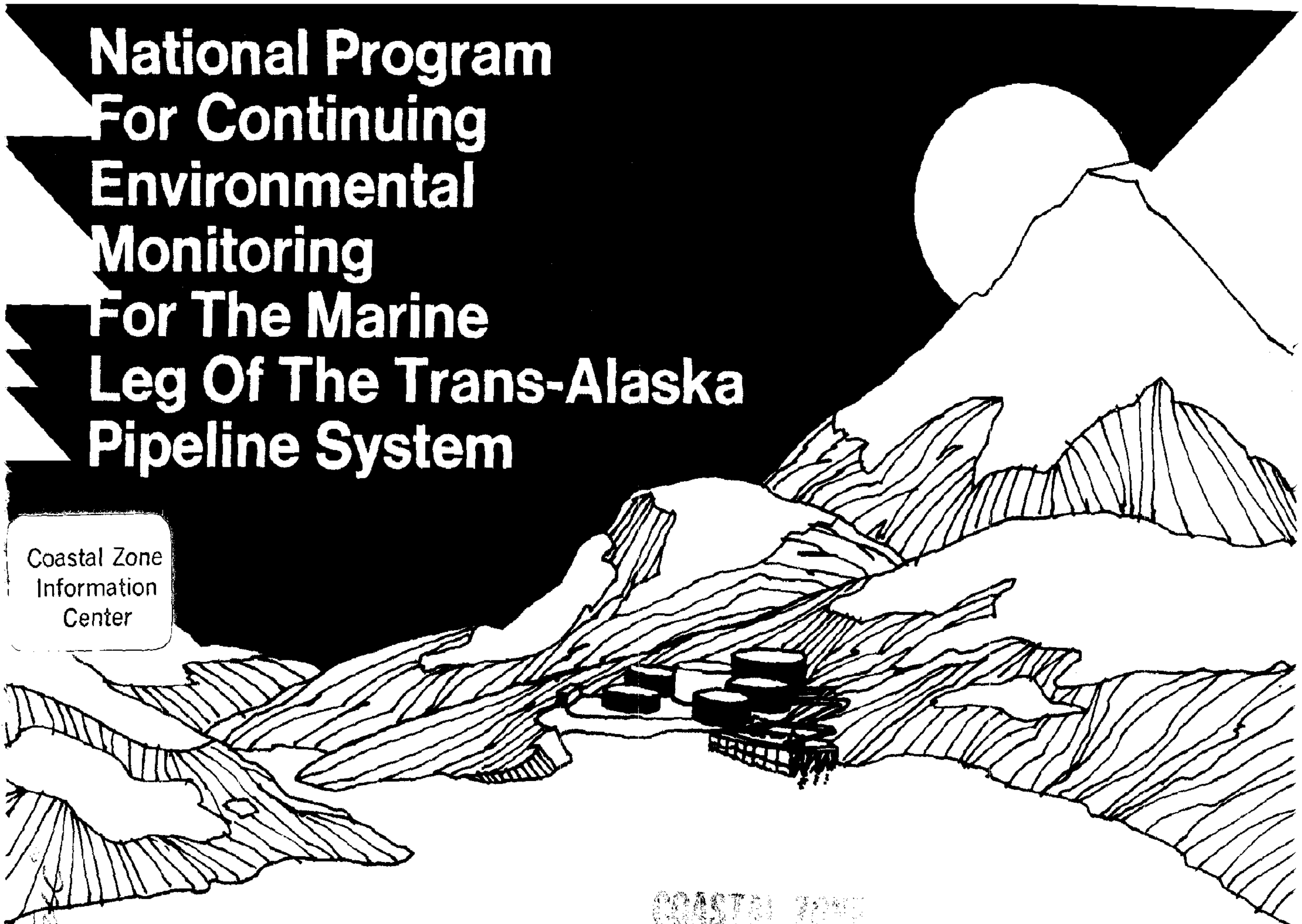
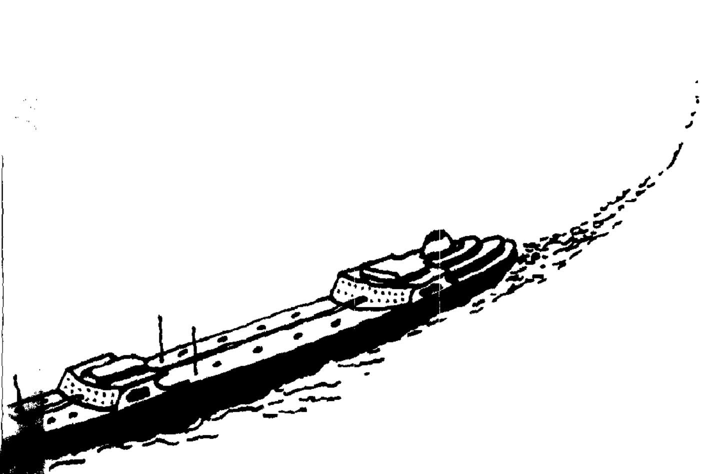
National Program For Continuing Environmental Monitoring For The Marine Leg Of The Trans-Alaska Pipeline System





Interagency Committee For Marine Environmental Prediction

October 1973

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U.S. DEPARTMENT OF COMMERCE
U.S. NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION.
FEDERAL COORDINATOR FOR MARINE
ENVIRONMENTAL PREDICTION

NATIONAL PROGRAM

FOR

CONTINUING ENVIRONMENTAL MONITORING

FOR THE

MARINE LEG OF THE TRANS-ALASKA PIPELINE SYSTEM

Rockville, Md.
October 1973

FOREWORD

A program of continuing environmental monitoring, as described in this Federal Plan, will help assure safe and efficient transport of oil from the Alaskan North Slope along the marine leg of the Trans-Alaska Pipeline System. At the same time, this Federal effort in environmental monitoring will provide baseline and impact information and an early warning capability that are so vital to the preservation and enhancement of marine environmental quality in these relatively pristine waters.

The Federal Task Force for Alaskan Oil Development assigned to the National Oceanic and Atmospheric Administration the responsibility to prepare this Plan which has been coordinated by the Interagency Committee for Marine Environmental Prediction (ICMAREP). Federal agencies of ICMAREP include the Departments of Commerce, Defense, Interior, Transportation, and State; the Atomic Energy Commission; the Environmental Protection Agency; the National Aeronautics and Space Administration; and the Smithsonian Institution.

This Plan includes a description of the environmental conditions expected along the marine leg of the Trans-Alaska Pipeline System, the components of an environmental monitoring capability, the preparation of warnings and forecasts, the assessment of marine environmental quality, and the detailed implementation of the program.

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I. INTRODUCTION

The growing demands for energy resources are of concern to people everywhere. The President's message to Congress on June 4, 1971, calls attention to these demands for resources and the critical problems that we must face.

> "For most of our history, a plentiful supply of energy is something the American people have taken very much for granted. In the past twenty years alone, we have been able to double our consumption of energy without exhausting the supply. But the assumption that sufficient energy will always be readily available has been brought sharply into question within the last year. The brownouts that have affected some areas of our country, the possible shortages of fuel that were threatened last fall, the sharp increases in certain fuel prices and our growing awareness of the environmental consequences of energy production have all demonstrated that we cannot take our energy supply for granted any longer."

To help satisfy part of our growing energy needs the Secretary of the Interior granted a permit for construction of a Trans-Alaska Pipeline System (TAPS) to transport the rich oil resources from Alaska's North Slope to points where it can be used by the vast consumers of energy. The permit was granted only after an exhaustive and detailed study conducted under the National Environmental Policy Act by the Federal Task Force on Alaskan Oil Development.

The cost for construction of the 800-mile pipeline is estimated as $2.8 billion, and the cost for building the tanker fleet is estimated as $1.7 billion. The system is being designed for a maximum throughput of 2 million barrels per day. From the southern terminus of the pipeline at Port Valdez in Prince William Sound, tankers will transport oil over a marine leg to west coast ports (figure 1).

In explaining his decision to grant the permit before the Joint Economic Committee of Congress on June 22, 1972, the Secretary stated:

> "The nucleus of my decision to grant the Alaska route is based on the urgent need to bring North Slope oil and gas into the American marketplace as rapidly as possible. Our studies have clearly articulated the need for these petroleum resources and the costs of delay. The trans-Alaska route presents the only feasible means of transporting Arctic oil within an acceptable time frame."

Taking into account the environmental concerns, to be taken in implementing the Trans-Alaska Pipeline System (TAPS) Secretary Morton also stated:

> "A continuing environmental monitoring system will be required during the lifetime of oil movement in American coastal waters."

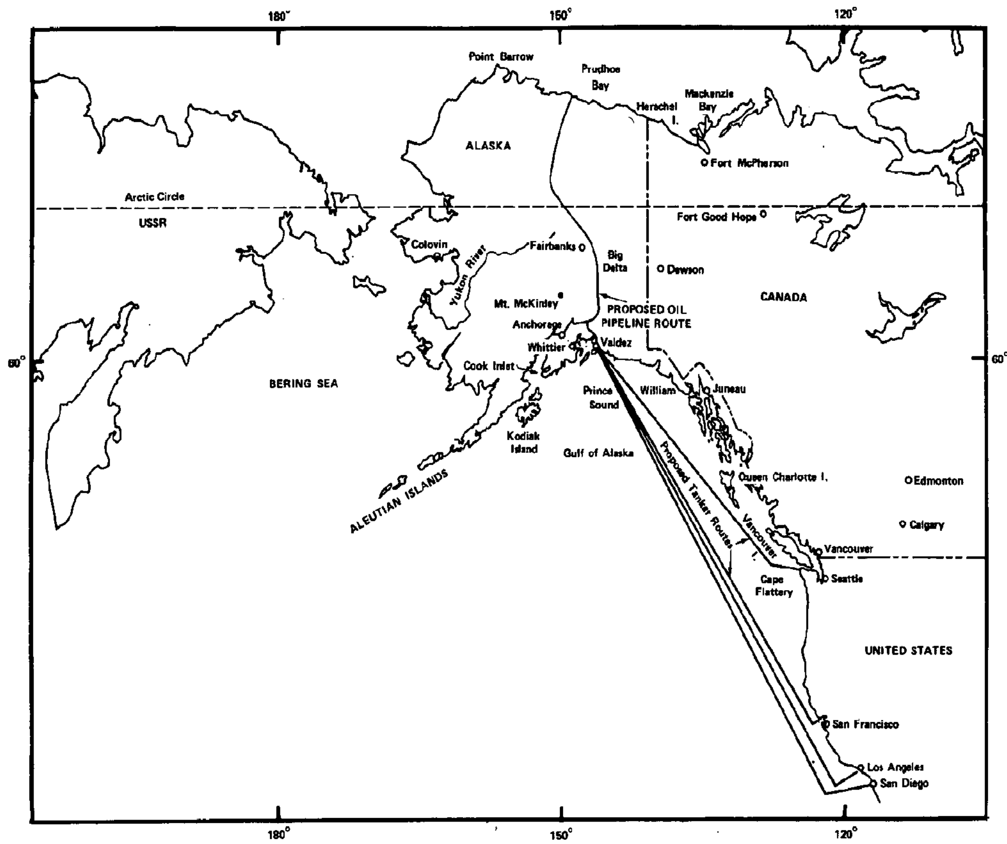
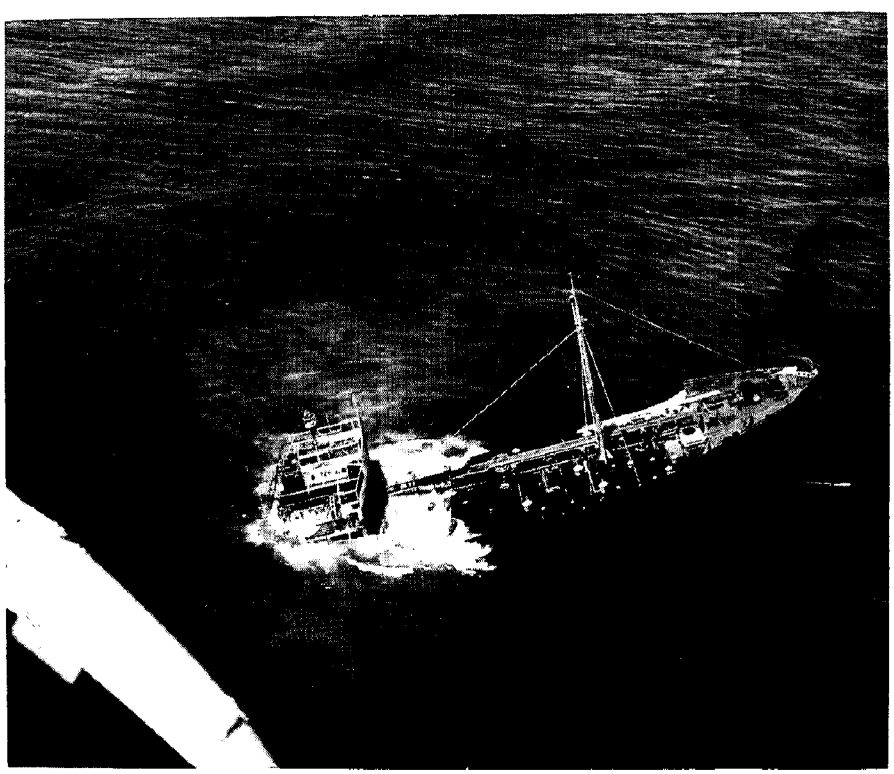


Figure 1. Proposed Trans-Alaska Pipeline System.



Sinking Tanker Spilling Two Million Gallons of Crude Oil.

In response the Federal Task Force on Alaskan Oil Development requested NOAA, as lead agency, to develop a national program for establishing this continuing environmental monitoring system for the marine leg of TAPS.

The program objective is to provide a continuing environmental service which would include warnings, forecasts, and assessments of environmental conditions.

- Warnings

  High winds and waves
  Heavy fog
  Tsunamis
  Storm surge

- Forecasts

  Wind
  Currents
  Precipitation
  Air temperature
  Ocean temperature
  Upwelling

- Assessments

  Petroleum
  Heavy metals
  Halogenated Hydrocarbons.

The services to be provided will aid marine navigation in minimizing collisions, groundings, and rammings which could cause catastrophic spills of hazardous materials; improving basic guidance for making more efficient tanker routings and operation of associated coastal facilities; supporting assessment and cleanup operations for inevitable spills; and providing a system for constant monitoring and assessment of long term changes in oceanic environmental quality.

Besides specific benefits to TAPS, the continuing environmental monitoring system will provide capability to meet other needs. For example, new or improved forecast, warning and assessment services will be available to the merchant fleet, commercial fishing, coastal residents, sport fishermen and other marine recreation, the offshore industries, and construction and operation of offshore ports.

The major milestones are as follows:

<u>FY 75</u>

--Begin implementation of new improved marine observations from cooperative ships, automatic weather stations, and data buoys in key locations.

--Begin initial marine environmental quality baseline studies in the area of the TAPS marine leg.

--Establish a Satellite Field Service Station as part of an Interdisciplinary Environmental Service Unit for Alaska.

--Establish a marine forecast group at the National Meteorological Center and assign marine forecasters at WSFO's along the TAPS marine leg.

--Establish a test and evaluation program for measuring sea state in the Gulf of Alaska by long range skywave radar.

--Establish a Marine Environmental Quality Service Office for the TAPS marine leg.

FY 76

--Complete Test and Evaluation Plan of Skywave Radar.

--Begin improving Tsunami warning in the Pacific by using data relay system of GOES.

--Make assessment of marine environmental quality along TAPS marine leg.

FY 77

--Complete implementation of automatic weather stations.

FY 78

--Complete implementation of improved systems for marine observations from buoys and cooperative ships.

--Complete implementation of improved Tsunami Warning System using the GOES satellite relay capability.

The continuing monitoring system over the TAPS marine leg involves the identification and integration of ongoing Federal activities as a framework upon which the future program can be improved and expanded. The area of interest extends from southern California to southern Alaska with prime emphasis on environmental monitoring services in support of increased ocean tanker traffic and the associated coastal facilities. Because certain techniques required for making marine environmental quality assessment are still in experimental phases, specific planning for this part of the program is limited. It is expected that the evolutionary nature and time phasing of the program will permit necessary adjustments and added capability.

II. DESCRIPTION OF ENVIRONMENTAL CONDITIONS

The existing environmental conditions of the area encompassing the TAPS marine leg can be characterized as almost contaminant and ice free, rich in marine resources, complex with regard to ocean dynamics, and with highly variable--sometimes hostile--environmental phenomena. A few protected port and harbor areas, such as Port Valdez and Puget Sound, provide relatively safe havens for loading and unloading vital cargo.

Although climatological information for the Prince William Sound area is inadequate, it is known that the open Gulf of Alaska does encounter instances of heavy wind and surface waves. The warm summers and cold winters of this area also produce periods of restricted visibility, and localized hazardous environmental phenomena are common because of the extremes in coastal terrain. Of particular concern to shipping are the localized heavy fogs and the periodic and localized tide rips from tidal currents reaching 8 knots.

Another major set of environmental features in the TAPS area are the large tongues of differing water masses, eddies, and areas of upwelling. These conditions make determination of ocean contamination and its transport difficult, since contaminants can get locked into circulations that would normally distribute concentrated pollution far from its source.

Prince William Sound is also an area of historic seismic activity and was in the epicentral region of the great earthquake of March 27, 1964. The train of long-period tsunami waves generated by uplift of the Continental Shelf inundated low-lying portions of southern Alaska, damaging homes, boats, and harbor facilities.

The 1964 Alaskan earthquake was but one of many earthquakes of moderate and high intensity that have occurred in or near the Gulf of Alaska, other equally devasting earthquakes will doubtlessly occur in the future. Even relatively small earthquakes can produce substantial damage near the shore, and an enormous tsunami was produced by large rockslides loosened by the 1958 earthquake at Lituya Bay. In this instance water displaced by the slides destroyed forest to a height of 170 feet on the walls of the Bay. Environmental data collected during the 1958 and 1964 earthquakes resulted in rebuilding the Port Valdez area on new ground which is historically free of tsunami occurence.

Extratropical cyclones frequent the Gulf of Alaska throughout the year (figs. 2 and 3). These storms derive their energy from contrasting air masses and generate very active frontal zones. It is not unusual to have winds of hurricane force ($\geq$ 64 knots) in these storms. In winter there are four areas of cyclogenesis (fig. 2) in the Northeast Pacific; cyclones move into the area from the west or southwest. Two primary tracks converge on the Gulf of Alaska, and another primary track approaches Vancouver Island. During 5 of the 6 months from November through April more low pressure systems are found in the Gulf of Alaska than in any other part of the Northern Hemisphere. Also during this period winds in excess of gale force ($\geq$34 knots) are observed 26% of the time.

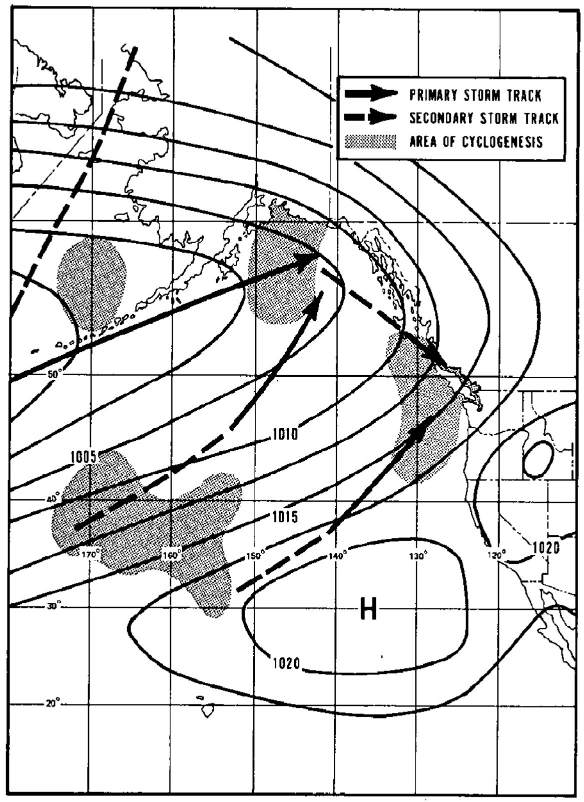


Figure 2. Winter Storm Tracks and Areas of Cyclogenesis.

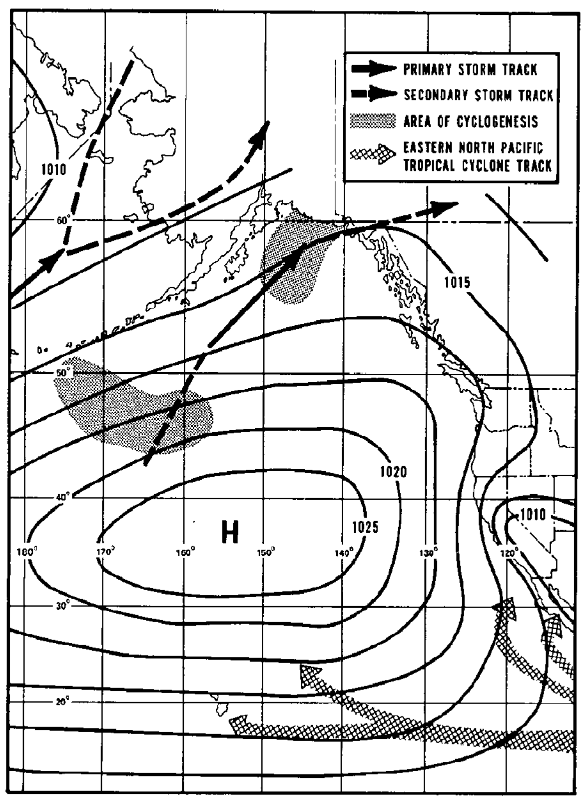


Figure 3. Summer Storm Tracks and Areas of Cyclogenesis.

Adverse environmental conditions of the Gulf of Alaska area can limit effective recognition and identification for safe piloting and navigation; these include the winter darkness, snowstorms, wind and rain squalls, and heavy fogs. To illustrate the maximum sustained winds that can be expected in the Gulf of Alaska, Table 1 shows the winds of record at ocean station "P".

Table 1.

Wind Record

Ocean Station "P" (Gulf of Alaska)

Mean recurrence interval-----years-----	2	10	20	25	50	100
Maximum sustained wind---------knots----	80	99	107	109	118	128

As might be expected, the distribution of high waves is similar to that of high winds. In winter, waves greater than 20 feet are observed at least 9% of the time. The maximum significant and extreme wave heights of record is shown in table 2.

Table 2.

Wave Heights of Record

Ocean Station "P" (Gulf of Alaska)

Mean recurrence interval (Yr)	Maximum significant wave height (Ft)	Extreme wave height (Ft)
2	36	64
10	49	89
25	58	104
50	65	118

Perhaps the most persistent environmental hazard to the TAPS area is reduced visibility, especially from fog. The frequency of restricted visibility ($\leq$2n.mi) for the area north of 36°N is between 5% and 10%. Even greater frequencies of fog occur along the California coastal areas, reaching 20% near Santa Barbara. Besides being hampered by fog, the northern part of the TAPS marine leg has many snowstorms which reduce visibility. The annual snow accumulation of Prince William Sound is 100-250 inches and frequently is accompanied by gusty downslope winds.

The Puget Sound area is not plagued with so many of the extratropical storms as is the Gulf of Alaska, but the chance of severe conditions was demonstrated by the merging of three storms off the Washington coast in 1962, causing millions of dollars in damage. Similarily, a quick-moving storm in this area in 1968 caused an abnormal wave 100 feet high. This area also experiences much advection fog accentuated by upwelling and radiation fog associated with stagnating air masses held by the semipermanent North Pacific high pressure center. The onset of fog near the Strait of Juan de Fuca is not always easily predicted or even recognized. Sometimes thick fog banks are held almost perpendicularly offshore by the air mass characteristics, whereas clear weather persists inshore allowing a vessel to arrive at its destination without difficulty. At other times the fog will move slowly into the strait, enveloping both shores for some distance. These same types of fog are also encountered all along most of the U.S. west coast. For example, Humboldt Bay experiences extremely dense fog and shoals near there are dangerous to vessels sailing through such weather.

Although tropical cyclones off southern California are relatively infrequent, they can pose an environmental hazard when they do occur. The last tropical cyclone to hit Los Angeles brought gales of 34-47 knots with waves as high as 30 feet. The cyclone claimed 45 lives at sea and caused damage exceeding $2 million to shipping, shore structures, and power and communication lines. In the same area of southern California hazardous conditions occur yearly from Santa Ana winds. These high velocity winds occur out to 50 miles off the coast and present forecasting techniques give only warnings of short notice.

During much of the winter, storms traversing the North Pacific send heavy swells into California coastal waters. Also, Southern Hemisphere storms propagate swells that travel along great circle paths and traverse thousands of miles of ocean relatively undetected and dissipate their energy upon the coast of California. Breakers up to 20 feet high occur, have contributed to loss of lives, and on occasion caused damage totaling millions of dollars.

From Los Angeles to San Diego there is coastal fog nearly every month, and heavy fog (visibility $\leq$1/4 mile) can be expected on about one day in six during the winter.

The foregoing description cites only a portion of the potentially hazardous environmental conditions in the TAPS area that point to the need for an oceanic monitoring, assessment, and prediction service to insure safe and efficient operations and to protect environmental quality. In most cases the selection of harbors, ports, and other coastal facilities associated with TAPS has been based on climatological data so that potential environmental hazards are minimized. This fact and adequate oceanic environmental monitoring, prediction, and assessment services will provide substantial assistance in assuring that the TAPS marine leg can be operated safely, efficiently, and without excessive stress to the environment.

III. MONITORING SYSTEM

Monitoring underpins the effectiveness and efficiency of warning, forecast and assessment services. The improvement and expansion of a monitoring system to support TAPS will evolve from three major elements:

- Integration of existing federal capabilities.
- Expansion by means of instrumenting platforms of opportunity.
- New observing systems brought about by technological development.

Data needs for the monitoring system are based on the information required to prepare operational warnings, forecasts, and assessments using available techniques and theories. A listing of the types of parameters needed is shown in appendix A for each product. The density and frequency needed in monitoring will depend on location and the parameters to be measured. For most parameters, requirements for data density and frequency decrease with distance from the shoreline. One reason is that the number of users decreases seaward. Secondly, the scale of most atmospheric and oceanic phenomena increases with distance from the shoreline, requiring less data density and lower frequency of observations.

Needs for monitoring oceanic contaminants have resulted from a rise in toxic metals, halogenated hydrocarbons, and oil in the ocean environment indicated by random observations and mass budget calculations. This need is particularly amplified for the TAPS area because of the vast amounts of oil which will be loaded, unloaded, and transported through the area. It is generally agreed that day-to-day operations will release some oil to the ocean environment even with the best of controls, and a large spill is still a distinct possibility. The exposure of increased oil to the TAPS marine environment is a phenomena that will cause heavy concentrations of toxic metals and halogenated hydrocarbons in surface films. The concentrations of these contaminants in oil films and tar balls have been found to be 1,000 times the normal concentration in seawater.

The advantage of combining ocean contaminant monitoring with those environmental observations needed for marine weather and oceanographic phenomena in the TAPS marine area is the opportunity to assess contaminant distribution and transport. The substances to be monitored initially in the TAPS area are those generally recognized as hazardous pollutants or as indicators of environmental quality:

- Petroleum hydrocarbons
- Heavy metals: mercury and lead
- Chlorinated hydrocarbons: DDT and PCB
- Nutrients and dissolved gases.

Frequency of sampling will vary depending on location and contaminant involved; it will be highest in the coastal areas and near known sources of pollution. Stations will be occupied often enough to provide seasonal and annual analyses of concentrations. However, in certain locales sampling will be monthly to adequately monitor fluctuations of pollutants known to be in relatively high concentrations or having high variability.

The monitoring system will be a mix of platforms to monitor the oceanic environment and include satellites, buoys, ships, and fixed facilities near and on the coast. Many cost effectiveness studies have pointed out that the use of a mix of platforms in monitoring the oceanic environment has major advantages over a system that uses only one or two different platforms.

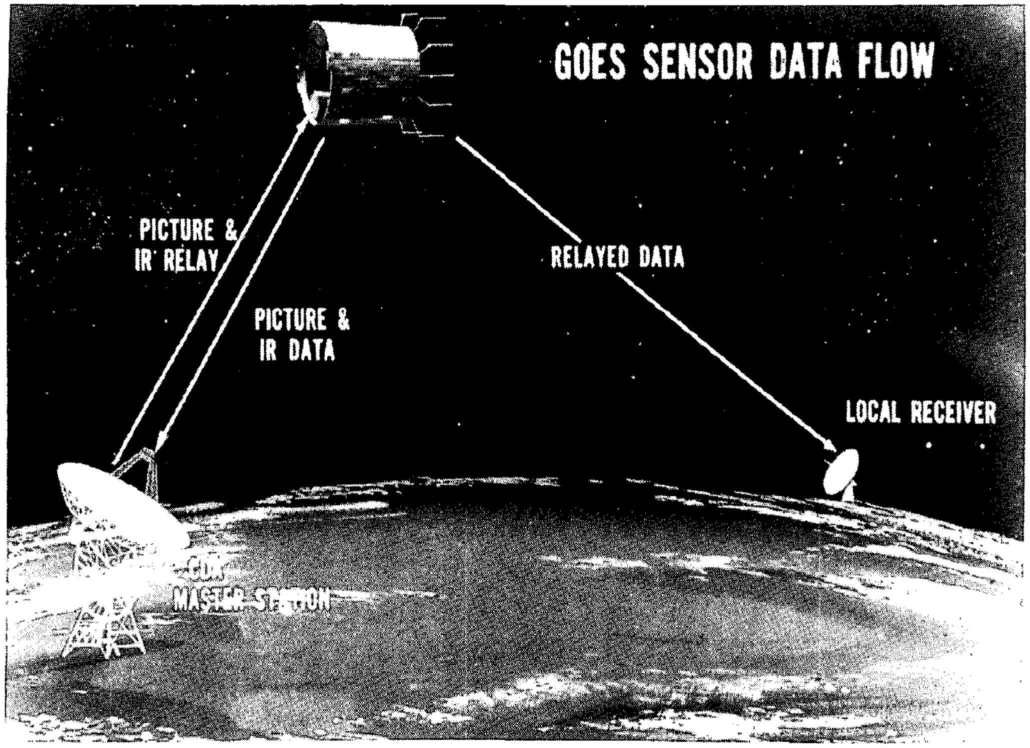
Clearly, no one platform can provide the most cost effective monitoring for all locations and for all types of data, i.e. surface, subsurface, upper air, etc. Also, in implementing the monitoring system in the TAPS area where the density and frequency of observations vary with different classes of parameters (meteorological, physical ocean, pollutant), a mix of platforms can be used most effectively. The monitoring platforms are described in table 3 and discussed below.

Satellites.--Two major operational satellite systems will be included in the monitoring system in the TAPS area. The satellite systems will provide a unique platform capability for both global and regional synoptic monitoring. Operational polar orbiting environmental satellites (sun-synchronous) of the ITOS-type carry visual and infrared imaging sensors with resolutions from 1/2 to 2 miles, providing twice daily global cloud photographs, both day and night, and sea surface temperatures once a day in cloud free areas. Coverage is even more frequent at high latitudes. In addition these satellites carry a Vertical Temperature Profile Radiometer (VTPR) which provides vertical temperature soundings of the global atmosphere above the clouds or to the surface in cloud-free areas. With this combination of sensors and orbit, the ITOS satellites (called NOAA satellites once in operational orbit) will provide information on location and movement of major weather systems over the Pacific Ocean, identify and track the many ocean storm systems of the Gulf of Alaska, permit surveillance of polar and coastal sea ice, provide mapping of surface temperature for computing energy balance, and provide data from the VTPR to permit analysis and forecasts of the upper atmosphere. One satellite (NOAA 2) of this variety is already operational and available. Plans include keeping at least one environmental satellite with this capability operational at all times until the late 1970's, when an improved polar orbiting system (TIROS N) is proposed.

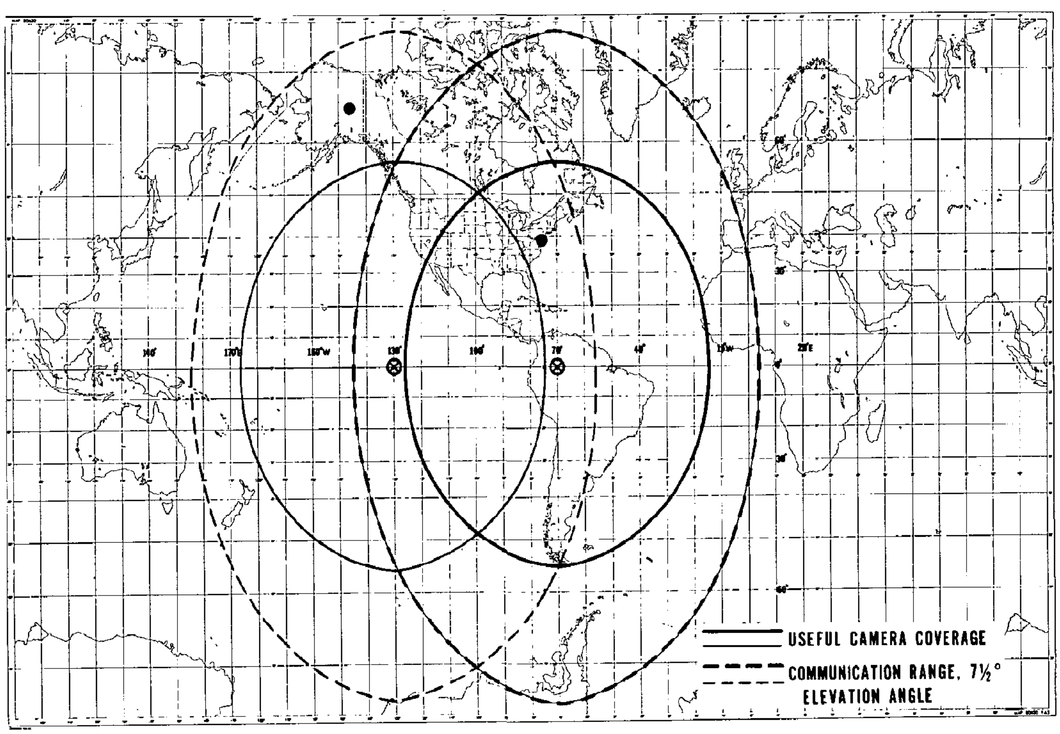
The Geostationary Operational Environmental Satellites (GOES) will provide nearly continuous visual and infrared imagery of the ocean's surface below latitude 55° covering most of the ocean adjoining the TAPS area. The nearly continuous coverage of this satellite system is ideal for disaster warning by observing origin, growth, and movement of ocean storms and will permit computation of wind fields at cloud top levels. GOES carries a data collection system that will relay data from ocean platforms or remote shore locations to Wallops Island, and on to the National Meteorological Center (NMC) as well as the Weather Service Forecast Offices (WSFO's). This capability will be important in early identification and location of coastal hazards such as weather systems producing storm surge conditions and high sea state.

Table 3.--Monitoring Platforms

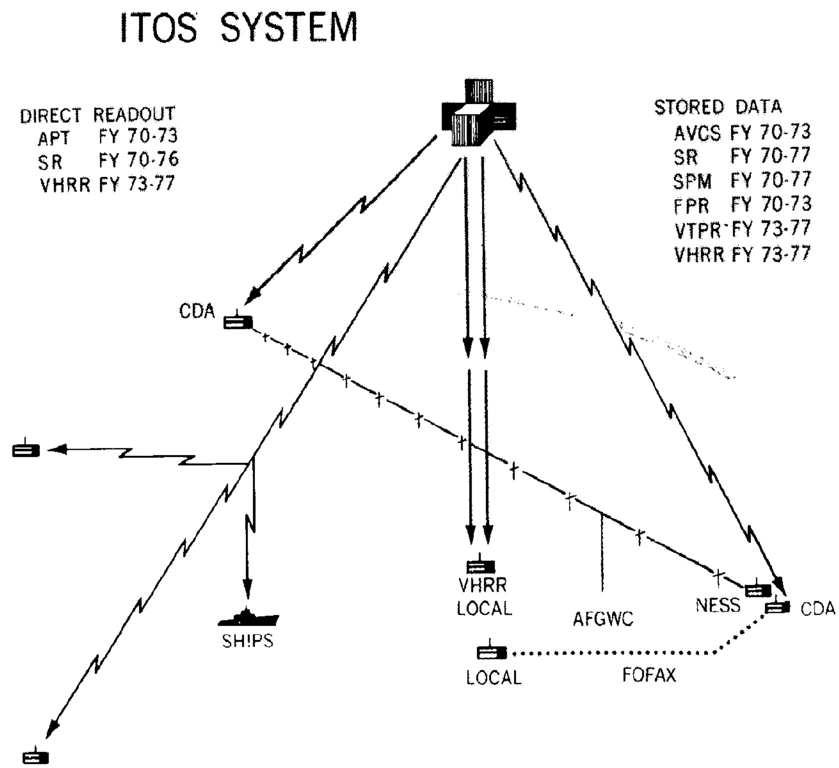
Platform	Initial Data Reports	Future Data Reports	Data Communication
Polar-Orbiting Satellites	Radiation temperature (cloud top or sea surface) Atmospheric Sounding Visual Imagery (Clouds)	Wave spectra Estimate of wind velocity Chlorophyll Turbidity	Telemetry
Geostationary satellites	Radiation temperature (cloud top or sea surface) Visual imagery (clouds)	Atmospheric sounding Wave spectra Estimate of wind velocity Chlorophyll Turbidity	Telemetry Data relay system for remote platforms, e.g., ships, buoys
Data buoys	Wind velocity Atmospheric pressure Air temperature and moisture Sea temperature Wave height	Water quality Current velocity salinity	High frequency Ultrahigh frequency
Coastal stations	Wind velocity Atmospheric pressure Air temperature and moisture Sea surface temperature Breakers and surf Sea level Contaminant samples	Air pollutants Turbidity	High frequency Hardwire
Offshore facilities	Wind velocity Atmospheric pressure Air temperature and moisture Sea surface temperature	Current velocity Wave spectra Salinity Chlorophyll	High frequency Ultrahigh frequency
Cooperative ships	MOOS; Wind velocity Atmospheric pressure Air temperature and moisture Sea surface temperature Sea surface salinity	Sea temperature profile Wave spectra Sea salinity profile	High frequency Ultrahigh frequency
Patrol vessels, buoy tenders, and research vessels	MOOS Contaminant samples	Sea temperature profile. Wave spectra Sea salinity profile	High frequency Ultrahigh frequency
Aircraft	Radiation temperature (sea surface) Oil slicks		High frequency
Tide gages and wave gages	Sea level		Hardwire High frequency Ultrahigh frequency
Skywave radar	Sea state Estimated wind velocity	Estimated current velocity	Hardwire



GOES Data Flow



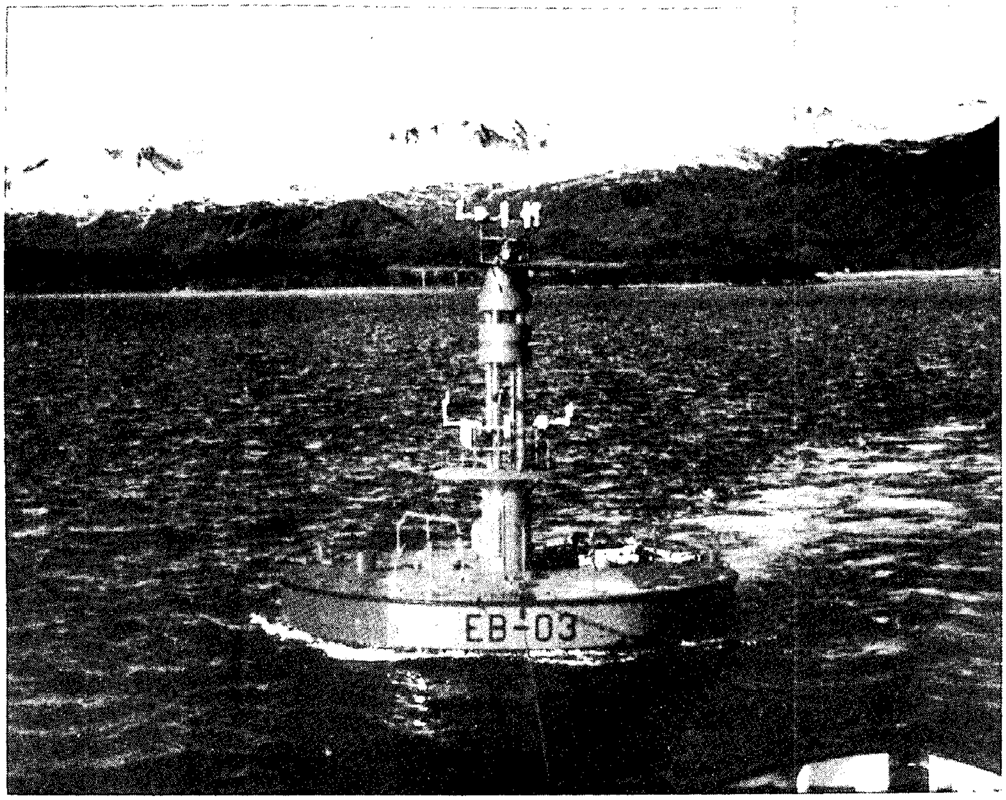
Coverage by Two GOES Systems.



ITOS (Polar Orbiting) System.

Improvements may be expected in the capability of both operational satellite systems during the next 5 years as a result of adapting prototype sensors used on the NASA research satellites like the Earth Resources Technology Satellite (ERTS 1) now in orbit and the Nimbus series. ERTS 1 has a multi-spectral, high resolution sensor and will be of only marginal value for most applications in the TAPS area because of its spectral characteristics, its 18-day cycle interval, and the 1 week delay in obtaining the data. However, information on distribution of discernible contaminants in coastal waters, behavior of longshore currents, and distribution of sea ice can be derived from ERTS data and will contribute to the monitoring system.

Buoys.--Data buoys are necessary to provide surface and subsurface data in the TAPS marine area where other platforms such as satellites and cooperative ships are inadequate for providing data needs. Deployment of environmental data buoys for TAPS is planned for the next 5 years in two major areas shown in figure 4. These areas were selected because of their proximity to major storm tracks and cyclogenesis as was shown in figures 2 and 3. It is expected that nine deployment locations will be needed. One experimental platform (EB 03) is now deployed at 56°N, 148°W and providing surface weather observations on a routine basis via high frequency telecommunication. The demonstrated technology and usefulness of even a single experimental environmental data buoy in the Gulf of Alaska provides the basis for making data buoys an integral part of the monitoring system. A second buoy deployment



Experimental Environmental Data Buoy for the Gulf of Alaska.

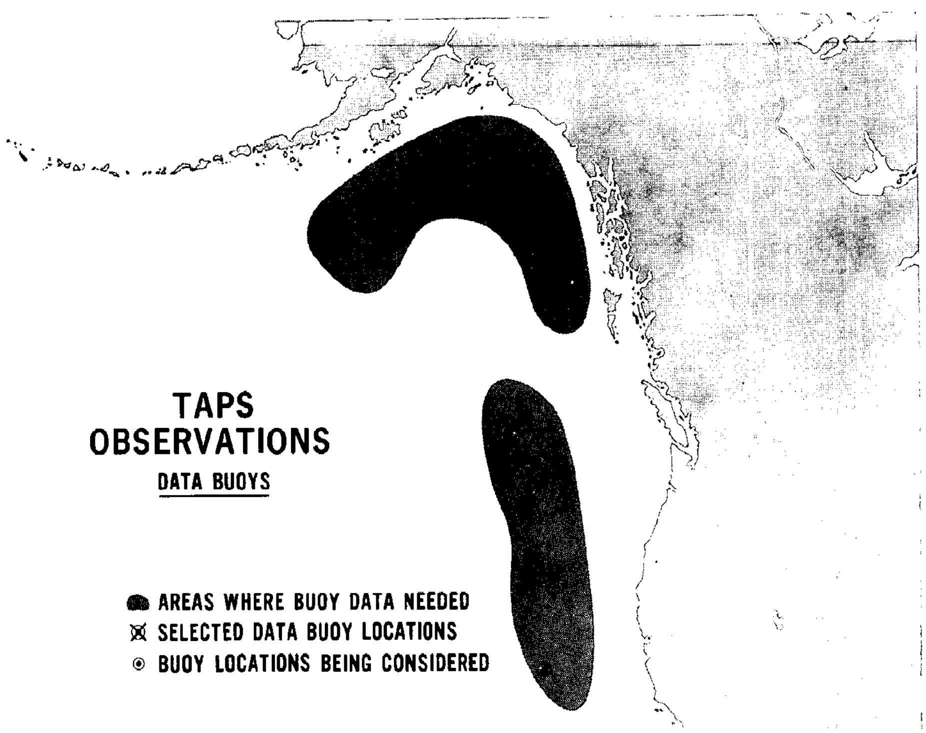


Figure 4. Data Buoy Locations.

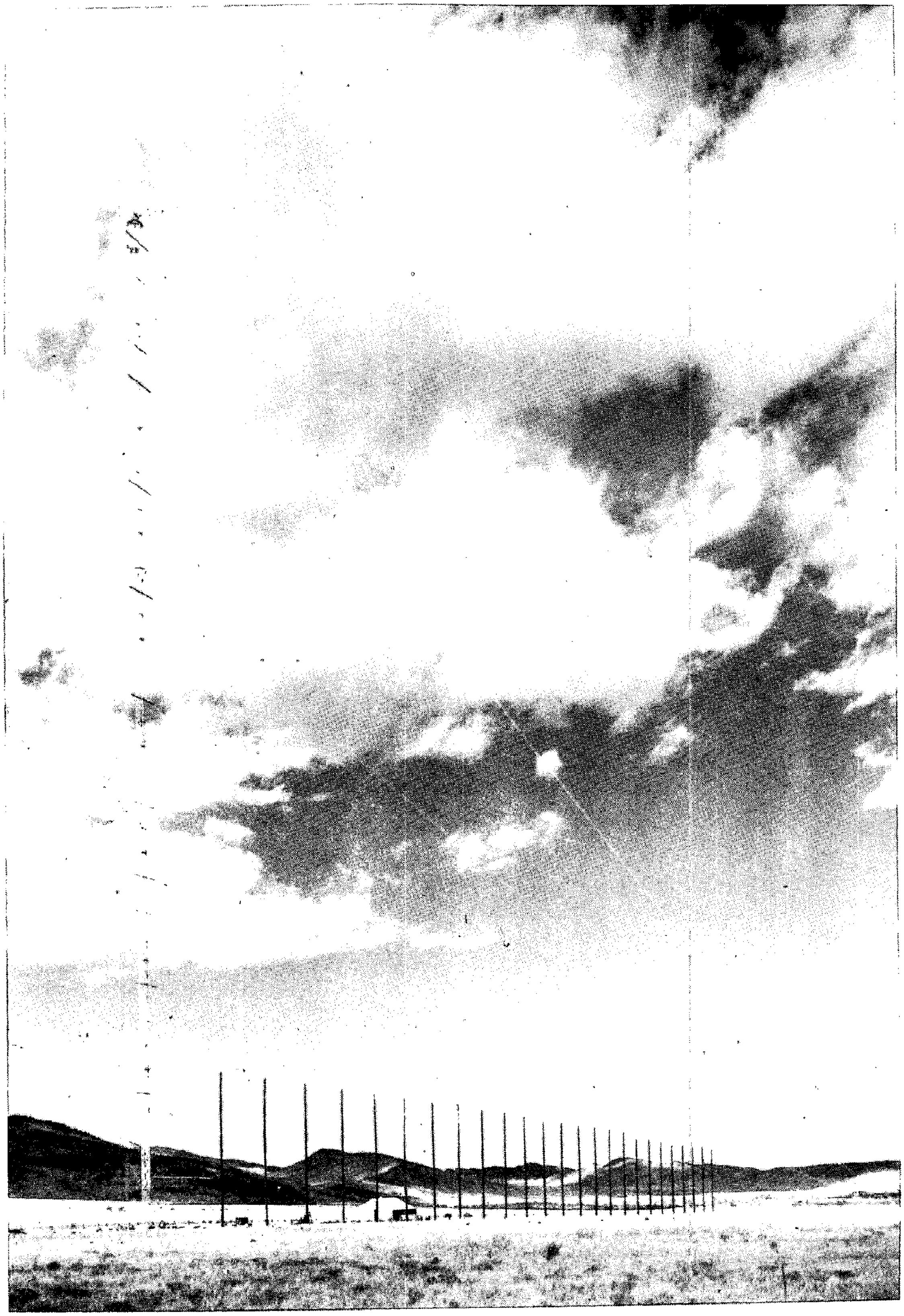
is scheduled for late FY 74 or early FY 75 at 47°N, 131°W. Seven additional locations are being developed and are shown in figure 4.

Planned configuration for buoys in support of TAPS initially will include surface measurements of air temperature, pressure, dewpoint, wind velocity, and sea state; subsurface measurements of ocean temperature; and pressure (depth). Future subsurface measurements will include salinity and current velocity. Telecommunications to service centers (e.g. NMC and WSFO's) will be via HF initially with conversion to satellite relay using UHF in FY 76. It should be pointed out that certain buoys will not be configured with all sensors described, but measurement designs will be dependent on location and hull type selected.

Coastal and offshore facilities.--Observations from the coastal areas and seaward to 50 n.mi. will be made from a variety of opportunity platforms including coastal stations, coastal automatic meteorological stations, tide stations, offshore towers, large navigational buoys, and skywave radar. Charts showing existing and planned coastal and offshore observing facilities are given in figures 5, 6 and 7. These facilities will be instrumented to measure those parameters needed to prepare and disseminate warnings of hazardous environmental conditions which could cause spills from tankers and associated shore side facilities. Manned coastal stations will be used predominantly along the west coast whereas automatic and remote observing systems will be placed along the rugged and sparcely populated southern Alaska coast. Strategically placed tide stations in the TAPS area will provide the measurements needed for tide and tidal current predictions and warnings of tsunami and storm surge. Offshore towers and platforms in the southern California area and eventually Cook Inlet will provide surface weather and subsurface measurements for forecasts and warnings in the offshore zone. These observations can be complemented by providing environmental sensors on Large Navigational Buoys (LNB). Initially, two LNB's are planned to be instrumented: Blunts Reef (40.3°N, 124.5°W) and San Francisco (37.8°N, 122.7°W). Because of the importance of sea state forecasts, a skywave radar system will be developed. Once developed, this radar is planned from a site located on St. Clemente Island, here it will provide continuous observations of sea state characteristics and surface currents for the entire TAPS marine leg. An added feature of the skywave radar will be its ability to track transponder equipped ships which are along the marine leg.

Ships.--Cooperative ships appear to be effective means for acquiring some necessary surface and subsurface data needed for preparing marine service products. As envisaged in TAPS, at least four tankers will be en route between Valdez and the west coast ports at a given time and, with onboard monitoring systems, will provide data needed for forecasts and warnings. In addition to the TAPS tankers, merchant shipping between the west coast ports and Anchorage, as well as a section of the major sea lane between west coast ports and Japan will provide a significant number of data points for service products (fig. 8).

The cooperative ship program provides data from this area, but the quality and quantity have been poor because of both inadequate sensing and delay from insufficient radio communication arrangements aboard merchant ships. To



Experimental Skywave Radar Antenna System.

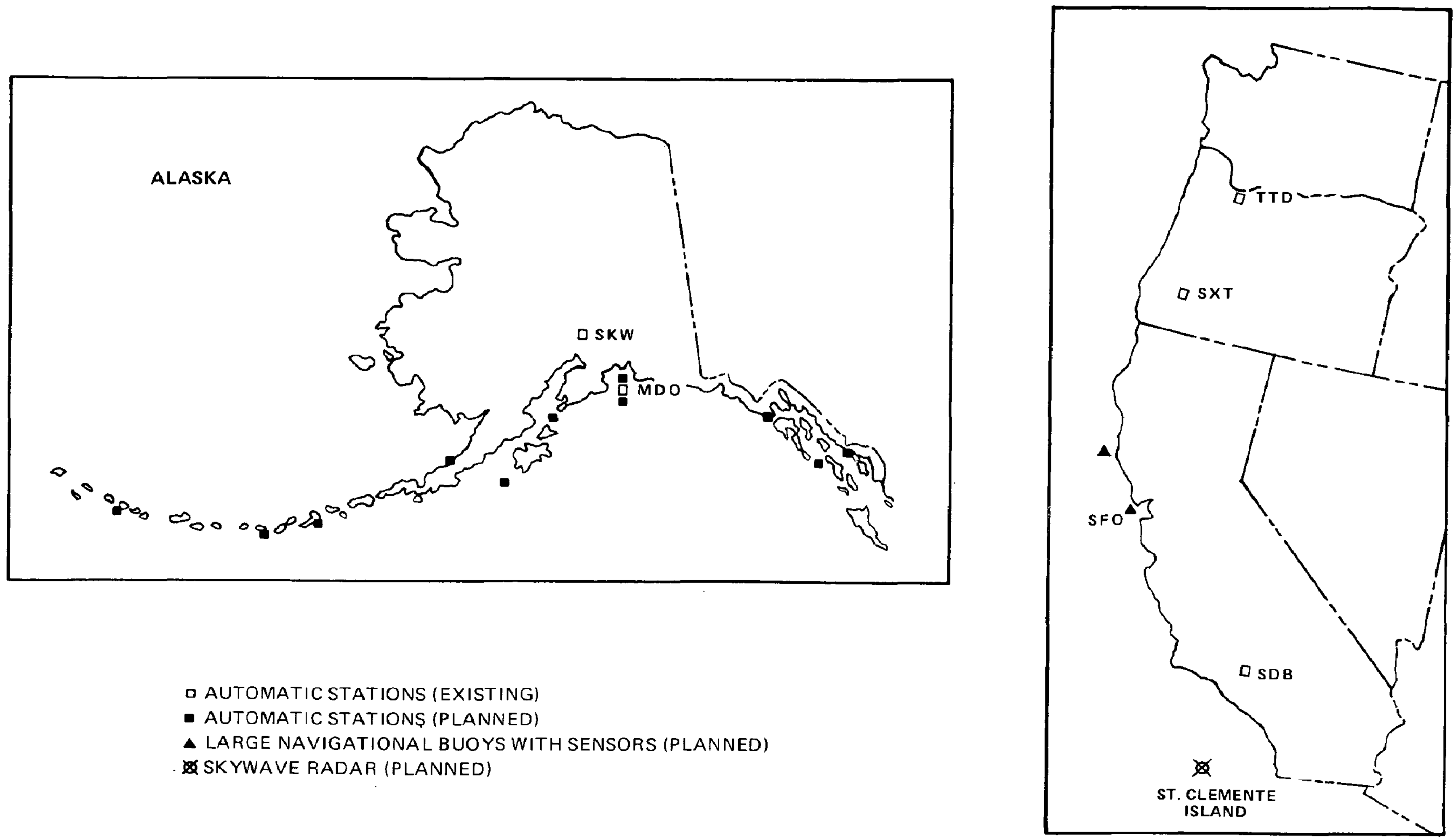


Figure 5. Automatic observing stations and skywave radar.

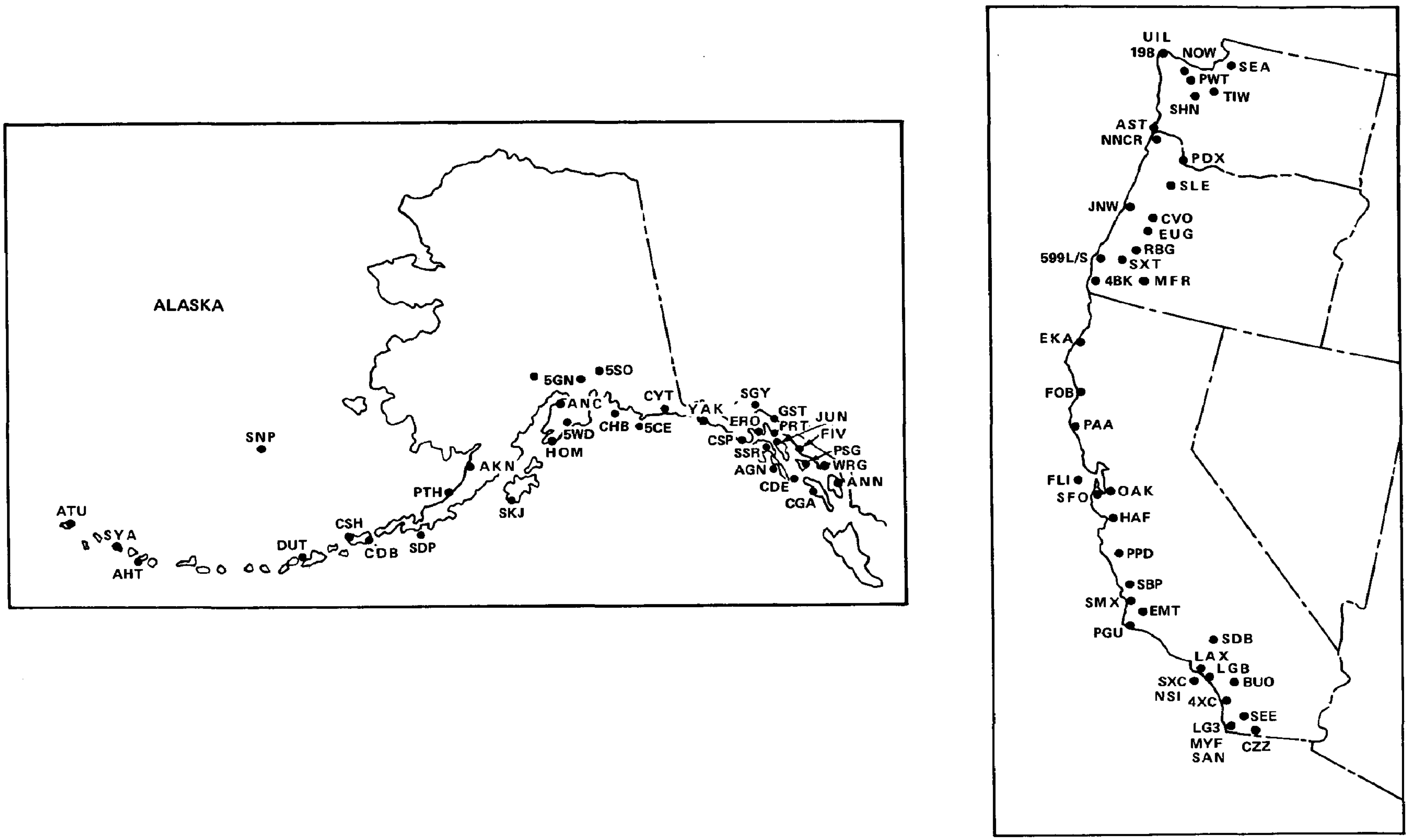


Figure 6. Staffed surface observing stations.

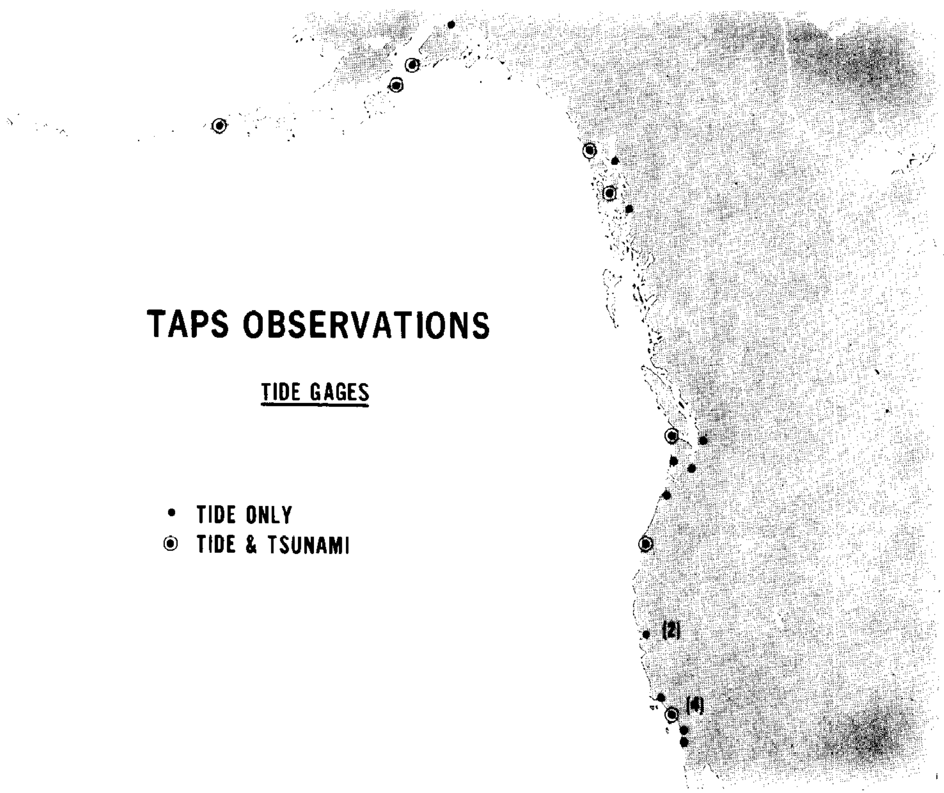


Figure 7. Tide gage locations.

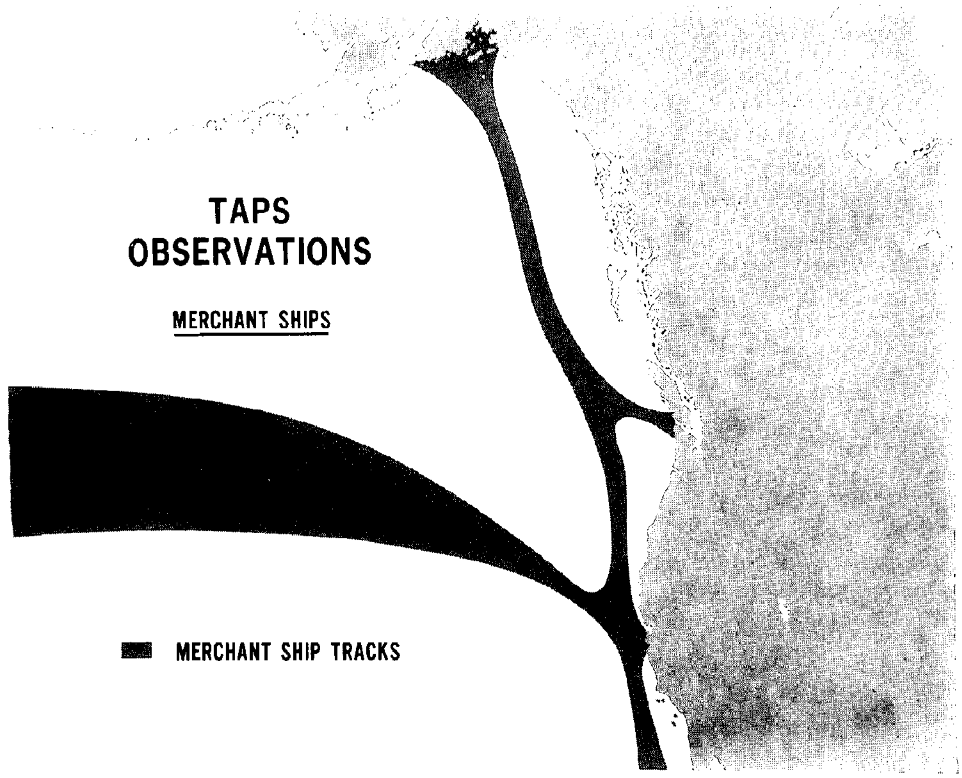


Figure 8. Major merchant ship tracks.

improve the quality and quantity of data from the cooperative ship program, modular oceanic observing systems (MOOS) will be implemented which will provide for automated observations with data relay through the GOES satellite. MOOS will eventually include 200 ships in the TAPS area. In addition, new ships will be selected which have minimal port time and which make routine transits of the TAPS area. Those cooperative ships not equipped with a MOOS will continue to participate by taking manual and visual observation and reporting through MF or HF radio via stations shown in fig. 9.

To provide maintenance for equipment on cooperative ships and to make available information on the environmental services, Port Meteorological Offices have been established and will be expanded as shown in fig. 10.

The Continental Shelf and offshore ocean areas are regions where increased contamination by certain heavy metals, halogenated hydrocarbons, and oils could have serious effects. Although these contaminants now appear in low concentrations, the increases predicted from mass budget estimates may severely damage many of the ocean resources. To support continued assessments and trend analyses, a program of environmental quality monitoring will be established from Coast Guard coastal patrol vessels, buoy tenders, and Government supported research vessels. These platforms will provide a significant number of the samples needed for oceanic environmental quality indications. Figure 11 shows the home ports of the Coast Guard patrol vessels. In geographic areas where government research vessels are unavailable, contract vessels will be used to obtain the needed samples for marine quality assessment.

Ocean station vessels.--The ocean area encompassing the TAPS tanker route does include one ocean station vessel occupied by Canada. Ocean station "P" is located at 50.0°N, 145.0°W and provides 6-hourly observations of the surface and subsurface conditions and 12-hourly observations of the upper atmosphere. In addition the Canadian government will be requested to increase the scope of observations at OSV "P" to include environmental quality data.

Other platforms.--Several other platforms will be available for monitoring the marine leg portions of TAPS and will include Coast Guard coastal aircraft flights (fig. 12). Also, the instrumentation network for the Tsunami Warning System, shown in fig. 13, will use the data relay system of geostationary satellites to advance the warning time.

System mix.--The monitoring platforms discussed in the foregoing are diverse in their capability, with each type having certain attributes for operating and providing selected kinds of information needed in support of the marine leg of TAPS. It is this diversity and multitude of capability that will strengthen the monitoring system. For example, data needed at the air-sea-land interface for predictions and warnings will be fulfilled in large part by offshore facilities, automated observing systems, radar, and coastal stations. A significant amount of the water quality sampling in the zone 0-50 miles offshore will be provided by patrol vessels and buoy tenders. Data for prediction and warnings in the zone about 20 nautical miles offshore and into the open ocean along the major shipping lanes, including the TAPS tanker route and the transit between the west coast and Anchorage, will be provided by

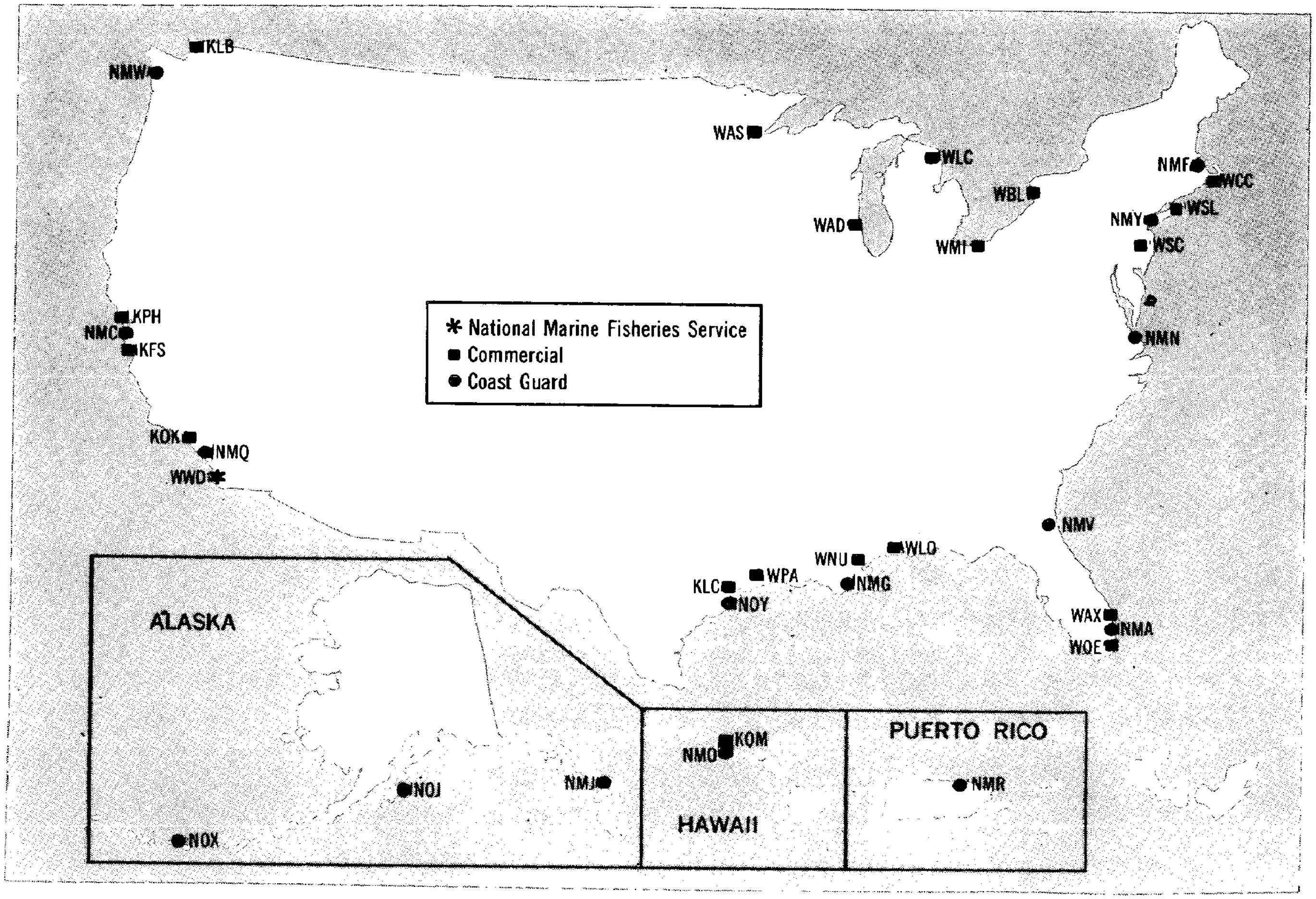


Figure 9. U.S. radio stations which receive environmental information from ships.

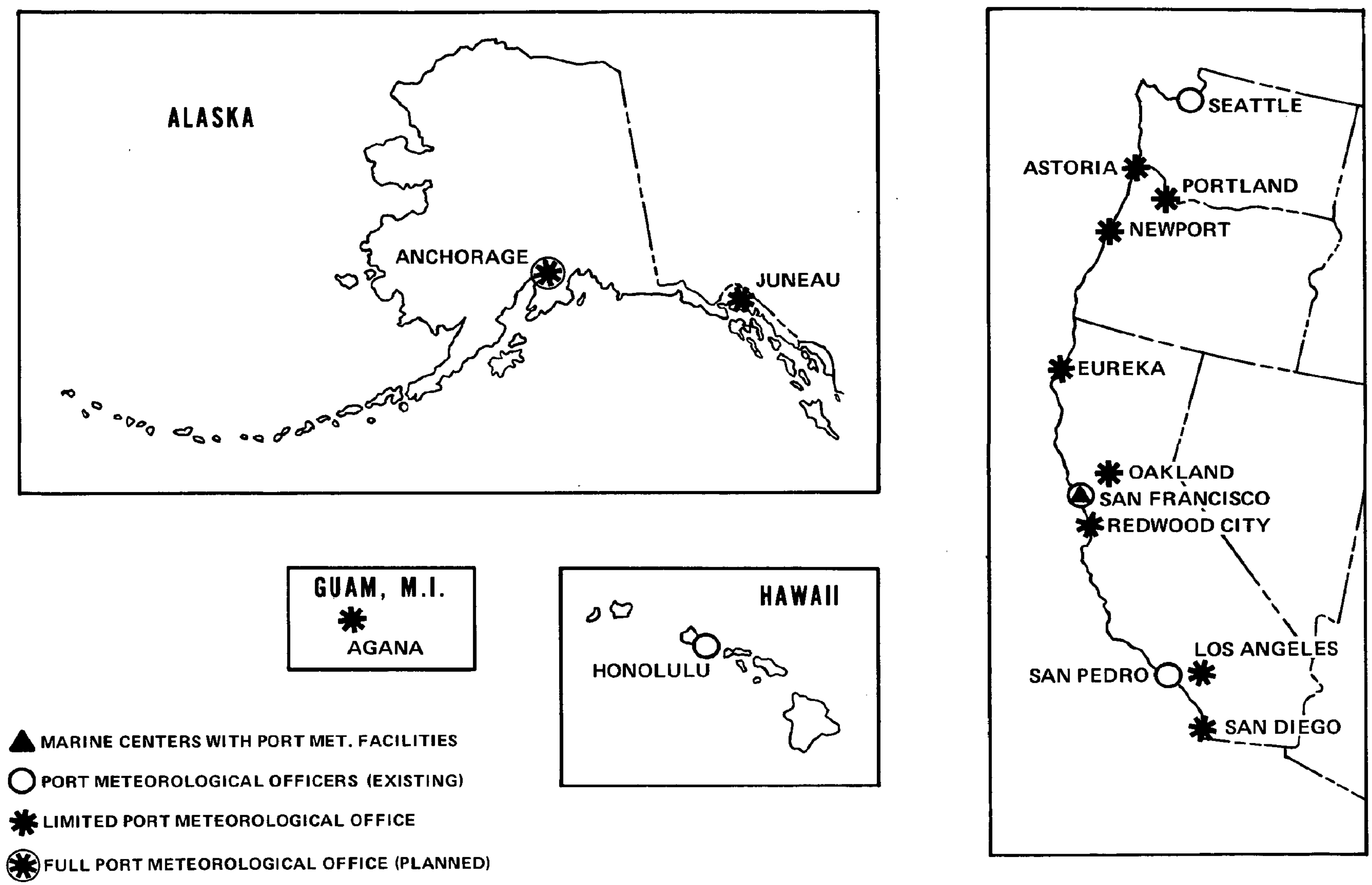


Figure 10. Port meteorlogical offices.

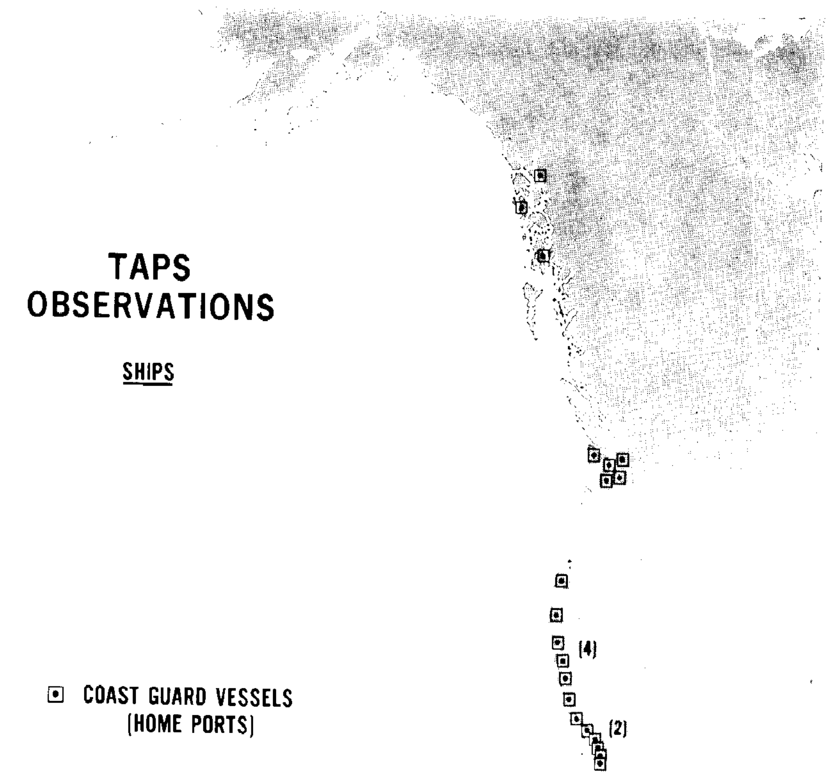


Figure 11. Location of patrol vessel ports.

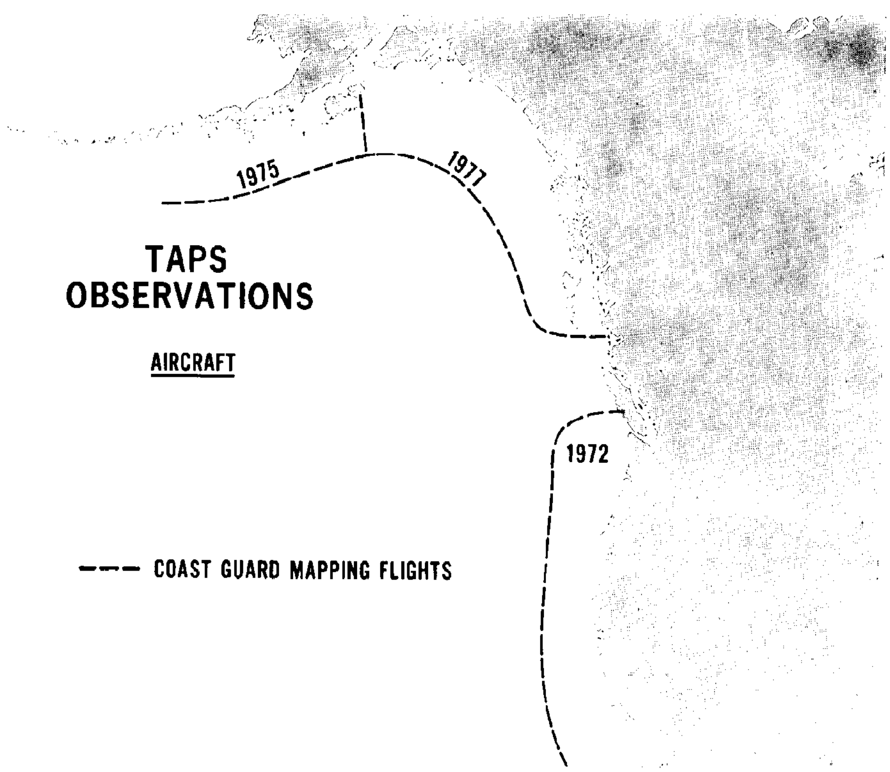


Figure 12. Areas of coastal mapping flights.

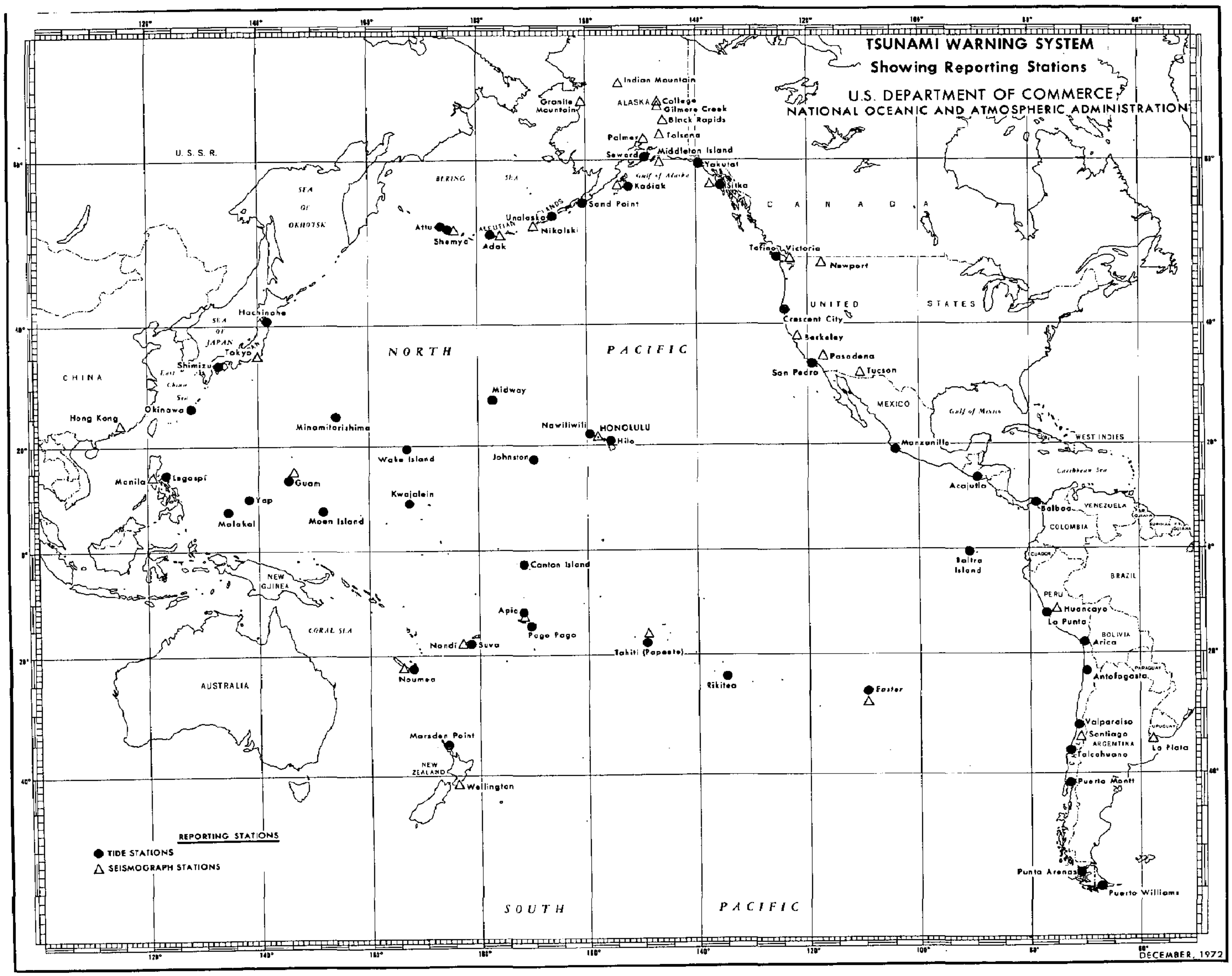
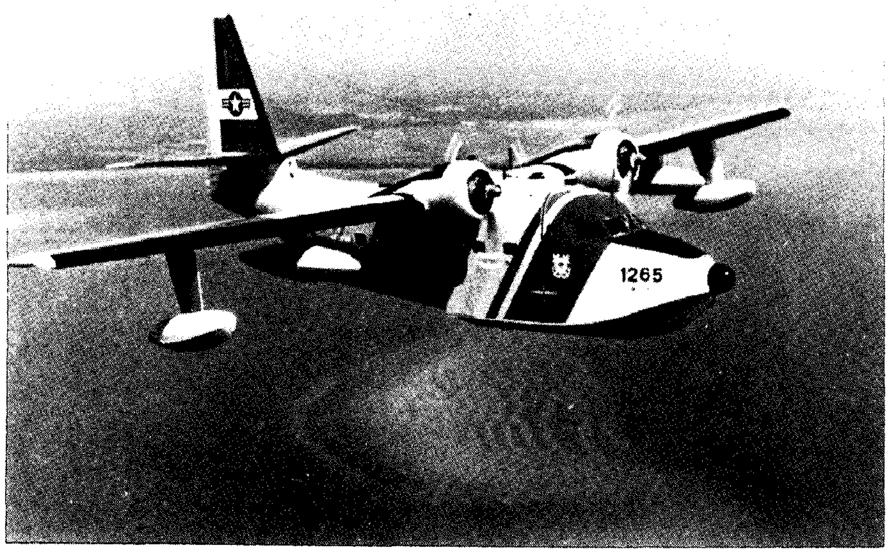


Figure 13. Tsunami warning network.



Coastal mapping aircraft.

cooperative ships. Large area coverage for describing temperature fields at the sea surface and in the atmosphere, and cloud systems from which winds aloft can be estimated, will be provided by both polar orbiting and geostationary satellites. Oceanic areas where other platforms are inadequate for providing surface data needs and areas where subsurface data are needed will be monitored by various configurations of environmental data buoys. Appendix A lists the basic data needs for providing services. The monitoring system will utilize a variety of communication modes for data transmissions and will be dependent on their use in prediction, warning, and assessment. Platform communication modes for each platform was shown in table 3.

The communication of data from the sensor platforms to the processing centers for preparation of service products will be through expansion and improvement of present environmental data communication systems used by the national weather services. These systems (see appendix B) include the Service C, O, and RAWARC teletypewriter circuits; the forecast office facsimile network; the intra-Alaska facsimile network systems; the NOAA, Coast Guard, and Navy radio station network for cooperative ship reports; the NOAA west coast marine circuit; and the tsunami warning system network. The major planned improvements include use of the data relay system aboard the GOES satellite for the tsunami warning system, selected platforms including ships of opportunity, and extension of the west coast marine circuit from San Francisco to Anchorage.

IV. WARNING AND FORECAST PREPARATION

The basic framework and structure for providing warning and forecast services are now available. However, certain shortcomings exist:

- Regional and local forecasting techniques need improvement and better data.

- Physical oceanographic forecasting techniques on all scales need development.

Within the National Weather Service, three echelons of centers (fig. 14) exist to provide these services. The National Meteorological Center (NMC) will provide basic guidance products on a synoptic basis and long range forecasts on ocean basin or hemispheric scales for use by lower echelon centers. Planned improvements that will support the services for the marine leg of TAPS include the establishment of a marine forecast group at NMC.

The NOAA Weather Service Forecast Offices (WSFO) provide the second echelon services. Marine Forecast Units already exist at San Francisco and Anchorage to provide warning and forecast services for the Northeast Pacific and Gulf of Alaska. Marine focal points are available or planned for WSFO's at Los Angeles, Portland, Seattle, and Juneau. In addition to these WSFO's a special Marine Environmental Service Office (MESO) is being established at Valdez for support of TAPS.

The third echelon centers are composed of Weather Service Offices (WSO) along the coast. Each coastal WSO (fig. 14) will have a marine focal point responsible for warnings and forecasts for harbor and anchorage conditions, coastal shipping and operations, and local shore side facilities.

In addition to the warning and forecast centers described above special centers at Honolulu and Palmer, Alaska, will provide tsunami warnings.

Dissemination of marine forecast and warning services will be made by voice, CW, and radio facsimile broadcasts, commercial radio telephone, VHF-FM, and commercial radio television broadcast stations. Government broadcasts will be through the facilities of NOAA, Coast Guard, and Navy (fig. 15). Additional facilities available for communication of both data and warning services are included in appendix B.

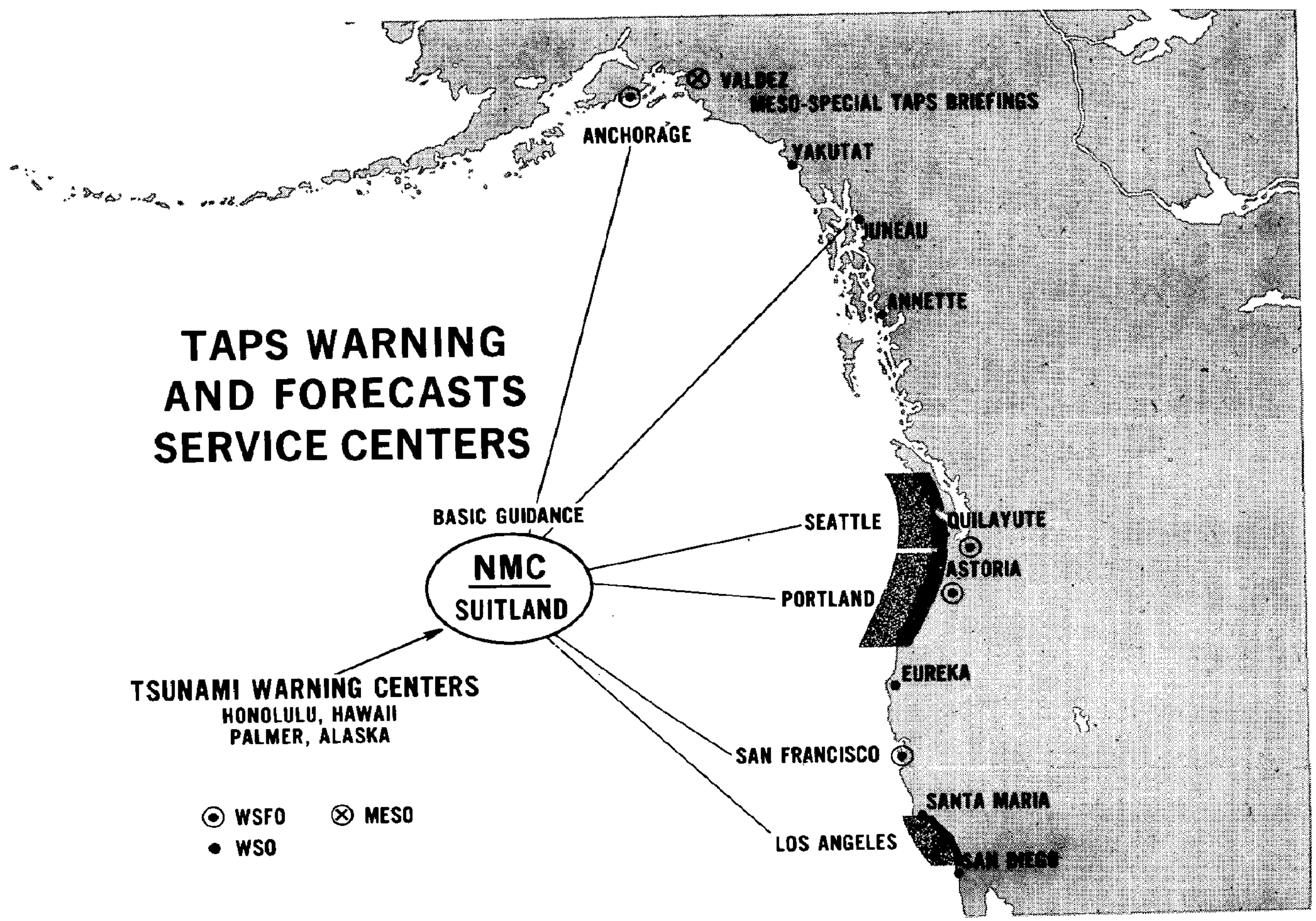
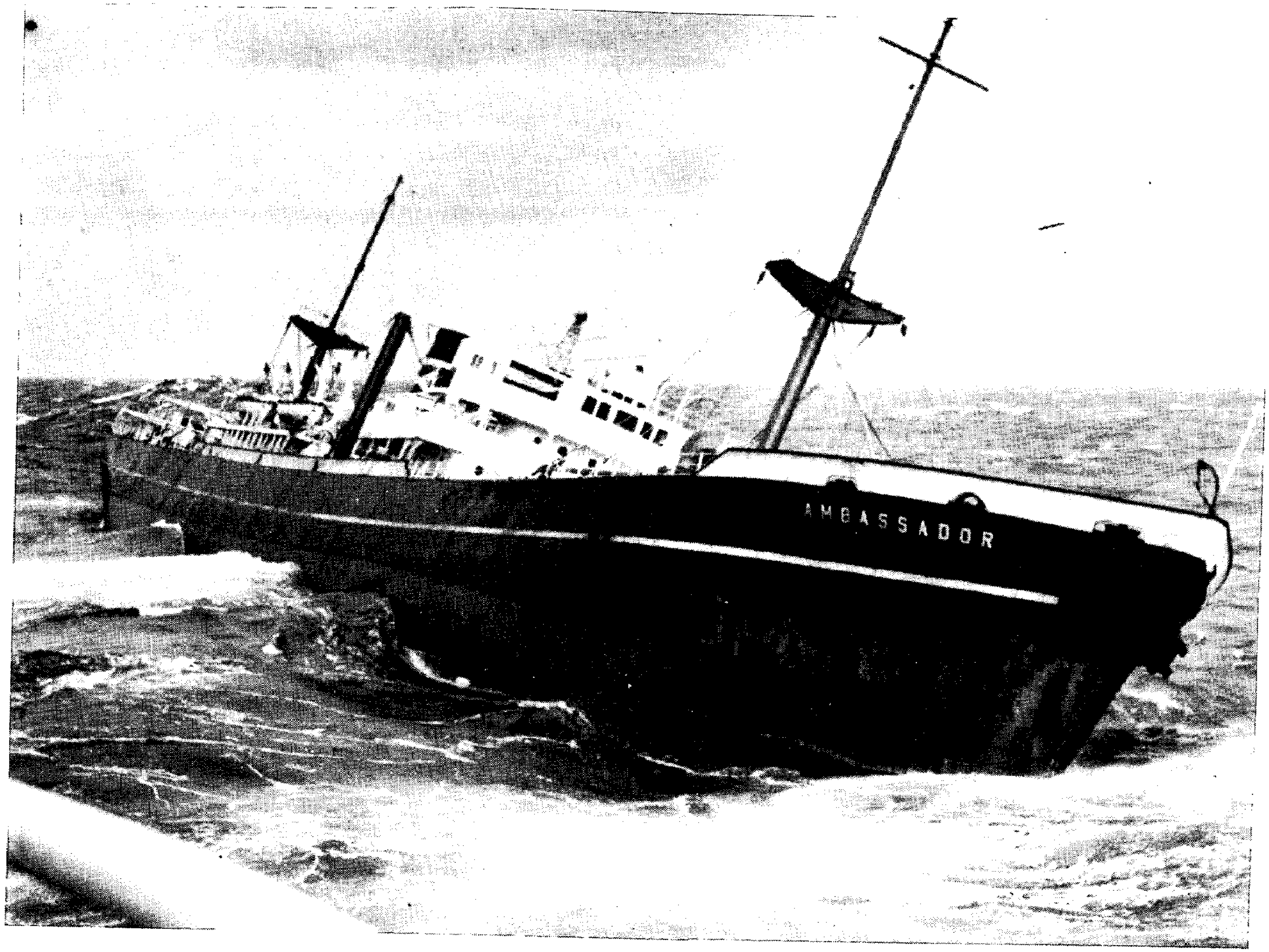


Figure 14. TAPS warning and forecast centers.



Transitting through the ocean environment.

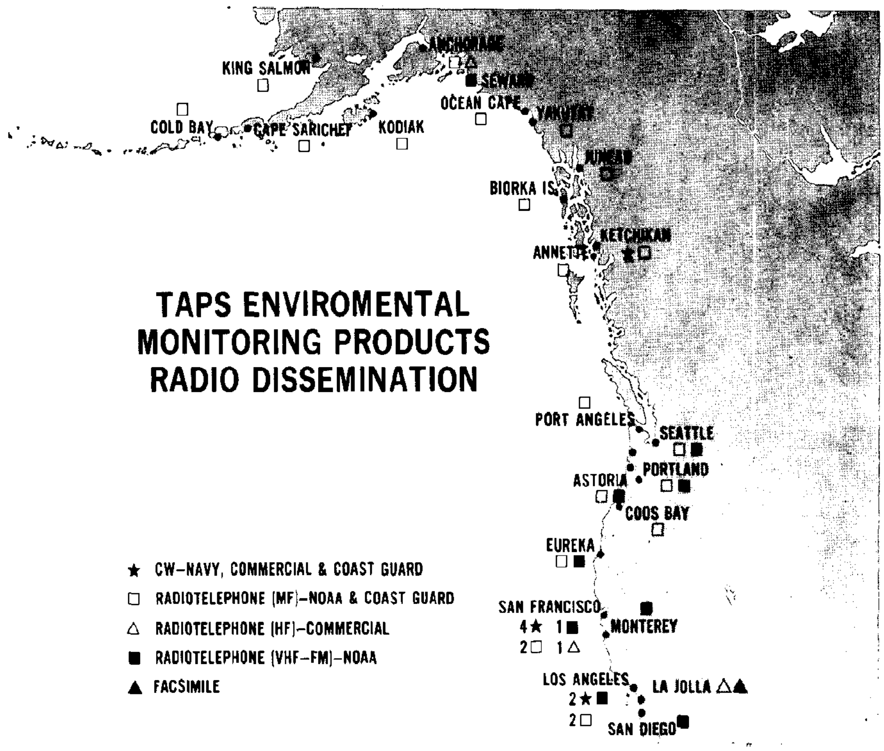
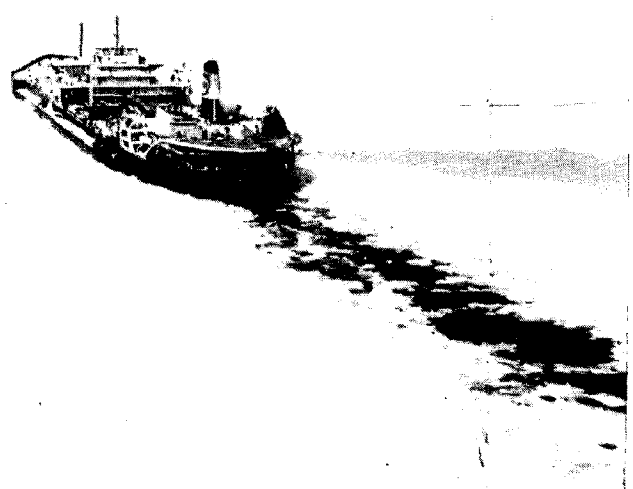


Figure 15. Radio stations broadcasting warnings and forecasts.



Tanker with ice breaking hull.

V. MARINE QUALITY ASSESSMENT

The preservation and enhancement of the relatively pristine marine leg of TAPS will depend upon the establishment of a viable marine quality assessment service.

- Pre-operational baseline description of contaminant concentrations.
- Periodic assessment of environmental quality.

In providing this service monitoring techniques will emphasize the method and frequency of contaminant introduction into the ocean and the mechanisms of transport within the marine environment.

The evaluation of an effective environmental assessment service will rely upon recent actions, such as: the establishment of a Pacific Northwest Environmental Coordinator, located in Seattle, Washington; the initiation of a research program to determine hydrocarbon concentrations and their possible effects in the northeastern Pacific Ocean including Prince William Sound; development of standard sampling and analytical techniques for petroleum hydrocarbons; and initiation of ecosystem research planning for Puget Sound and Prince William Sound.

Further work in support of TAPS will use available historical data and integrate governmental, industrial, and academic activities where pertinent. In order to provide a quality assessment service for the marine area of TAPS, sampling and analysis need to be made throughout the environment.

- Biological indicators
- Atmospheric transport
- Water and sediment

Biological indicators.--Biological indicators of petroleum hydrocarbons and other contaminants will be included for three reasons: (1) the biota is of immediate importance to man as food, and hence concentrations of pollutants may present health hazards; (2) they are useful as indicators of the spatial and temporal distribution of pollutants because marine organisms concentrate most contaminants; and (3) the biosphere represents an important reservoir and transport medium for pollutants.

Organisms to be sampled will be chosen on the basis of several criteria, e.g., importance to man, ease of sampling, ecological "importance," and biochemical, physiological, and behavioral diversity. Sampling sites will be chosen to represent major coastal and oceanic habitats, each of which differs in ecosystem structure and function.

Because of the patchiness of both spatial and temporal abundances and of variations in physiological and behavioral states and in age-frequency distribution, there can be expected large variances within habitat for all measured variables. Preliminary sampling studies at each of the sites and for each of the species of organisms and pollutants will be conducted. Variance estimates, thus derived, can be of some use in the interpretation of subsequent samples taken during the operational program. For coastal monitoring, one contaminated and one "clean" site will be selected for each area of interest.

Coastal species proposed for monitoring are as follows: Engraulis mordax (anchovy), Microstomus pacificus (Dover sole), Oncrhynchus kisutch (silver salmon), Mytilus edulis, or M. californicus (mussels), Loligo opalescens (squid), Cancer magister (dungeness crab), and other subtidal and intertidal invertebrates.

Open ocean species proposed for monitoring are: Thunnus albacares (yellow fin tuna), Thunnus alalunga (albacore tuna), Onchorhynchus gorbuscha (pink salmon), Coryphaena hippurus (dolphin) Ommastrephes spp. (squid), myctophids, macrozooplankton.

Existing marine contaminant programs in the National Marine Fisheries Service and similar programs in other agencies will be periodically reviewed to determine expansion needed over several years to provide the necessary areal, species and chemical coverage for the TAPS area.

Atmospheric transport.--The atmosphere is a major transport pathway for many contaminants found in the marine environment. The monitoring of atmospheric transport to the oceans will be approached in two ways. First, transport models will be used as guides for determining areas of interest. This will include established numerical models to predict the path and concentrations of pollutants. Second, field measurements of deposition and deposition rates will be made to understand actual pollution input. Each approach will complement the other in the overall ocean monitoring program. In the first instance, the results of numerical diffusion or trajectory models would be used to give guidance for a source inventory, measuring sites, and an overview of the contamination configuration.

Field measurements will be accomplished in three steps: First, a system of land measuring sites near the coast will monitor the flux of pollutants that move into the ocean area, precipitation chemistry and high-volume filter samples. The second step will be designed to determine the feasibility of flux gradient methods for estimating the deposits of pollutants. Third, ocean platforms (described in section 3) will be used to measure the same parameters as the land stations for determining flux measurements and ocean deposition.

Water and sediment contamination.--Samplings of marine waters and sediments will be used to provide long-term accounting of the accumulation of chemical contaminants in the marine environment and for information to determine pathways by which contaminants are distributed, both before and after they are deposited in the ocean.

As general guidelines for ocean sampling, the following will be included: (1) Selected, strategically acquired, annual observations in the TAPS area including at least one deep series; (2) more closely spaced seasonal observations near the Continental Shelf with special emphasis off estuaries where important pollution problems are suspected, and along the axis of prevailing flow; (3) the capability to respond rapidly with a sampling program after a serious oil spill; and (4) seawater samples and associated environmental data taken routinely with all biological samples

An estuarine water sampling program will be initiated to assess the significance of certain estuaries as major pathways for the introduction of contaminants to the sea. In addition to the quantification of the estuarine output to the open ocean, goals of this portion of the program will include a basis for assessing any immediate estuarine related public health hazard and a provision for assessing water quality trends in the estuarine zone.

Standard water sampling stations will be established in certain estuaries to evaluate major inputs to the estuarine system: rivers, industrial and municipal outfalls, and the atmosphere. As well, to assess the output to the open ocean regular samples will be collected in the major outlets to the sea.

Summary.--The overall problem of maintaining a healthy marine environment is very complex and requires basic information about specific processes at specific sites. Programs yielding monitoring data on the marine environment have been, are being, and are planned to be conducted under widely varying guidance provided by local, State, or Federal agencies, by academic institutions, by scientific foundations and by industry. The implementation of the National Program for a Continuing Environmental Monitoring System for the Marine Leg of the Trans-Alaskan Pipeline System will integrate the resources of diverse activities including, but not limited to, NOAA, Coast Guard, EPA, AEC, Smithsonian Institution and the states of California, Oregon, Washington, and Alaska to produce a focus on a problem of great national concern. Figure 16 shows major Federal facilities expected to be available for this program support.

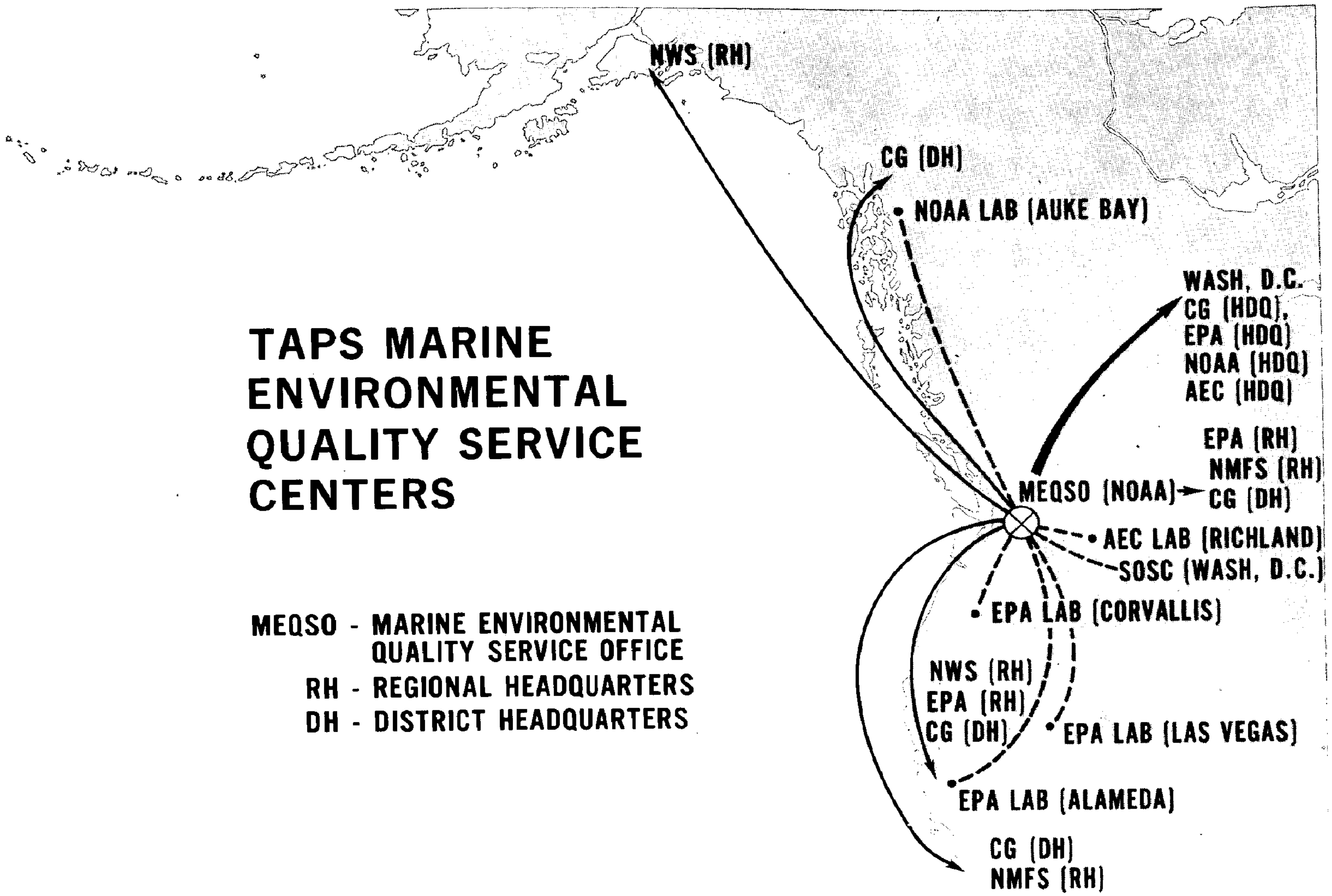


Figure 16. TAPS marine environmental quality service centers.

VI. IMPLEMENTATION PLAN

A significant portion of the program to provide continuing environmental monitoring for the marine leg of TAPS will be from ongoing basic Federal programs in marine environmental monitoring and prediction. In those program areas where the existing basic services are insufficient or nonexistent, new funds will be requested by NOAA. A description of the required program increases are shown in tables 4 and 5. Estimated costs for FY 1974-78 are $45K, $4055K, $6730K, $8055K and $7905K respectively. Recurring costs beginning in FY 79 are estimated at $5.5 million. However, it should be pointed out that these estimated costs are for planning purposes only, and do not represent a commitment in scheduling or funding.

Table 4.--Estimated costs for support of TAPS marine environmental monitoring
[thousands of dollars]

Budget items	FY 74 Costs	FY 75 Costs	FY 76 Costs	FY 77 Costs	FY 78 Costs
Monitoring systems:					
Automatic weather stations	45	45	45	45	45
Skywave radar	-	200	400	800	500
Buoys	-	1400	900	1000	900
Cooperative ship systems (MOOS)	-	500	1050	1100	1100
Marine quality sampling	-	250	400	500	500
Coastal station sensors	-	60	60	60	60
Tsunami automation	-	-	400	650	650
Alaska satellite center	-	500	1000	1000	1000
Monitoring system subtotal	45	2955	4255	5155	4755
Forecast and warning services:					
Marine forecasts and technicians	-	350	1250	1500	1750
Prediction technique development	-	400	500	500	500
Tsunami run-up models	-	-	200	300	300
Communications	-	100	250	300	300
Forecast and warning services subtotal	-	850	2200	2600	2850
Marine quality assessment:					
Analysis	-	200	225	250	250
Assessment	-	50	50	50	50
Marine quality assessment subtotal	-	250	275	300	300
Total	45	4055	6730	8055	7905

Table 5.--Implementation of TAPS continuing environmental monitoring system

Agency	Program	Status through FY 74	FY 75	FY 76	FY 77
NOAA	Satellites	2 geostationary satellites 1 polar orbitor (NOAA-2) SFSS at San Francisco	Begin Alaskan IESU	Alaskan IESU fully staffed	
NOAA CG	Buoys	1 buoy (Gulf of Alaska)	2 buoys (Gulf of Alaska and Northeast Pacific)	4 buoys (Gulf of Alaska and Northeast Pacific)	2 buoys (Gulf of and Northeast
NOAA MARAD* CG*	Cooperative ships	Development and Demonstration of MOOS	Install 25 MOOS	Install 30 MOOS Add PMO Anchorage	Install 140 MOOS
NOAA USGS*	Tsunami Warning System	47 tide gages and seismometers		Install GOES interface to 4 tide stations and 4 seismometers install data link Wallops to Honolulu	Install GOES interface on 15 tide stations
NOAA CG *	Contaminant sampling		Begin baseline sampling		Periodic sampling Program established

Table 5.--Implementation of TAPS continuing environmental monitoring system continued

Agency	Program	Status through FY 74	FY 75	FY 76	FY 77
CG*	Coastal mapping flights	Monthly flights San Diego to Seattle (oil detection and sea surface temperature)	Monthly flights Kodiak to Adak		Monthly flights San Diego to Adak
NOAA	Ocean remote sensing	None	Begin skywave sea-state radar for TAPS	Complete experimental skywave sea state radar	
NOAA	Coastal automatic weather stations	3 along Pacific coast 7 along southern Alaska coast	2 along southern Alaska coast	2 along southern Alaska coast	4 along Aleutian and Alaskan coast
NOAA CG *	Coastal station sensors	50 Coastal stations 1 instrumented LNB	Improve sensors at 25 coastal stations Instrument 1 LNB	Improve sensors at 15 coastal stations	Improve sensors at 10 coastal stations
NOAA	Forecast and warning services	6 WSFO's 7 WSO's FNWC NMC	Add marine fore-casters at Seattle, Portland, Juneau, Anchorage, and Valdez Establish marine forecast group at NMC Extend west coast marine circuit to Anchorage with seven drops		Complete marine forecast staffing for TAPS

Table 5.--Implementation of TAPS continuing environmental monitoring system continued

Agency	Program	Status through FY 74	FY 75	FY 76	FY 77
NOAA	Prediction technique development		Improve technique development for storm surge warning and anomalous water levels at TAPS coastal facilities Begin technique development for wind-driven currents and waves	Begin technique development for ocean thermal structure Begin development of tsunami run-up models for TAPS ports	
NOAA EPA* AEC* CG *	Marine quality Assessment		Establish marine quality service center at Seattle Prepare initial marine quality assessment	Prepare periodic TAPS marine environmental quality assessment	

*Agency request for budget increase presently not planned or being justified through a program other than TAPS.

Appendix A. Data Need for Environmental Products

Product \ Data Need	Tropospheric Profile	Wind Velocity	Atmospheric Pressure	Surface Air Temperature	Surface Humidity	Clouds	Precipitation	Tide (Sea Level)	Breakers and Surf	Wave Height and Period	Sea Surface Temperature	Icebergs	Current Velocity	Ocean Thermal Structure	Salinity	Ice Concentration	Coastal Geography	Contaminant Concentration	Turbidity
Warnings																			
Tsunami								x									x		
Storm Surge		x						x	x	x							x		
Heavy Surf		x						x	x	x							x		
High Winds	x	x	x	x		x													
Heavy Sea & Swell		x								x									
Icebergs		x									x	x	x	x					
Forecasts																			
Marine Weather	x	x	x	x	x	x	x				x			x					
Surf		x						x	x	x							x		
Water Temperature		x		x		x				x	x		x	x	x				
Tides								x									x		
Tidal Current								x									x		
Rip Currents		x						x	x	x			x				x		
Water Turbidity		x					x		x	x	x		x	x	x		x	x	x
Mixed Layer		x	x	x		x	x			x	x		x	x	x				
Sea State		x								x	x								
Current Velocity		x						x		x	x		x	x	x		x		
Salinity		x		x			x			x	x		x	x	x				
Upwelling		x	x								x		x	x	x		x		
Ice Distribution		x	x	x			x				x		x	x		x			
Marine Quality Assessment		x		x				x			x		x	x	x		x	x	x

Appendix B. Communication Systems

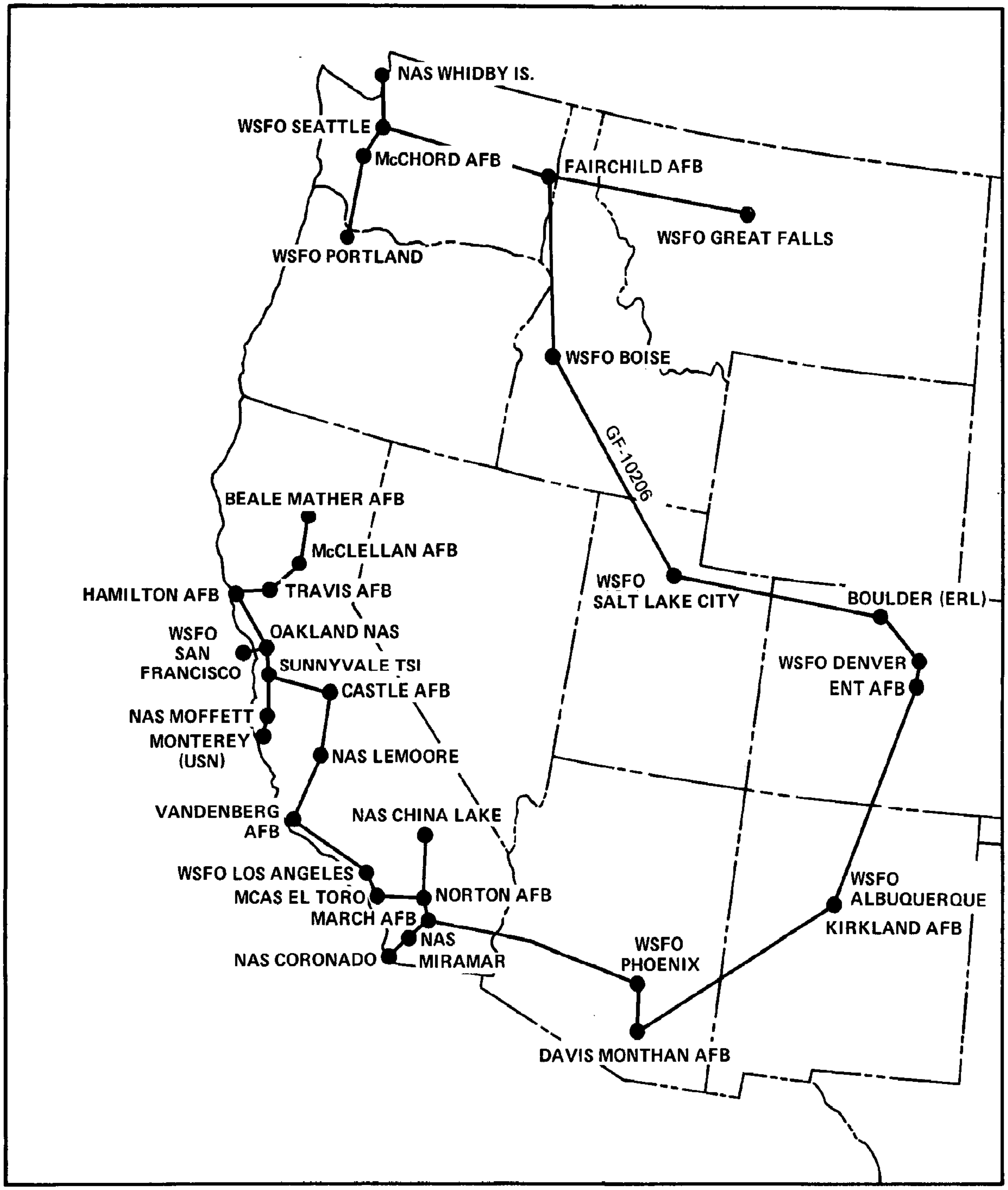


Figure B1. Forecast office facsimile network.

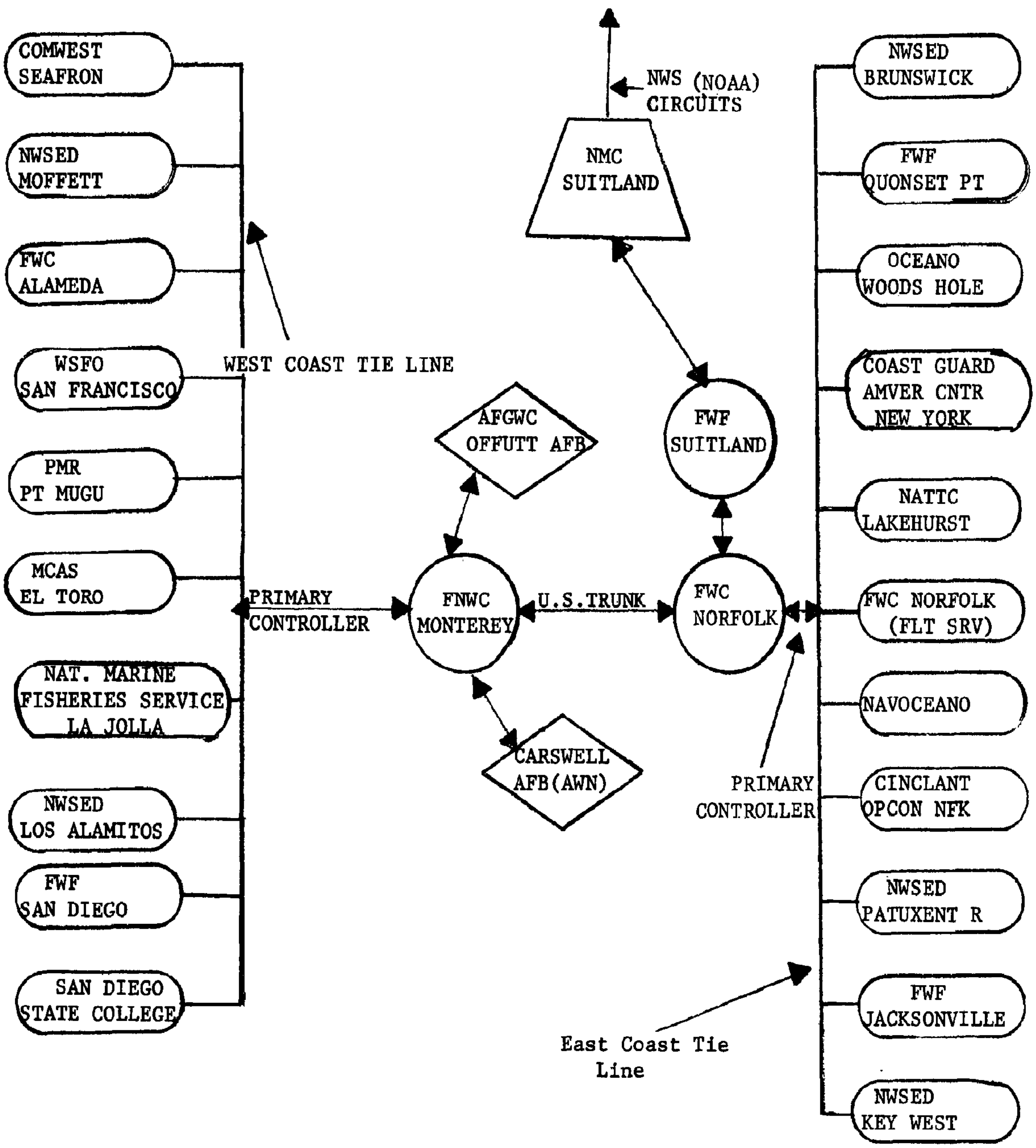


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Figure B2-Naval Environmental Data Network (NEDN) -coterminous United States