface. Further, CAORF can study requirements for mariner training and licensing. Recently, Hammell and Gardinier (28) reported on the initial phase of a study into the use of simulators for training and licensing. It was noted that the Port and Tanker Safety Act of 1978 requires the development of standards for license qualifications by the use of simulators. The conclusion of a three-man year study by Hammell was that on the basis of safety, cost, and level of training, the simulator is preferable to on-the-job training at sea for most shiphandling skills. Ship handling simulators for training are already available, for example, at Marine Safety International in New York City. El Paso and Texaco have trained masters at this facility for handling LNG carriers and tankers. Marine Safety International is now offering a new restricted visibility bridge simulator for training under this critical weather condition.

H.3.2.4 Emergency Response Systems. Although not a primary mitigation measure, credible emergency response systems can play a significant role in mitigating the effects of a spill, stranded vessel, etc. Emergency response systems are still poorly defined. Note that in the recent tanker NORTH DAKOTA platform collision in the Gulf of Mexico, Smits International of the Netherlands was called upon to free the tanker from the platform structure. In the Santa Barbara Channel, aside from local resources to counter an oil spill, immediate resources to handle platform fires or disabled ships are lacking. Tugs might be dispatched from the San Francisco Bay or Los Angeles/Long Beach area. More likely, Navy resources in Port Hueneme would be called upon. If the LNG terminal is constructed at Point Conception, the tug support system available at the terminal might play a multipurpose role. A specific study for the Channel is indicated to determine the optimum allocation of emergency response resources.

H.3.2.5 Navigation Aids. The Port and Tanker Safety Act of 1978 mandated a number of navaids, as is discussed above in Section H.3.1.2. The new generation of tankers such as turned out by the Avondale and Sun shipyards have a wealth of navigation aids. Figure H-1 shows the equipment aboard a 120,000-ton tanker. Major concern as reflected in the legislation was not with this type of tanker but with the older class of both domestic and foreign types. For navaids under development, the CAORF simulator can play an important role in assessing their effectiveness. Recently

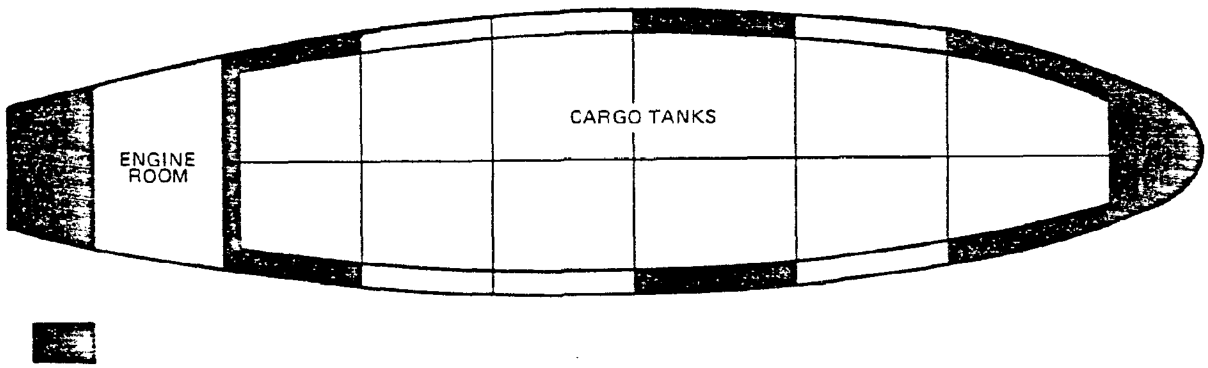
Dimensions

Length: 869 Ft.	Beam: 136 Ft.	Draft: 54 Ft.

Builder

Sun Shipbuilding and Drydock Company — Chester, Pennsylvania

Segregated Ballast and Cargo Systems



■ Ballast Tanks — Total Ballast Capacity = 42,000 tons

Ballast also carried in Double Bottoms

Navigational Equipment

Radio	Worldwide WT & RT Single Side Band Equipment.
VHF/UHF	UHF for on board communication. VHF for all marine channels.
Radio Direction Finder	ITT Mackay Automatic Radio Direct Finder.
Weather Facsimile Equipment	ITT Mackay equipment capable of receiving weather forecasts and charts.
Echo Sounders	Two echo sounders and transducers.
Omega	This navigation system is fully automatic and will give a position to within 1 to 2 miles anywhere in the world.
Loran	ITT Mackay type 4207A equipment will receive both Loran A and C.
Radars	10 cm and 3 cm radar installations by Radio Marine Corp. Two separate units with 16 inch displays.
Anti-Collision Equipment	The Digiplot system can display up to 40 targets and store data on a further 160 targets.
Gyro Compass	Two Sperry Mark 37 compasses plus repeaters.
Log	Modern doppler log equipment.

Figure H-1. Sun 120,000-Ton Ecological Tanker

Fee et al. (29) carried out a study for the National Maritime Research Center on an advanced capability vessel traffic serivce using a digital data link. The proposed test plan calls for evaluating advanced portable displays (navaid for pilot) in CAORF.

Transponders

The use of transponders as a link between ships and platforms has been studied as a collision mitigation measure by MarAd. Their value compared to other navaids such as visual, radar, collision avoidance system, etc., has been studied at CAORF (30). Figure H-2 shows a setup on the CAORF bridge while Figure H-3 shows information output by the transponder and experimental results obtained from tests of nine different open sea, clear visibility watches. Note that the collision avoidance gave the best results in terms of mean closests distance to target ships.

Figure H-4 shows how the transponder system on radar might be applied to the Santa Barbara Channel. RACON, which is a simplified transponder application; operates as an in-band swept radar frequency device. In the present limited use of RACONS, the frequencies in which they are designed to operate are the X-band, which is also allocated to the 3 cm marine radar. As the RACON will function with any available 3 cm radar, it will not provide any information on an S-band (10 cm) unit. The use of RACONS has been suggested for the Beta field platforms. However, the possibility of mutual interference with multiple RACONS and the potential for erroneous information to be provided due to stimulation by multiple ships simultaneously requires that further study be given their use. Jones (31) has recently reviewed the use of transponders at sea and concluded that they are experimental and not yet ready for widespread adoption.

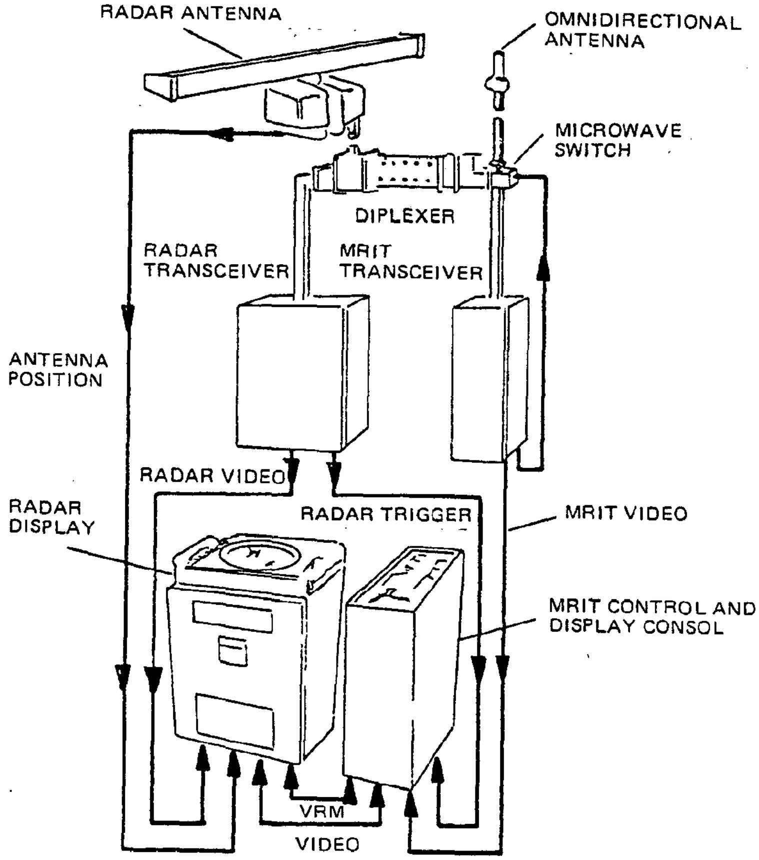
While the development of transponder technology is continued, a short-term solution might be the installation of large radar reflectors on platforms to enhance the intensity of the radar return, particularly on those platforms sited in proximity to the shipping lanes.

Precision Loran-C Navigation

The Loran-C navigation chain is now in full operation on the West Coast. A final rule by the U.S. Coast Guard (32) has now made it the preferred electronic navigation aid although satellite navigations systems (more costly) are acceptable. Standard Loran-C receivers are inexpensive ($2,000 to $6,000) and coming into widespread use for all types of vessels. The charted accuracy of this system in ordinary mode of reception is better than 500 meters. By using precision surveying techniques with a stable hyperbolic grid, accuracy to 10 meters is attainable. The Coast Guard has a major program underway on this precision navigation technique. The program was initiated in 1977 with an estimated completion date in 1982. Total cost of the effort will be over 7 million dollars. The program includes calibration of the West Coast chain and development of a low-cost precision navigator with appropriate displays. During the 1977-79 time period, the U.S. Coast Guard carried out a series of experiments with precision Loran-C navigation on the Saint Mary's River in Northern Michigan. The river is a water shipping route connecting withthe Saint Lawrence Seaway. Loran-C data was compared to other higher frequency positioning systems such as Raydist and Trisponder. The results of the Saint Mary's River tests indicated that Loran-C offered great promise for precision navigation. The experiments have continued. In the summer of 1979, experiments were carried out in Delaware Bay with the cooperation of the local pilots. The experiments for assessing precision navigation in the narrow Delaware river channel were successful. Calibration of the West Coast chain is expected to get underway in early 1981. Accuracy of 10 meters in navigating the Santa Barbara Channel would have a major positive impact on safety as compared to typical radar systems which suffer from clutter, weather effects, and interpretation ambiguities. A simple all weather display (precision Loran-C) would enable the master to quickly discern potentially-hazardous conditions even without the support of a shore monitoring station.

H.3.2.3 Vessel Traffic Systems (VTS)

Levels of Traffic Systems. Some years ago, the Coast Guard developed a generalized five-stage conceptional model of VTS based on increasing operational intensity. All stages assume the existence of adequate bridge-to-bridge and ship-to-shore communications. Level 1 is the lowest and includes only passive traffic separation schemes to help sort out traffic. The highest level, stage 5, includes full positive control of all marine traffic within a given area. In a recent review of the role of pilots in vessel traffic systems (33) Captain Koburger (U.S. Coast Guard-retired) makes the point that VTS is here to stay and pilots will have to live with them. Koburger states that the arguments for VTS are inescapable. At one time, marine accidents had limited impact. Now accidents like the AMOCO CADIZ impact thousands of people. As Koburger points out, no public is going to allow a threat of that magnitude to re-



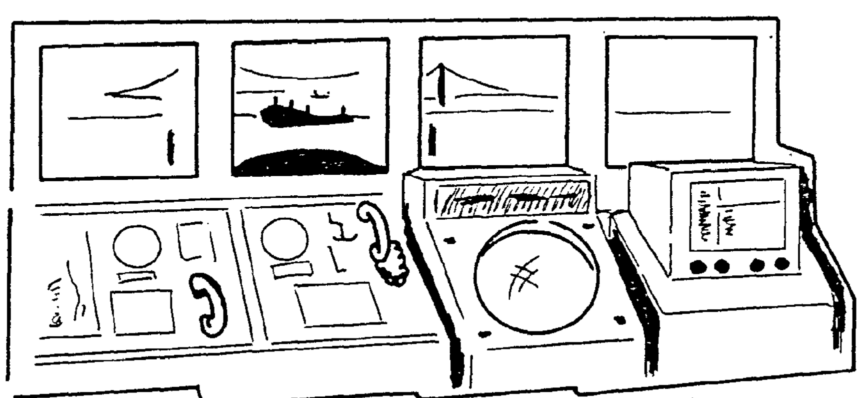
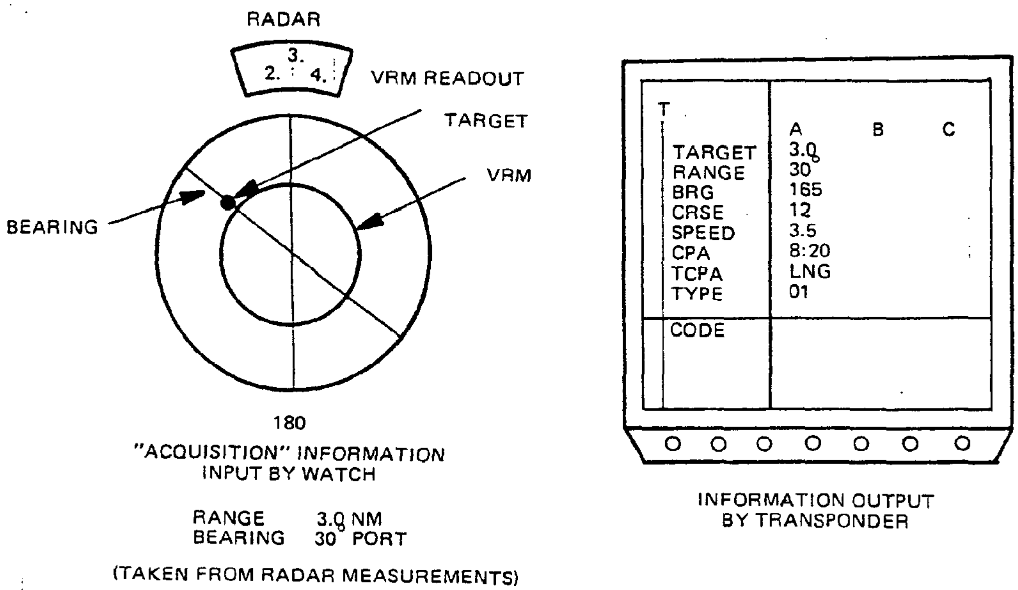


Figure H-2. Setup of Radar and Transponder on CAORF Bridge



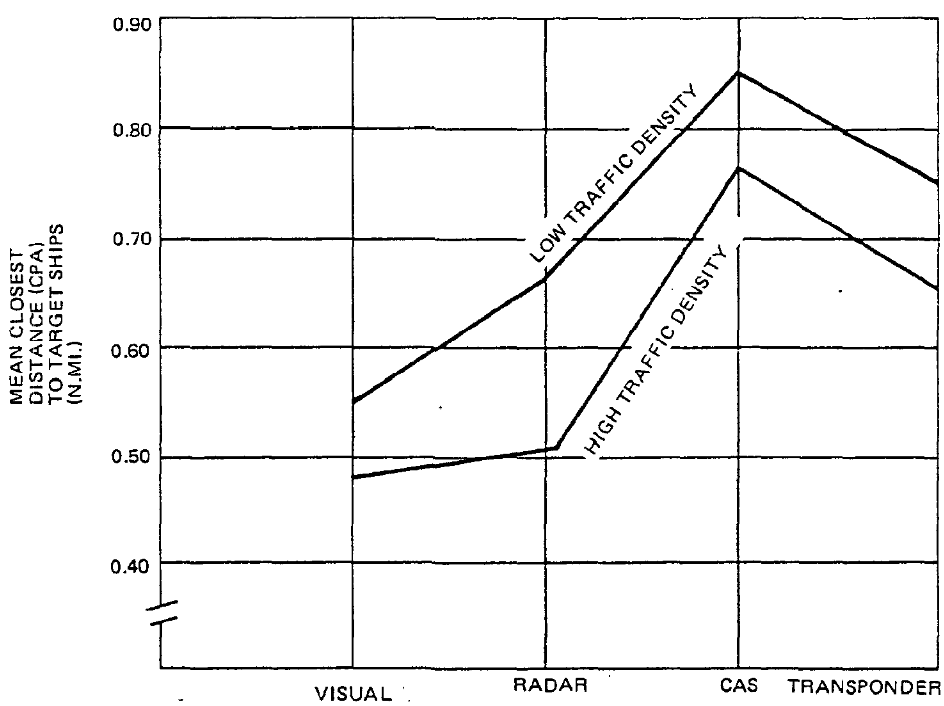


Figure H-3. Closest Distance (CPA) to Target Ships

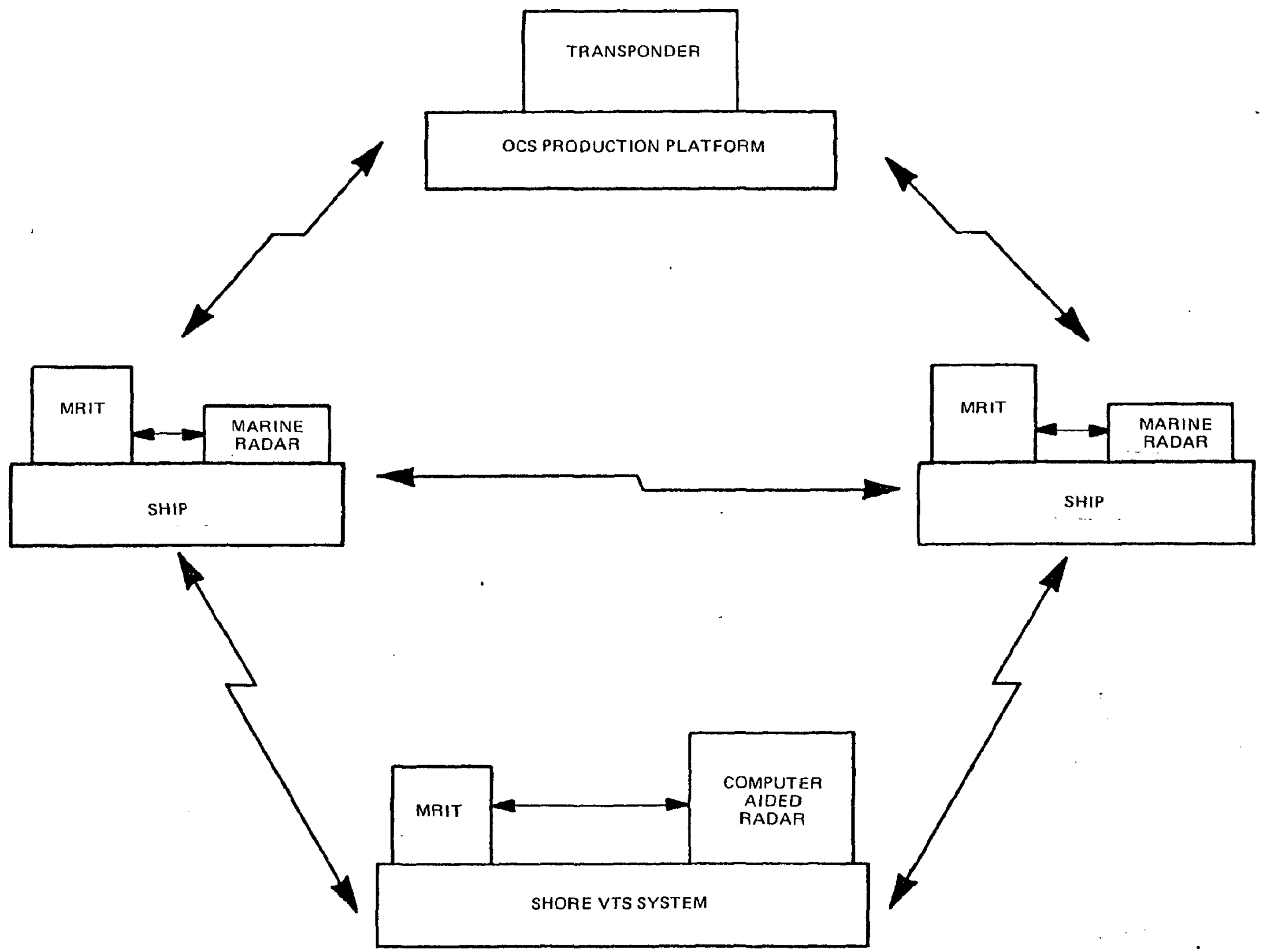


Figure H-4. Marine Radar Interrogator-Transponder System Application main without taking every reasonable additional measure to lessen the risk. Table H-1 shows the status of VTS as of March 1980. Note that Chesapeake Bay is under consideration because of recent marine casualties including a Coast Guard training vessel. Other regions are in an early stage of evaluation. Most of the current systems are combinations of radar, television, and radio communications.

Prince William Sound VTS

The Alaska pipeline act contained specific requirements for a VTS at Valdez using radar surveillance. The area covered is shown in Figure H-5. However, public and private interests wanted more surveillance than the Coast Guard originally proposed for the southern region of Prince William Sound as shown in Figure H-6. Since the TAPS tankers were already carrying Loran-C equipment, the development of a Loran-C position monitoring system was initiated a few years ago. In this system, Loran-C position data is transmitted to Valdez via a VHF radio link. The requirements for the radio link were recently defined (34) after extensive testing including tests with the ARCO FAIRBANKS tanker. The system is expected to become operational within the next 12 months. At the present time, the average daily volume of traffic in the sound is nine vessels transits per day of which four are tanker transits. Even the expansion of the Port of Valdez and construction of a proposed oil refinery, traffic will reach a maximum of 18 transits a day by 1985.

Loran-C Position Monitoring System
San Francisco Bay Tests

In the summer of 1978, the Coast Guard carried out a series of tests (35) to evaluate a prototype position monitoring system that used Loran-C as the surveillance sensor. The purpose of the tests was twofold: (1) to compare Loran-C position data against the standard radar position determination obtained with the San Francisco VTS and (2) improve and expand low cost VTS surveillance capabilities as authorized by the Ports and Waterways Act of 1972. The objectives of the tests were: (1) characterize a Loran-C surveillance system for use in VTS operations using easily available off-the-shelf components, (2) define the data communications link required, and (3) assess the potential accuracy of the system and evaluate its usefulness in enforcing vessel traffic separation standards.

Testing took place from 19 June through 30 June 1978. The boats used in the test included an Army Corp of Engineers tug and two boats operated by the U.S. Coast Guard auxiliary. Shipboard equipment consisted of a Loran-C receiver, a VHF-FM transceiver, and an interface between the two. Shipboard equipment transmitted a fixed format digital message at regular preselected intervals on a marine band VHF-FM frequency. The base station consisted of a DEC 11/34 computer, a floppy disk storage unit, a Tektronix 4014 direct view storage tube display, a Tektronix hard-copy unit, and the VHF transceiver. The basic block diagram is shown in figure 6-10. NOAA maps covering San Francisco Bay were digitized offline and stored on the floppy disk. The display module provides for user definition of submaps. Figure H-8 shows the screen display of map presentation on the left and system information on the right. System information consists of a real-time clock, a pad of operator instructions, and a list of vessels being monitored. Figure H-9 shows the logical flow of information into the Loran-C display system.

Evaluation of the key operator support function was conducted during these tests. The major test, that of easy operator acceptance, was passed successfully. A previously untrained operator learned to operate the Loran-C display unit in four half days of instruction. Estimated position accuracy for the bay with off-the-shelf hardware was ±330 feet. The following conclusions were drawn from the test program:

(1) A Loran-C based surveillance system can be implemented with a minimum of special purpose equipment.

(2) It is feasible to use Loran-C receivers and VHF-FM equipment of the type presently available to the maritime industry. However, radar-like position accuracies are not achievable with today's commercial equipment.

(3) The man/machine interface is extremely important. Lengthy operator training can be avoided by designing the system to interact with the operator. This is accomplished by thorough prompting, selecting from menus, and operator input error diagnostics.

Suez Canal Vessel Traffic Management System

This $30,000,000 system will come into full operation by the end of 1980. The system is financed jointly by the U.S. Agency for International Development and the Suez Canal Authority. The system was built by three American firms with close advisory support from the U.S. Coast Guard. The Suez Canal VTS consists of four major subsystems. These are radar, Loran-C, communications, and data management and display. Figure H-10 shows the general

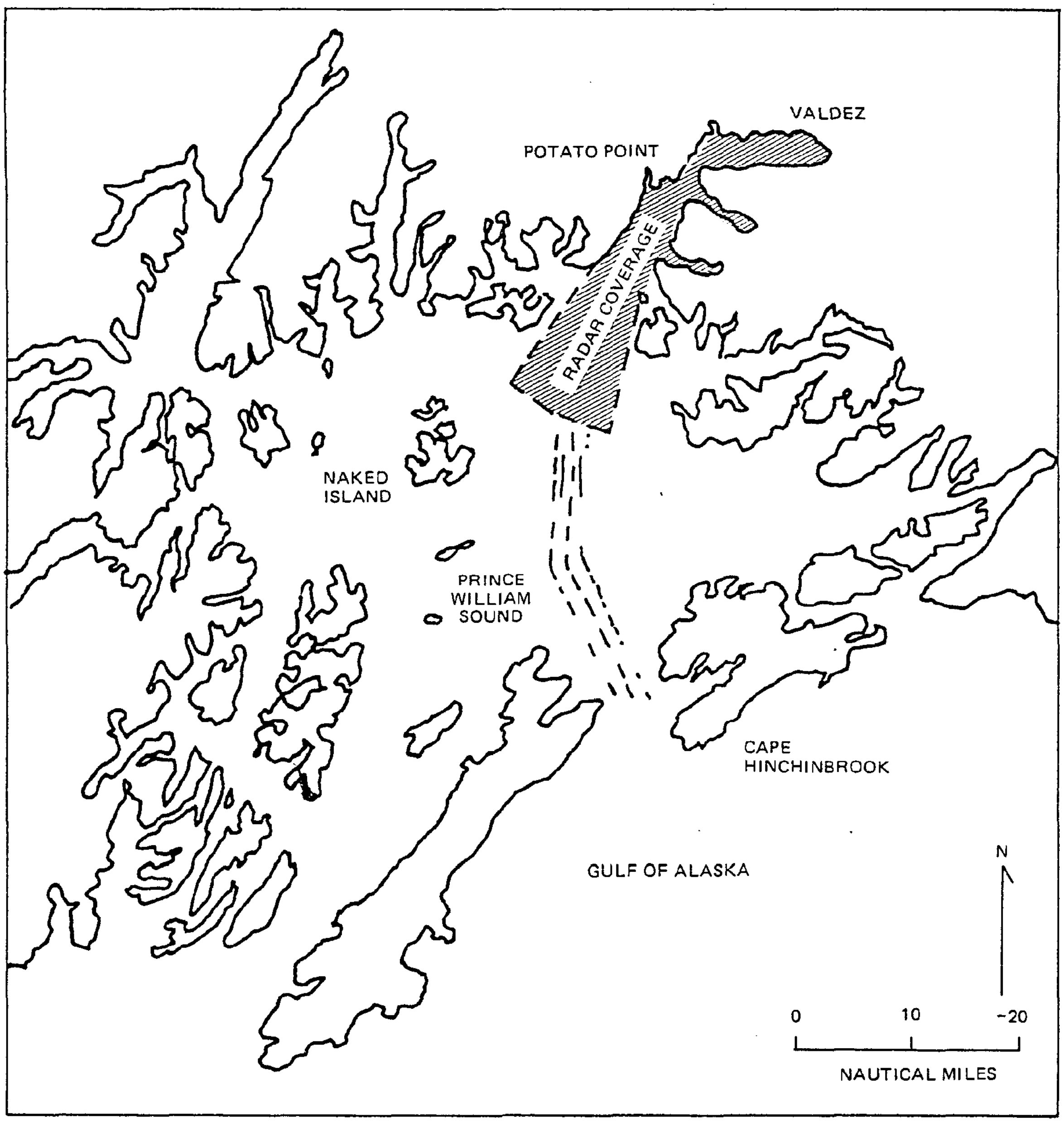


Figure H-5. Radar Coverage Area

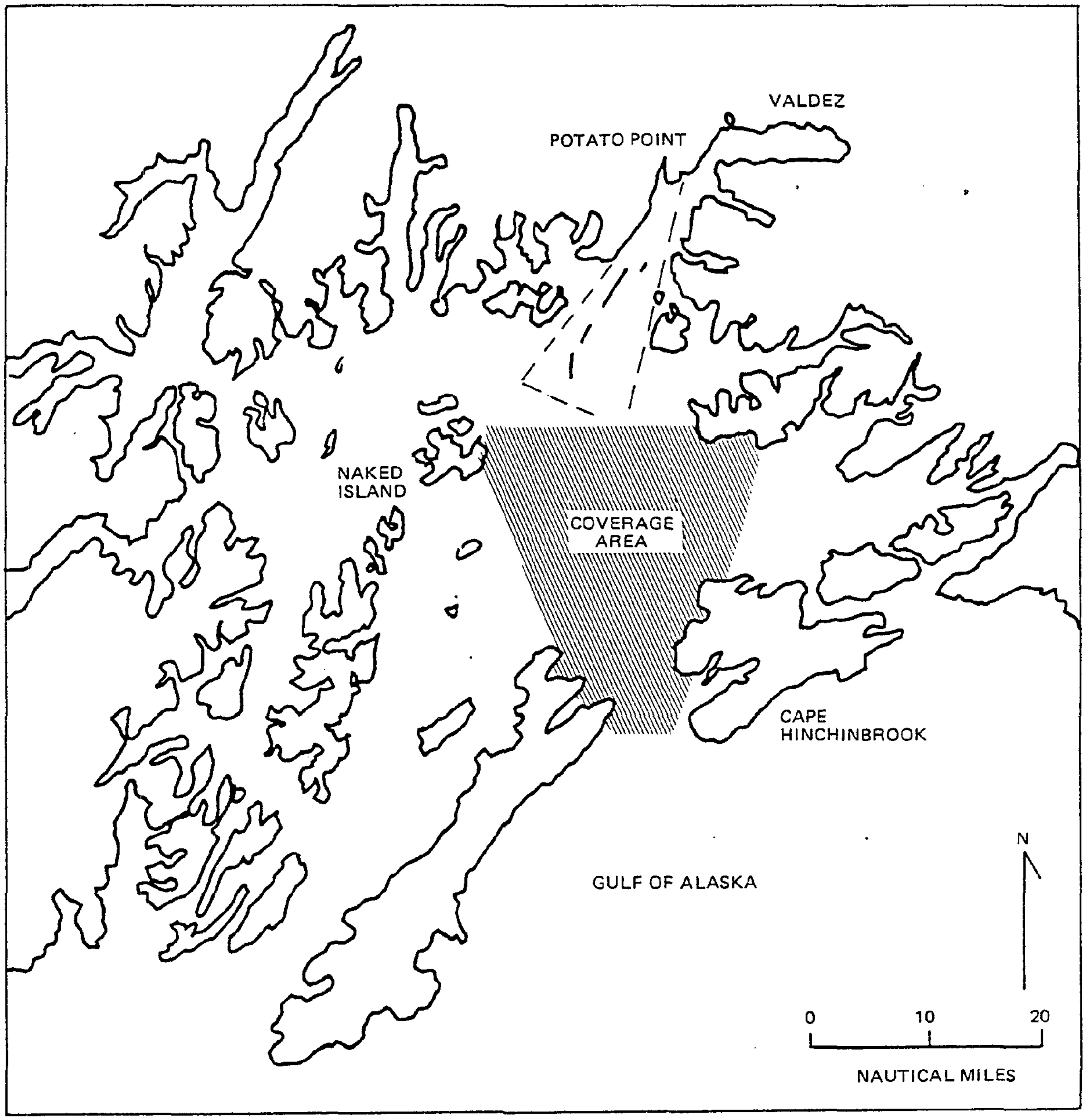


Figure H-6. Area of Additional Surveillance

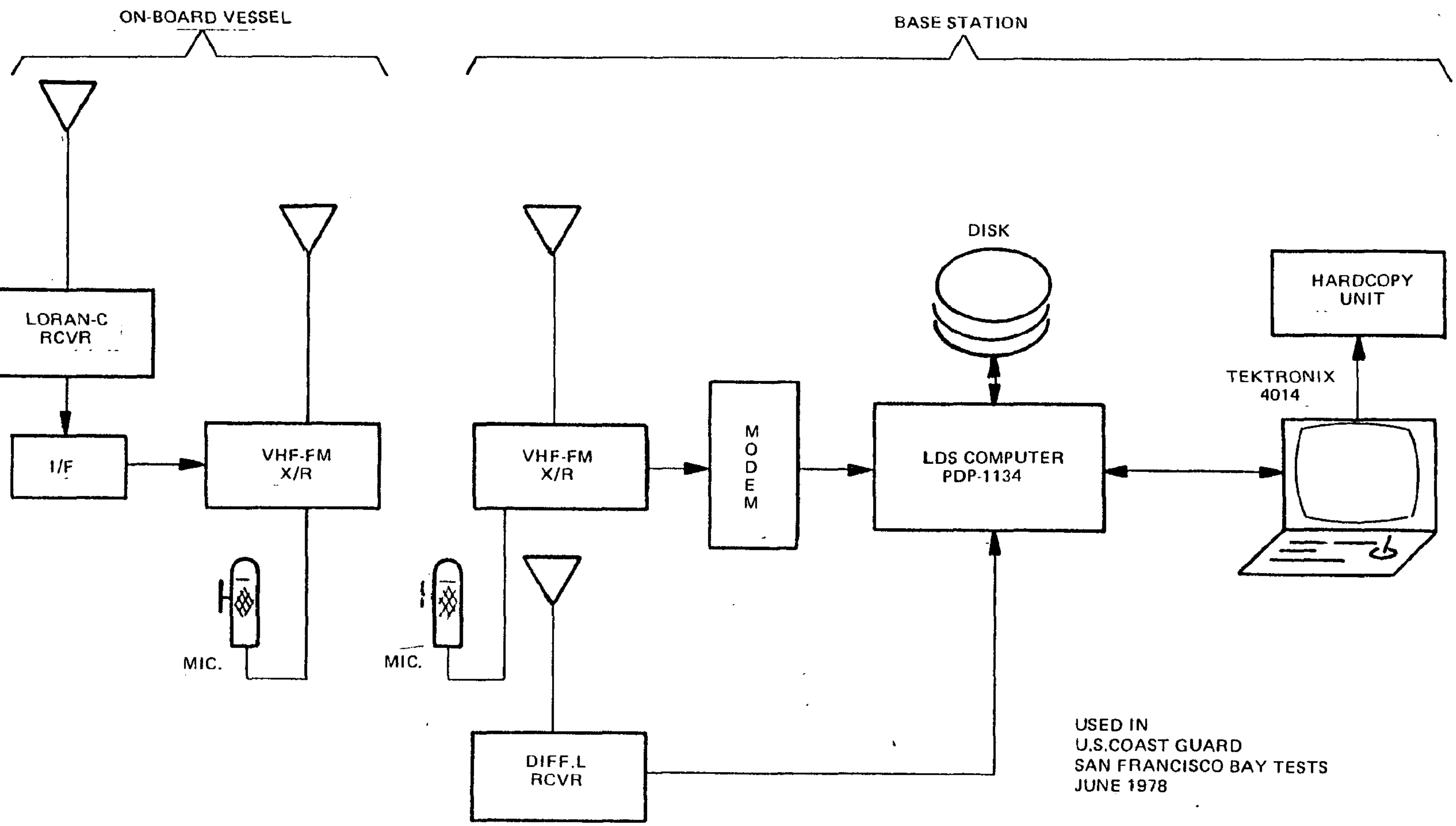


Figure H-7. Loran-C Display System Block Diagram

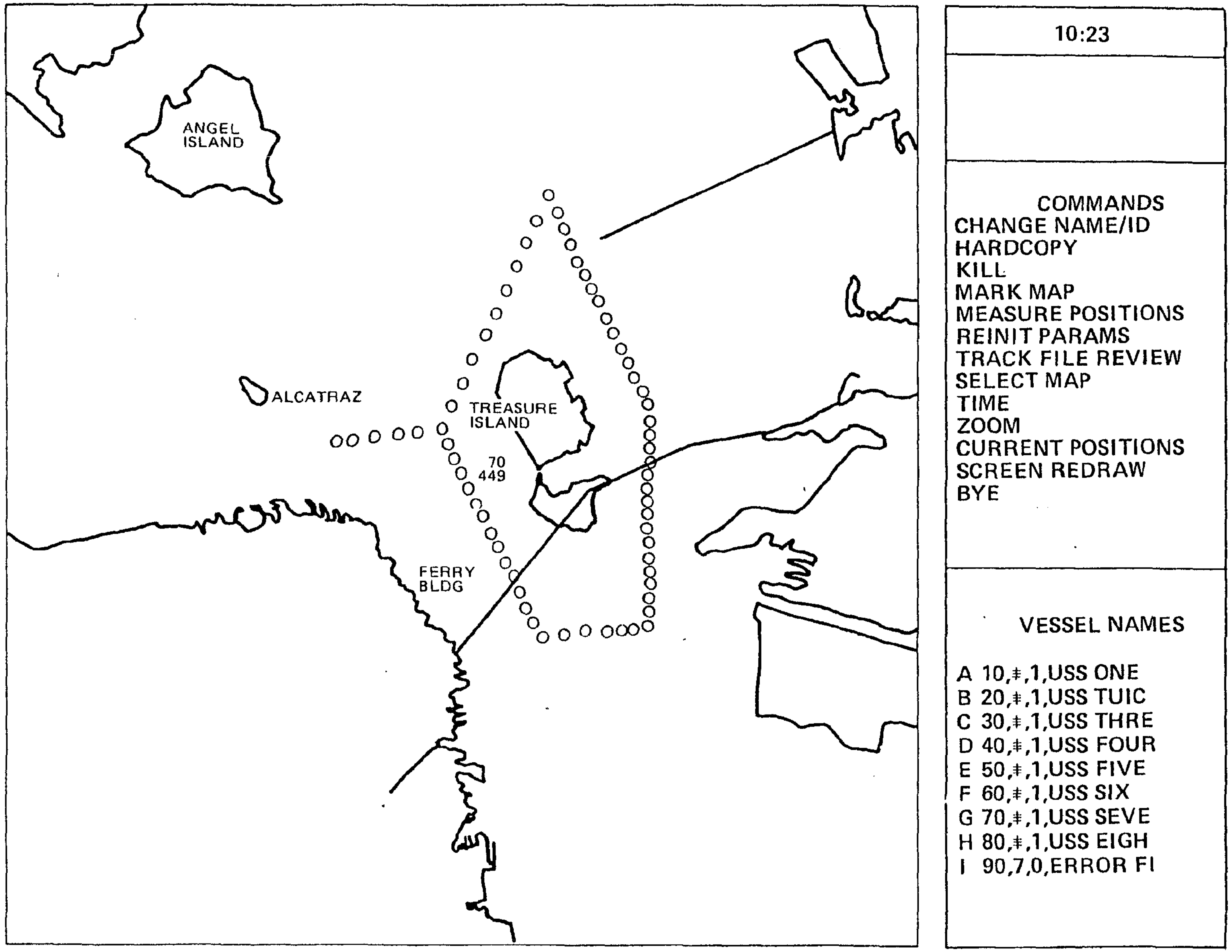


Figure H-8. LDS Display Format – San Francisco Bay

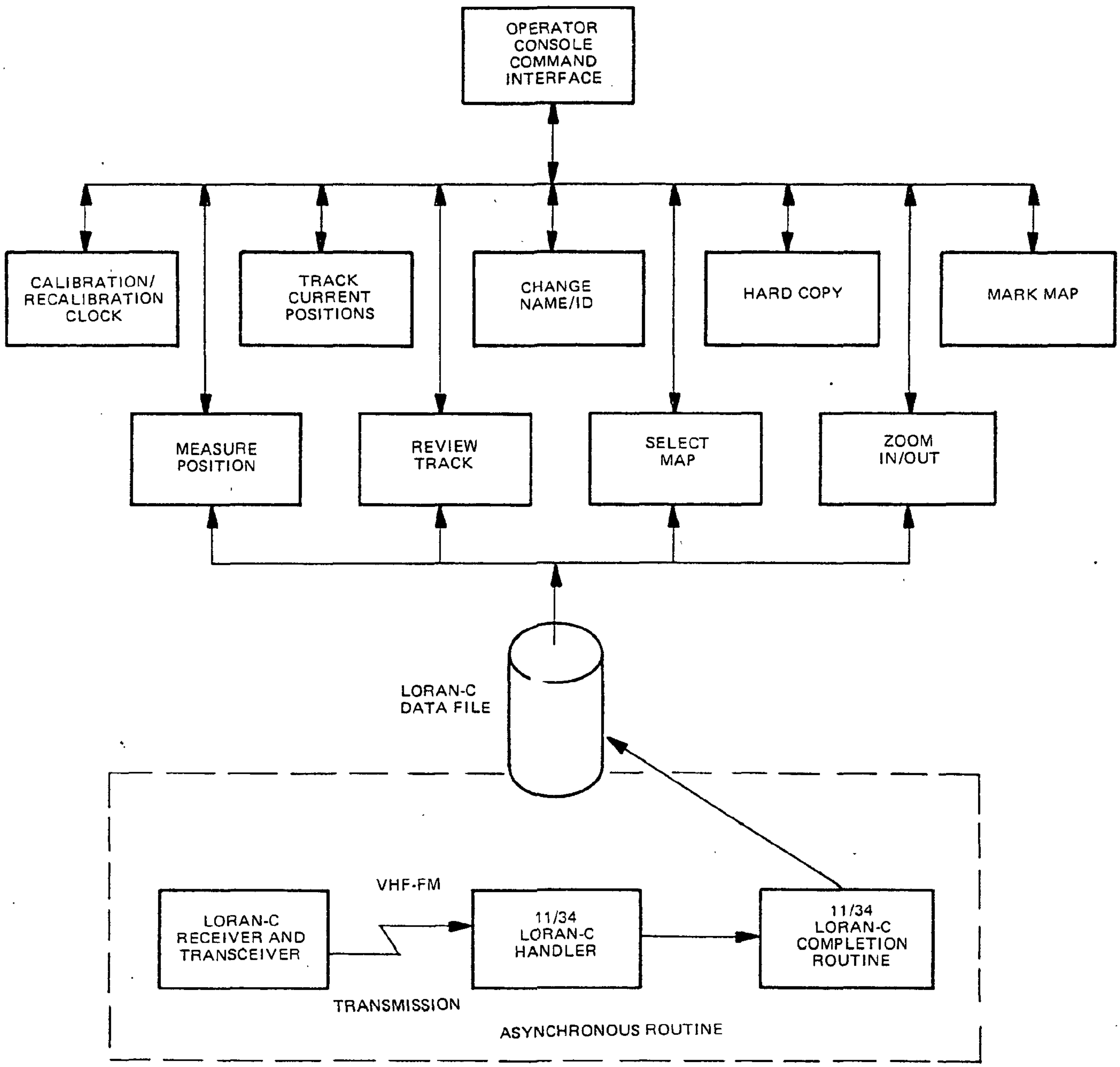


Figure H-9. LDS Logic Flow – San Francisco Bay

TABLE H-1. STATUS OF VTS IN U.S. – MARCH 1980*

Location	Date Operational	Participation	Remarks
San Francisco	1972	Voluntary	First VTS serves as R&D platform
Puget Sound	1972	Mandatory	installing new radars to replace old ones and to expand coverage to Strait of Juan de Fuca
Houston	1975	Made mandatory in 1980	Plans to expand TV coverage to include entire ship canal
Prince William Sound	1977	Mandatory	
New York	1980(?) (almost complete)	Will be mandatory after short voluntary period	
New Orleans	1977	Voluntary	

In addition to these coastal systems, there are VTSs in operation at Sault Ste. Marie, Michigan, at Berwick Bay, Louisiana, and in Louisville, Kentucky.

Remaining ports cannot support a VTS on the basis of a Coast Guard cost-benefit study. Chesapeake Bay, however, is under reevaluation as a result of recent casualties, and certain sections of the ICW are also under review.

*Courtesy U.S. Coast Guard.

layout of the Suez canal. The radar subsystem consists of three tracking radars, one covering each port and the third, Great Bitter Lake. Vessel position data obtained by these radars is converted to Suez map coordinates and presented visually at the operations center in a video map display. The data management system also presents on this same display (Figure H-11) vessel position data obtained from the Loran-C subsystem. Loran-C data is used to track vessels as they transit the canal. An interesting aspect of the Loran-C system is that a portable battery powered Loran-C receiver combined with a data modem and VHF transceiver is put aboard every vessel when the pilot comes aboard and is removed when the vessel transits the canal. During transit of the canal, the portable system receives Loran-C signals from on-shore transmitters. Periodically, the portable system is polled by the Loran precoder and responds with position measurements. The position measurements are transmitted to the central control facility at Ismailia by dedicated telephone circuits. The cost/benefit ratio for this facility is very attractive if the traffic is kept running smoothly and free of accidents for earnings of the Canal Authority exceed $700,000,000 per year.

Meteor Trail Communication Monitoring System

The use of meteor trails for low cost communication transmission has had a resurgence of interest during the past few years. The principal of operation is shown in Figure H-12. The signal from the sender is bounced off the ionized meteor trails in the upper atmosphere and deflected to the receiver. Meteors are constantly entering the earth's atmosphere and provide a highly reliable and cost-competitive alternative to other systems. The Department of Agriculture, for example, has about 250 snow pack gauges in eleven western states monitored by this technique. The Air Force is looking at Loran-C position data coupled to the meteor trail link while the U.S. Coast Guard has considered using the same approach for tracking icebergs.

In 1979, the Navy Electronics Command studied the feasibility of tracking Navy vessels using the meteor trail link. Using simple inexpensive antennas, vessels were tracked along the California coast from San Francisco to San Diego. The ship tracking results are shown in Figures H-13 and H-14. The only drawback observed from this test series is

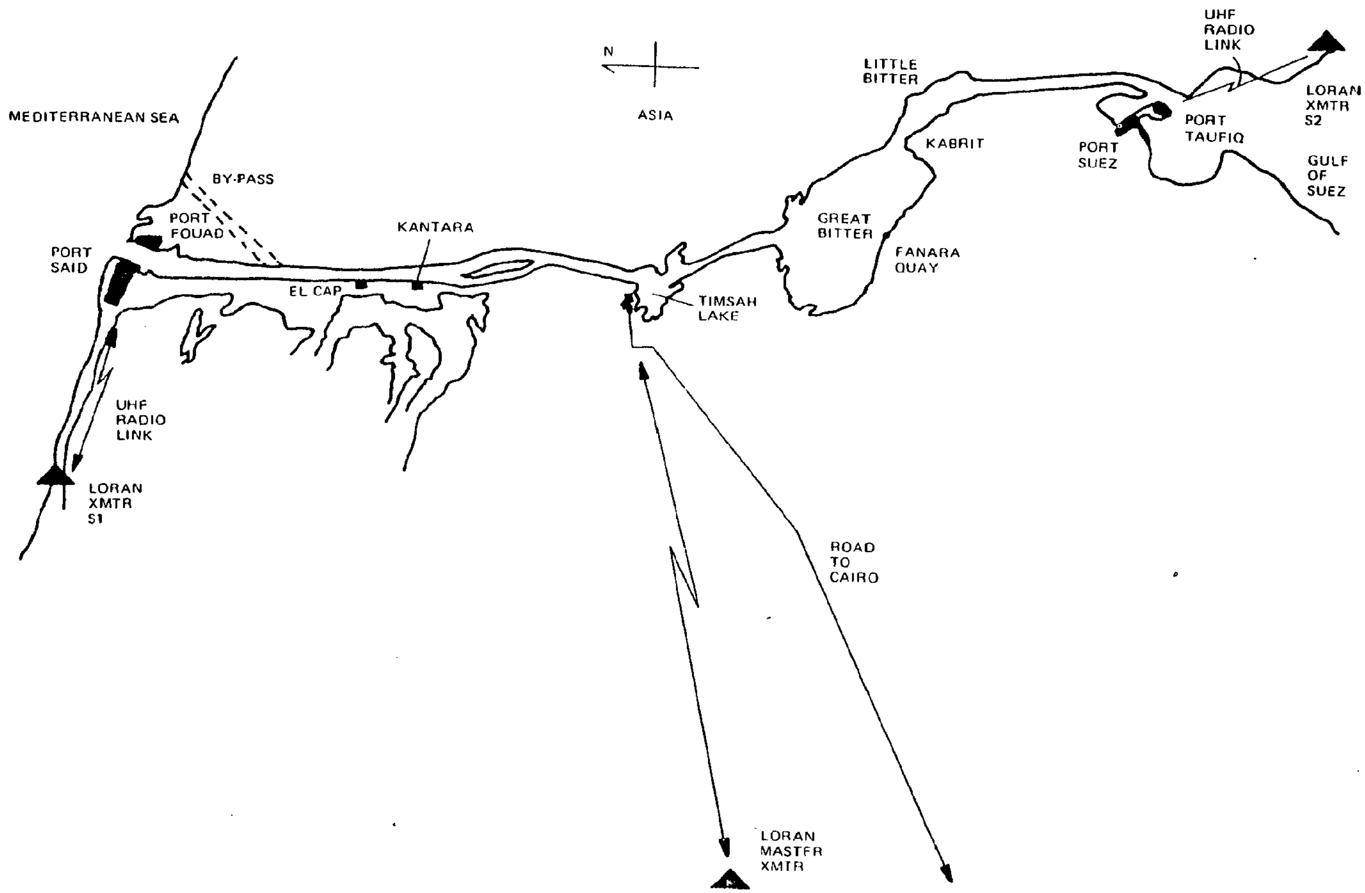


Figure H-10. Geographic Layout of Suez Canal Loran System

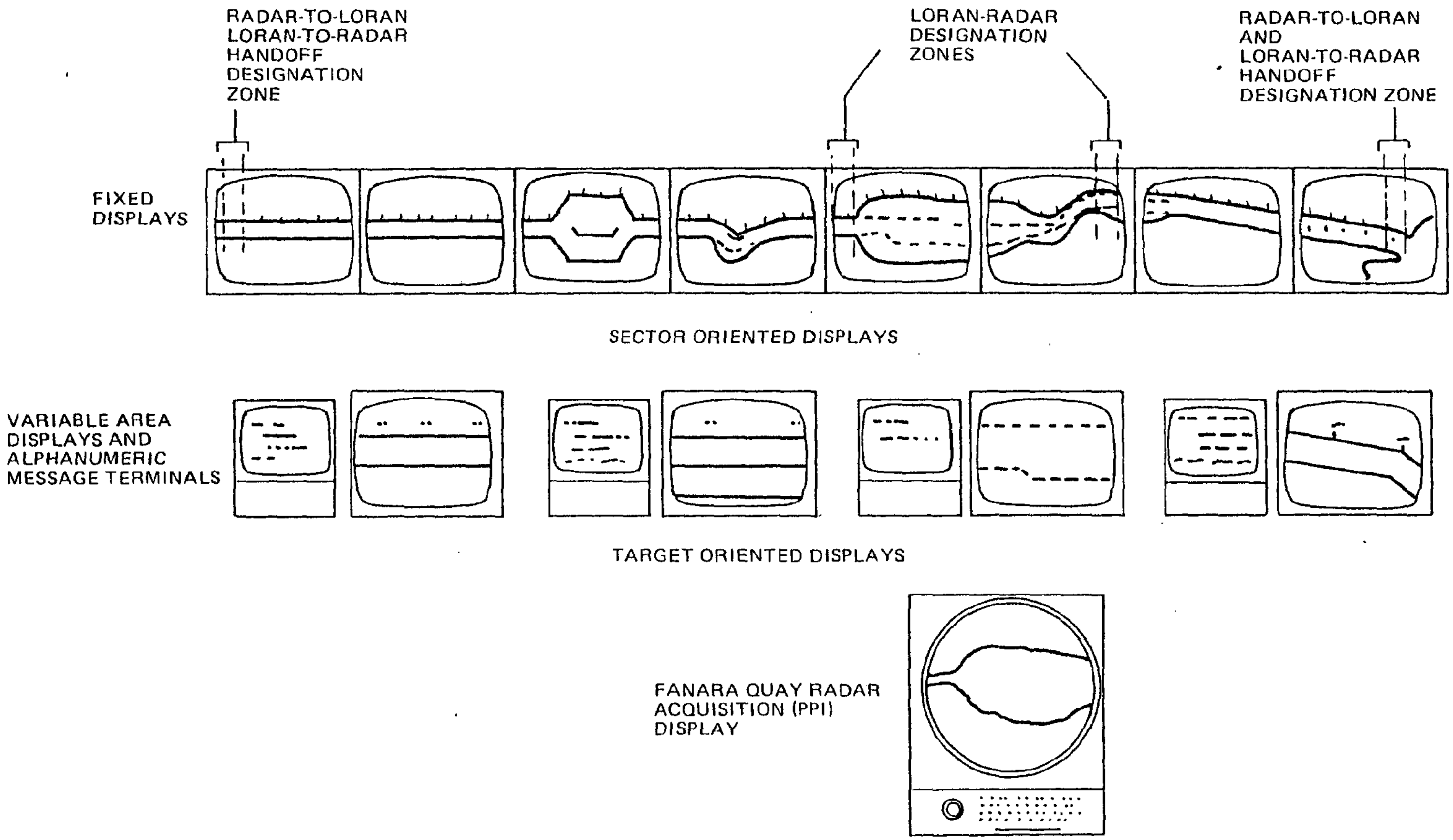


Figure H-11. Ismailia Central Operations Displays and Message Terminals

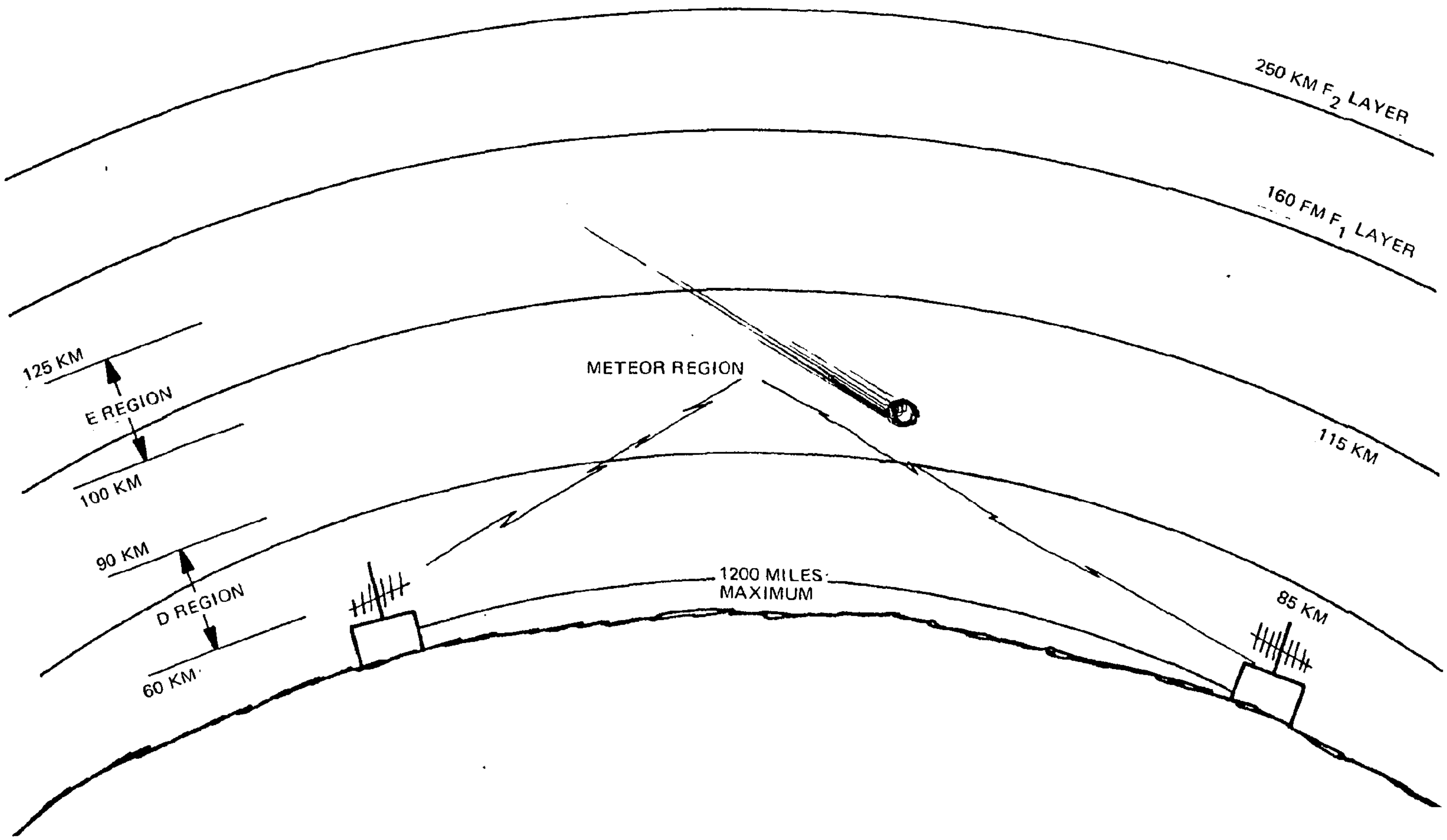


Figure H-12. Meteor Region

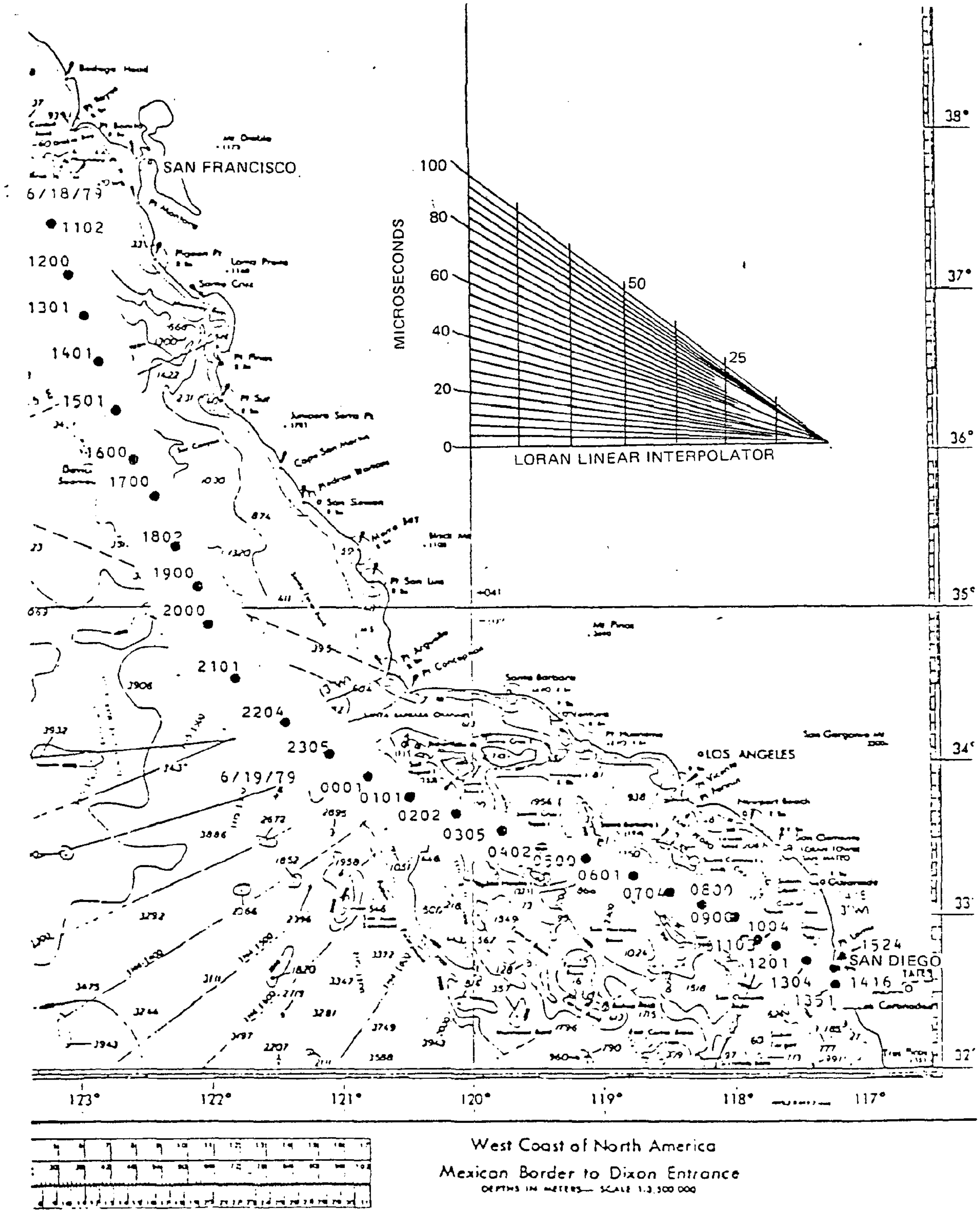


Figure H-13. Ship Tracking – San Francisco to San Diego

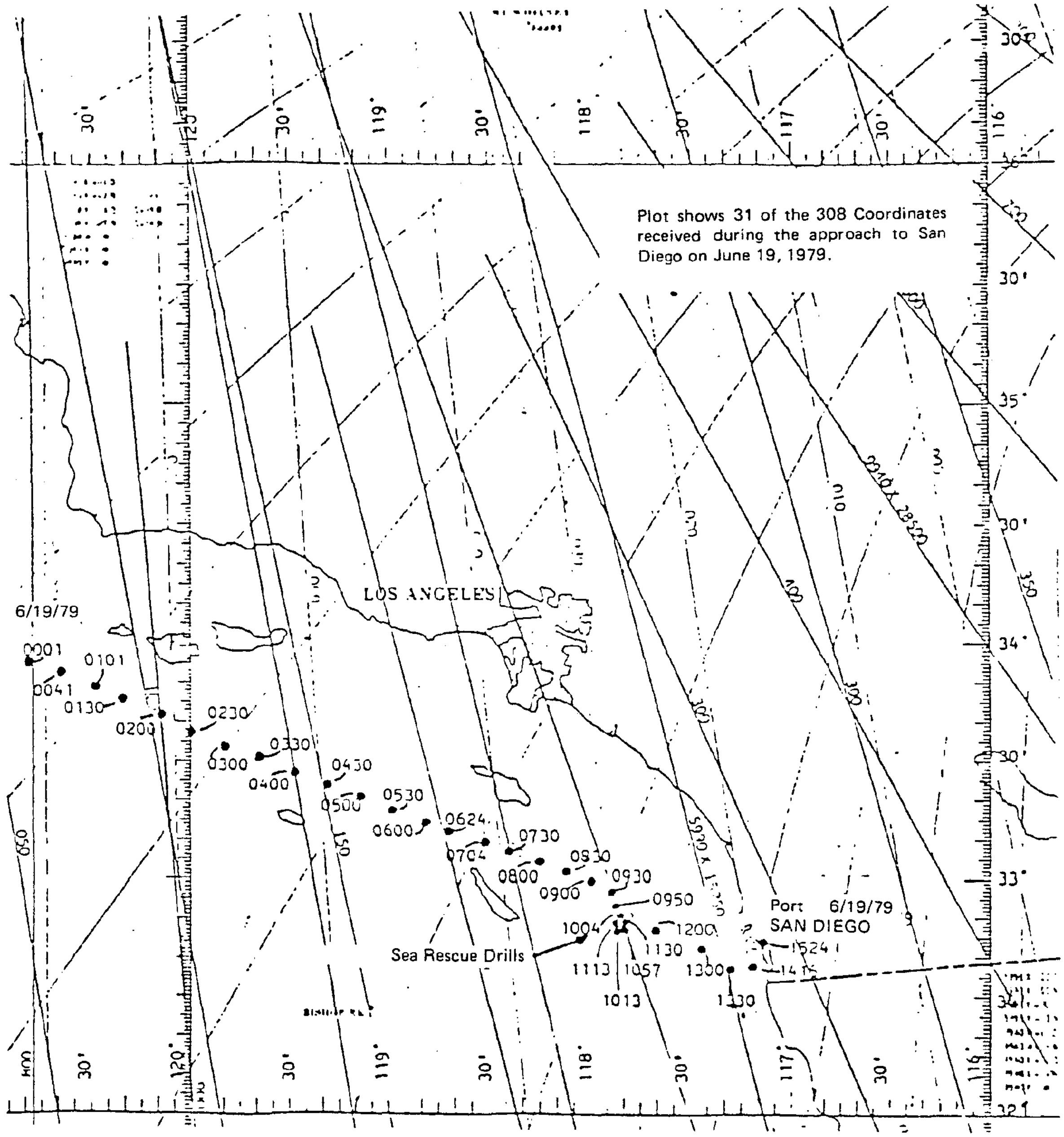


Figure H-14. Ship Tracking

that-the time it took to deliver a message on the ship's position varied from 2.5 to 9 minutes based on meteor trail availability. It is expected that in future tests, the waiting time can be reduced significantly. Figure H-15 shows a potential master station system that would provide coverage from Valdez to the Panama Canal.

Satellite Monitoring Systems
Global Positioning System (GPS) NAVSTAR

GPS is a satellite navigation system being developed by the Department of Defense. The system will contain from 18 to 24 satellites at an orbit of 11,000 miles. Direct line of sight signals will be available continuously to users from at least four satellites on a worldwide basis. Users must be equipped with a receiver capable of tracking the four satellites and making time-of-arrival measurements to obtain a solution as to position. GPS satellites will transmit on two MHz frequencies. Two types of user codes are planned: (1) precise code for military use and (2) coarse code for civilian applications.

The system is now in a concept validation phase with six satellites launched into orbit in 1978 and 1979. Full operational status for both military and civilian application is expected by 1987 (36). Both the U.S. Coast Guard and MarAd are participating in user requirement definition studies. Some ship tracking results obtained in Acapulco Bay, Mexico, and Coronado Bay, San Diego are shown in Figure H-16. The U.S. Coast Guard jointly with MarAd has carried out some static tests in Long Beach, California (37) during the May-September 1979 time period. The purpose of the test was to evaluate a low cost navigation set for future application to vessels. Figure H-17 shows a test demonstration of the GPS proposed by Rockwell International in 1977 to West Coast navigation control. Note that GPS only supplies position data. In this case, the Marisat satellite was the communications link to a shore control center.

Coast Guard Foreign Fishing Vessel Experimental VTS

The Fisheries Conservation and Management Act (P.L. 94-265) authorized the Coast Guard to monitor foreign fishing vessels within the 200-mile zone set by the act. Although vessels, airplanes, and even blimps could be used, satellite monitoring was considered the most cost-effective approach. In cooperation with NASA and NOAA, the Oceanographic Unit of the Coast Guard has carried out an analysis and preliminary tests of a satellite system using a data collection unit already developed by Handar Corp. of Sunnyvale, California for general oceanographic data. Operational Tests (38) aboard foreign fishing vessels were carried out in the North Atlantic from 17 January through 1 April 1980. The transponders were deployed on the vessels along with observers supplied by NOAA. In addition to transmitting position data, temperature, amount of catch, distress call, etc., were transmitted using the TIROS/ARGOS satellite system. The results of tests (39) were highly successful. A recommendation was made that the Coast Guard begin work on an operational satellite system to handle 300 or more fishing vessels. This system seems likely to be developed as it is very cost-effective compared to any alternate approach.

NASA Satellite-Aided Coastal Zone Monitoring and Vessel Traffic Monitoring System

In addition to the Coast Guard's own efforts on monitoring foreign fishing vessels with the TIROS/ARGO satellite system, the Coast Guard has requrested that NASA study potential methods for identification and location of all vessels within the 200-mile coastal zone. Not only was the Fisheries act a driver, but so also was Public Law 94-475, the Port and Tanker Safety Act of 1978. Under the guidance of the Goddard Space Flight Center, Greenbelt, Maryland, a study and experimental demonstration were carried out in 1979 using Loran-C for position fixing and the ATS-3 satellite in geo-synchronous orbit. A low cost modem for linking the Loran-C receiver to the satellite was developed. The demonstration experiment using a fishing vessel in Chesapeake Bay, Maryland was carried out in October 1979. The block diagram for the system is shown in Figure H-18. Data from the satellite was transmitted to a control center at the University of Miami facility at Malabar, Florida. From Malabar, the data was transmitted to the Goddard center where it was displayed on a GE video color display controlled by a PDP-11-45 computer. One of the video displays (black and white version) is shown in Figure H-19. Applications Technology Satellite No. 3 is located in orbit at 105 degrees west. This location provides ideal coverage of the 200-mile zone of the entire United States except for the upper portion of Alaska. A roll call method has been devised for ship interrogation in multiple vessel monitoring. A computer at shoreside automatically and sequentially interrogates Loran-C receivers aboard any vessel above 100 gross tons within the 200-mile zone in an operational system. Upon receipt of the vessel's ID number, each vessel answers by transmitting its own Loran-C position via the satellite to the computer-driven video color display at the control center. Here the operator can view the entire coast line or

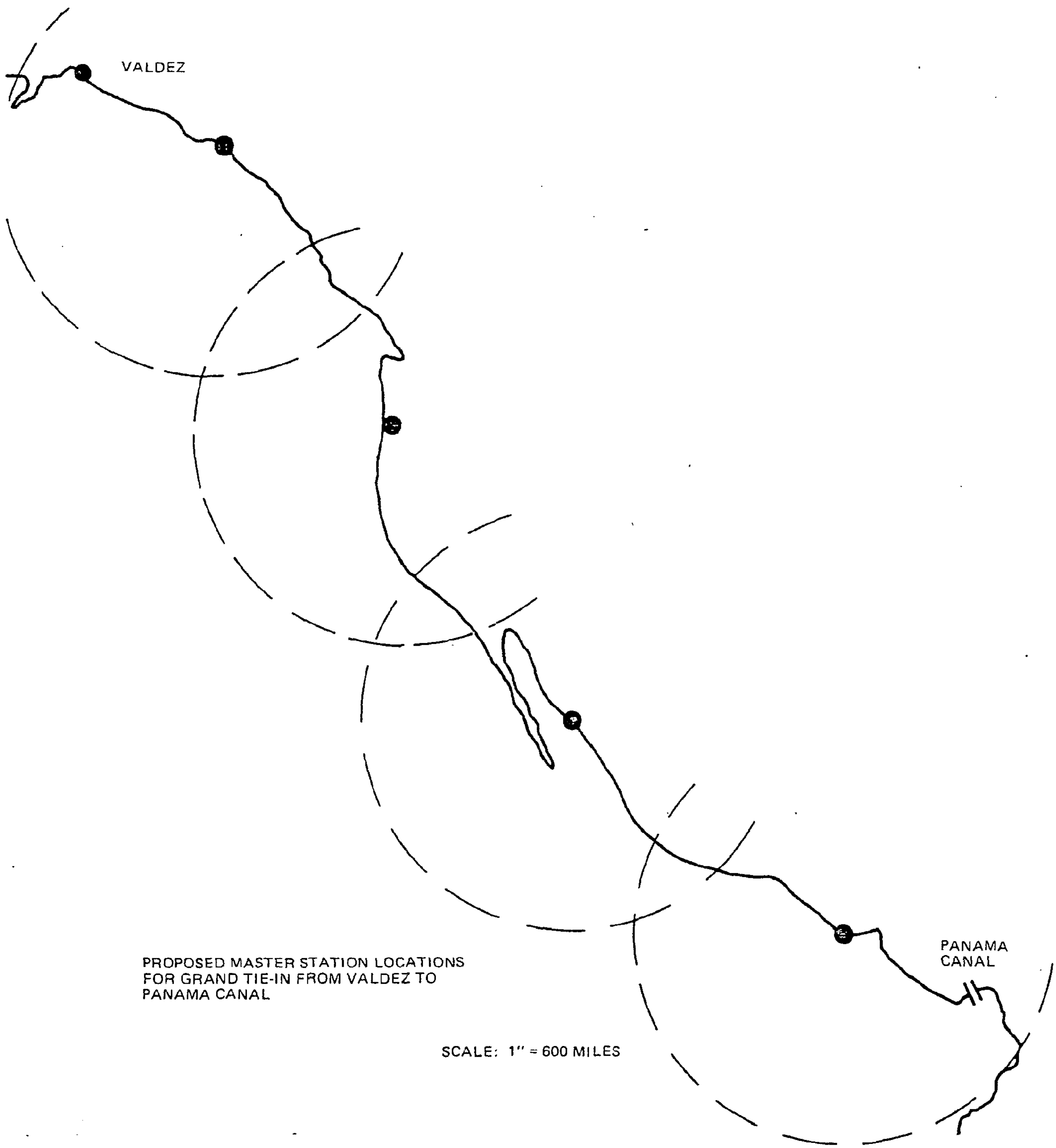


Figure H-15. Meteor Trails Communication Ship Tracking System: Proposed Master Station Locations for Grand Tie-In from Valdez to Panama Canal

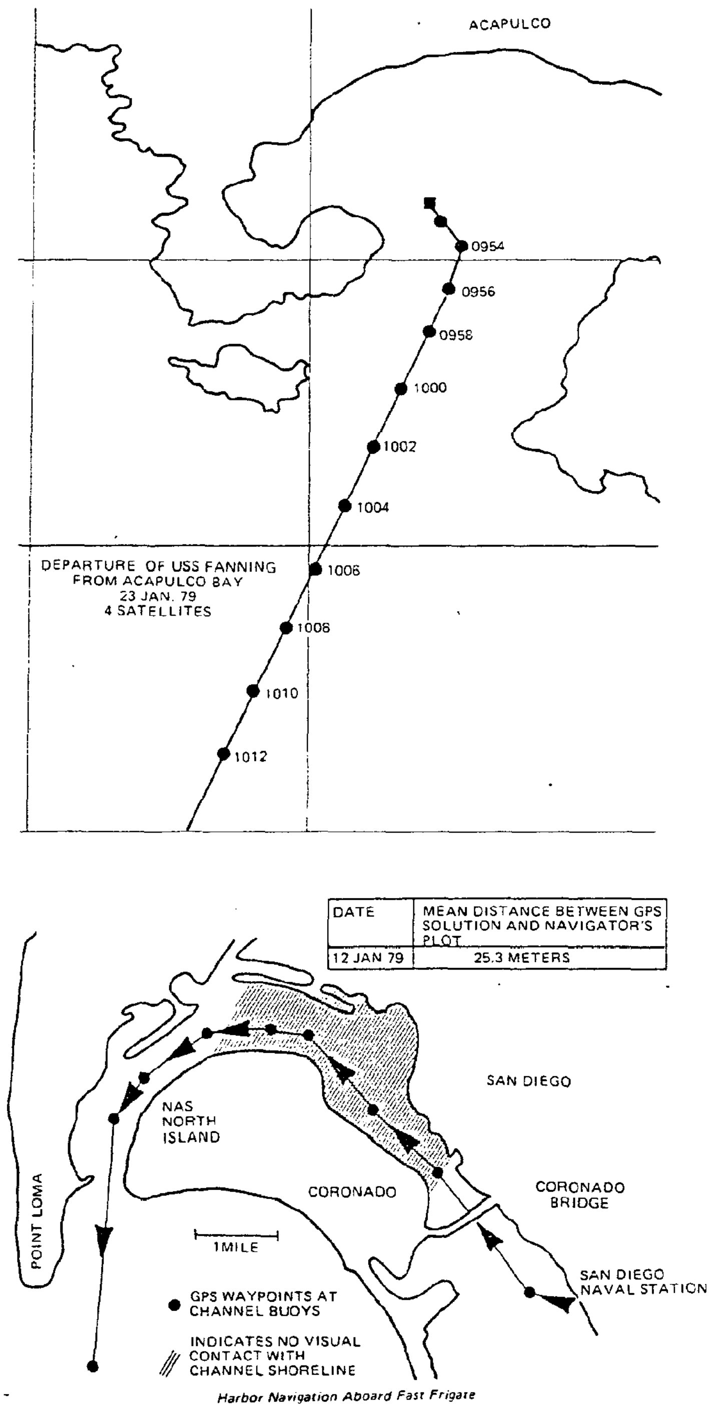


Figure H-16. NAVSTAR Ship Tracking Test Results (1979)

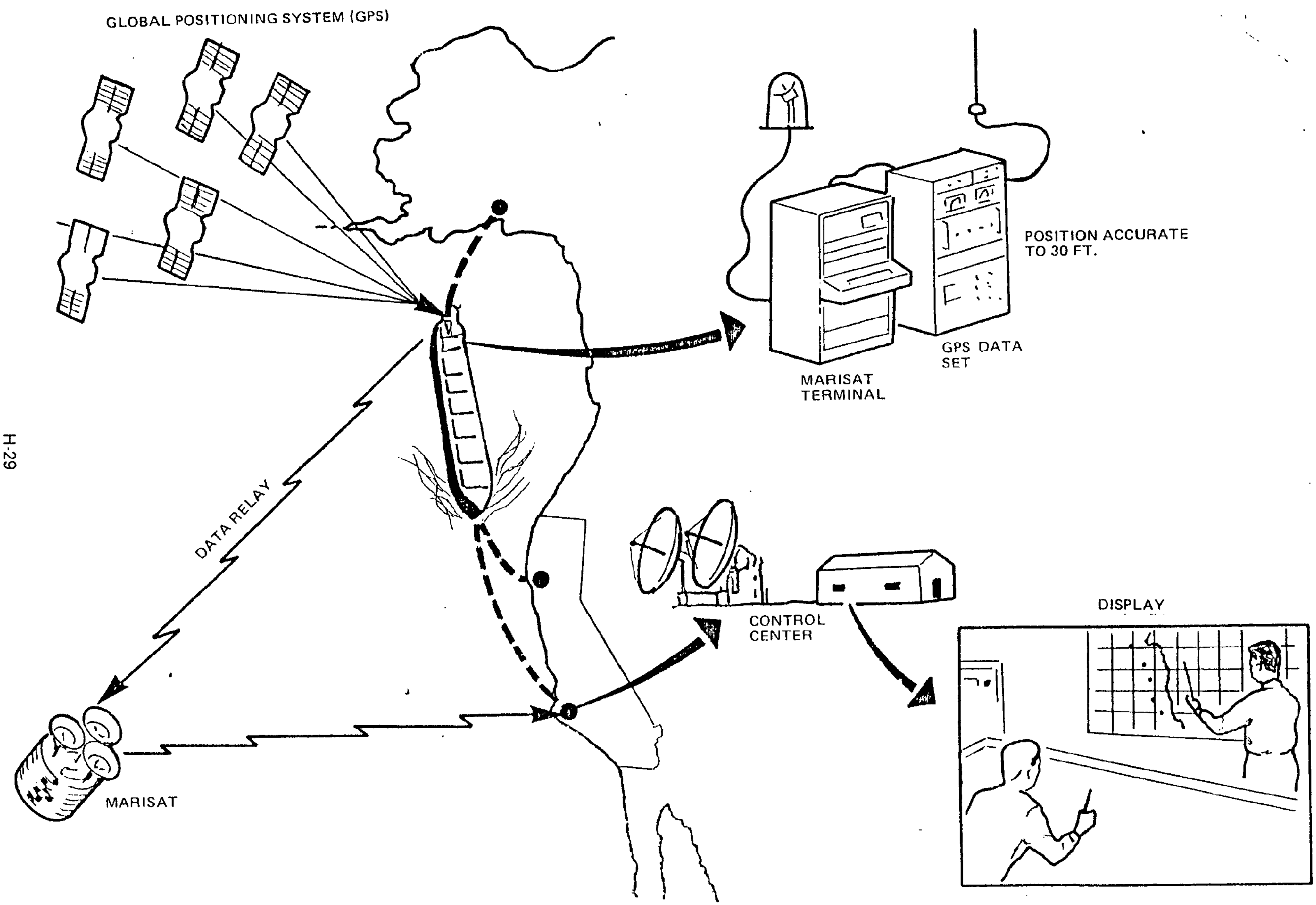


Figure H-17. Coastal Navigation and Control Test Demonstration

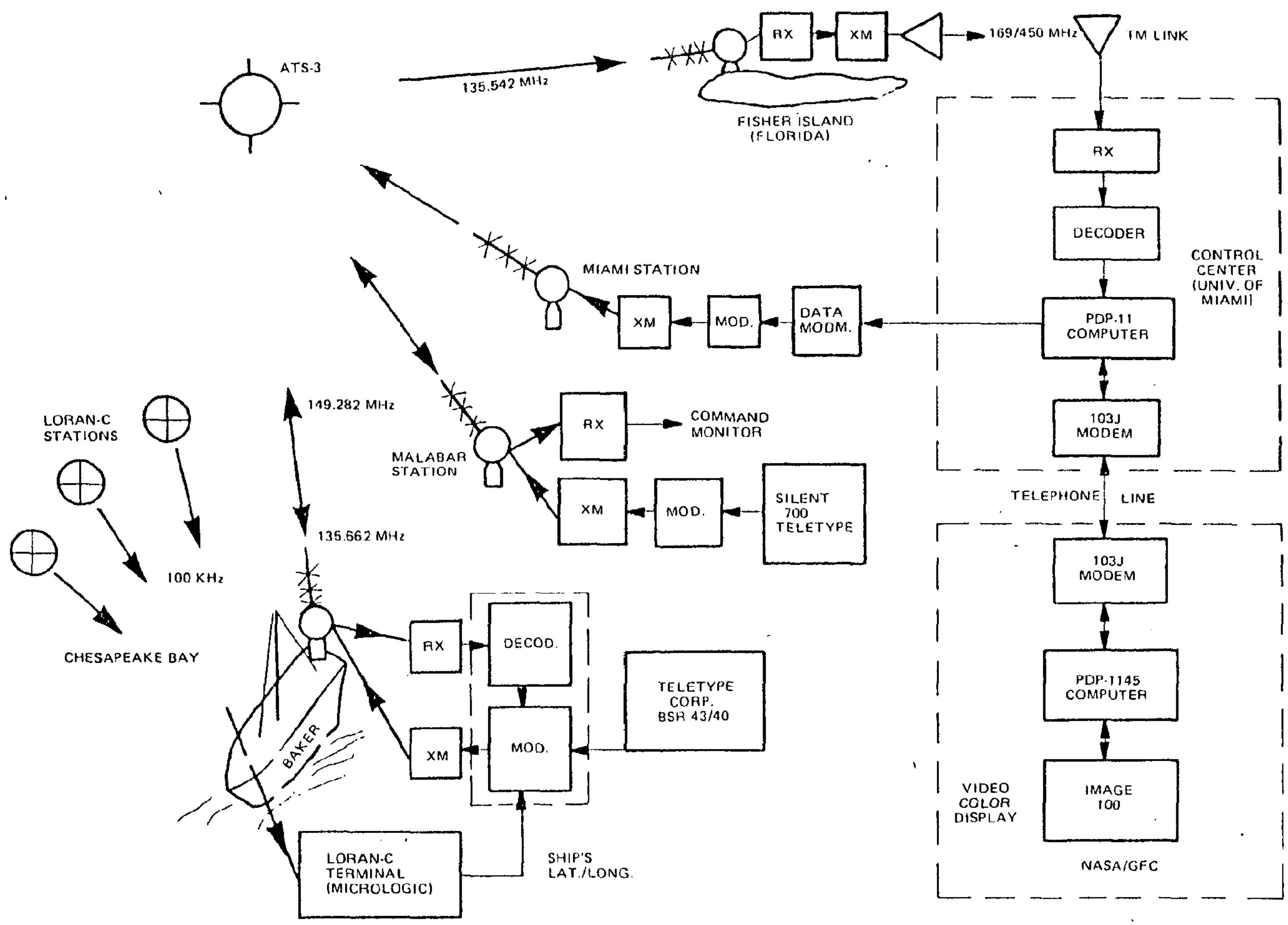


Figure H-18. Loran-C/ATS-3 Vessel-Traffic Monitoring Satellite System

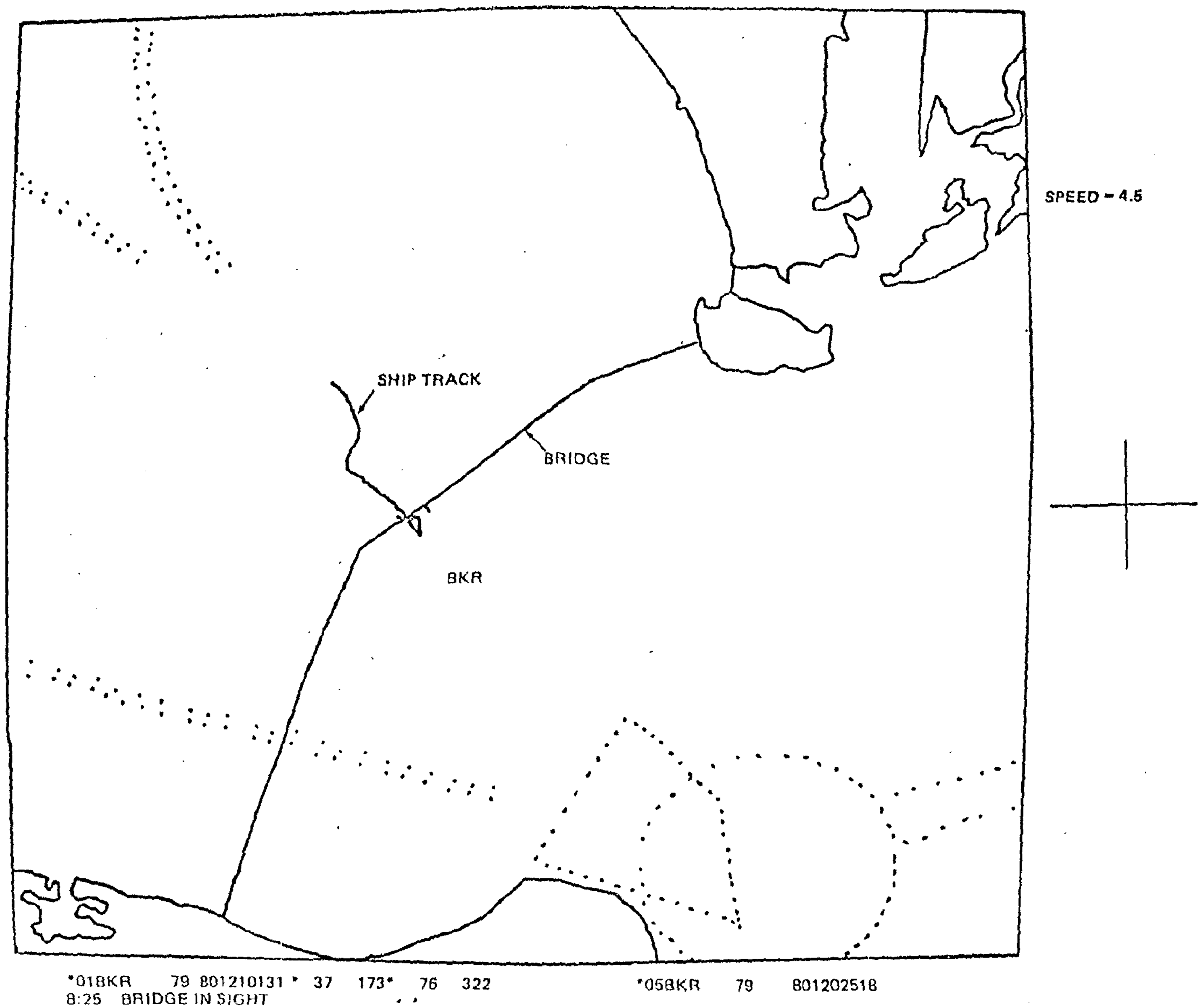


Figure H-19. Lower Chesapeake Bay — October 1979 enlarge a submap area in which there is a potential hazardous situation. Messages entered into the ship's teletype unit such as search and rescue, weather data, oil slicks, etc., can also be interrogated by the computer.

In a paper given at the Institute of Navigation annual meeting (Monterey, California) in June 1980, Baker (40) pointed out the following advantages for the system:

1. Unlimited range.

2. Many U.S. and foreign vessels already have Loran-C receivers.

3. Both the computer and the operator can make independent assessments of critical situations as they occur.

4. The vessel track history is a permanent record and can be brought up for instant replay/analysis.

5. Other navigation systems such as Transit, Omega, Decca, GPS, etc., can be used with an appropriate electrical interface.

6. A ship's manifest can be obtained automatically when the ship enters the 200 mile zone.

7. The system is operable in any kind of weather.

8. Shipboard installation is inexpensive since the technology has been developed.

Figure H-20 shows the satellite coverage for ATS-1 and 3. Figure H-21 is the functional block diagram for the satellite aided coastal monitoring system.

H.4 SANTA BARBARA CHANNEL VESSEL TRAFFIC SYSTEM

Currently, a low-level vessel traffic system consisting of a passive traffic separation scheme is in effect in the Santa Barbars Channel. As previously mentioned, this scheme is under review as part of the USCG vessel access route study. In a study carried out for the county of Santa Barbara, Hefferman (41) pointed out that the Coast Guard now located tankers during helicopter flights over the Channel, but pilot logs are not retained. Further, he noted that short-term tanker traffic studies conducted for 10-day periods have shown good compliance with the traffic separation lanes, but this small data base is not a substitute for long-term data in assessing risk. Therefore, a vessel traffic monitoring program was recommended. In 1978, the California Interagency Task Force (42) also recommended a vessel monitoring system.

A familiar argument heard against consideration of a higher level VTS system in the Santa Barbara Channel is the low level of ship traffic. Note that the Port of Valdez and Prince William Sound have both a radar and Loran-C position monitoring system for a lower level of traffic. A more meaningful parameter is the quality of the traffic in terms of a safety factor index. This is coupled with the social cost of a significant marine accident involving an oil or LNG spill. O'Rathraille and Weiderman (43) made the point that by focusing on the potential cost of a marine accident, a direct cost/benefit comparison can be made with the cost of operation of a high level marine traffic management system. Considering the value of the potential recoverable oil and gas resources, the cost of the system would be negligible compared to the added value obtained from optimum source recovery.

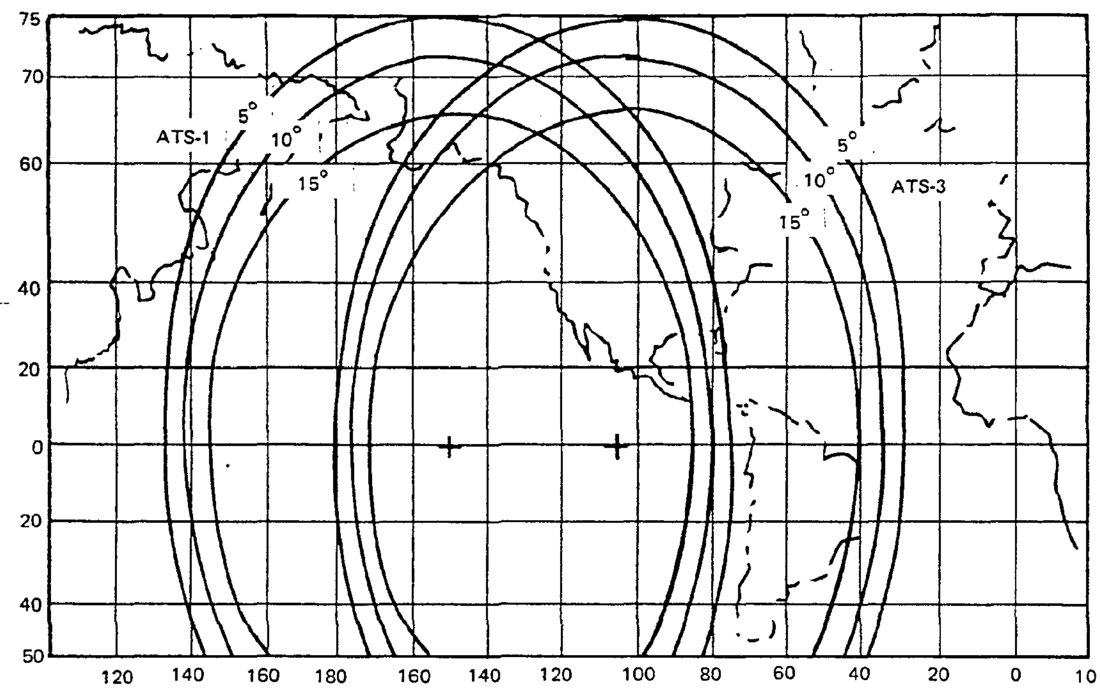


Figure H-20. ATS 1 and 3 Satellite Coverage

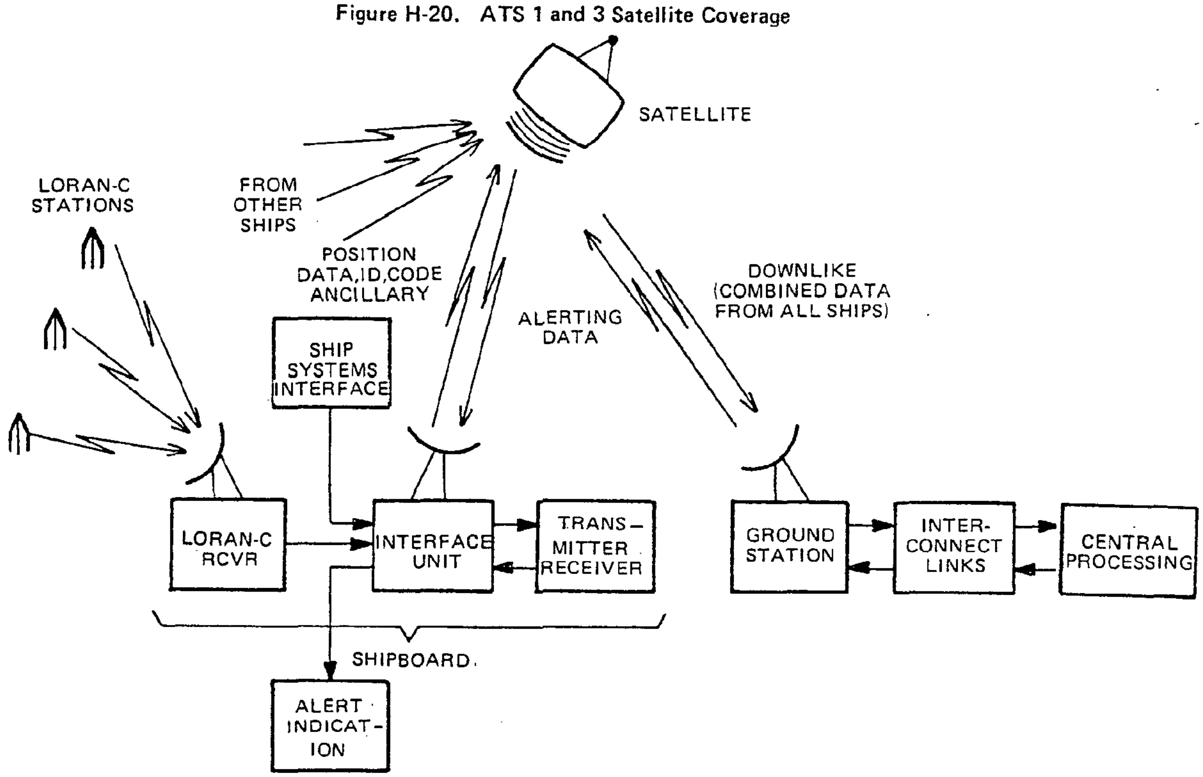


Figure H-21. Coastal Zone Monitoring System — Functional Block Diagram

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