



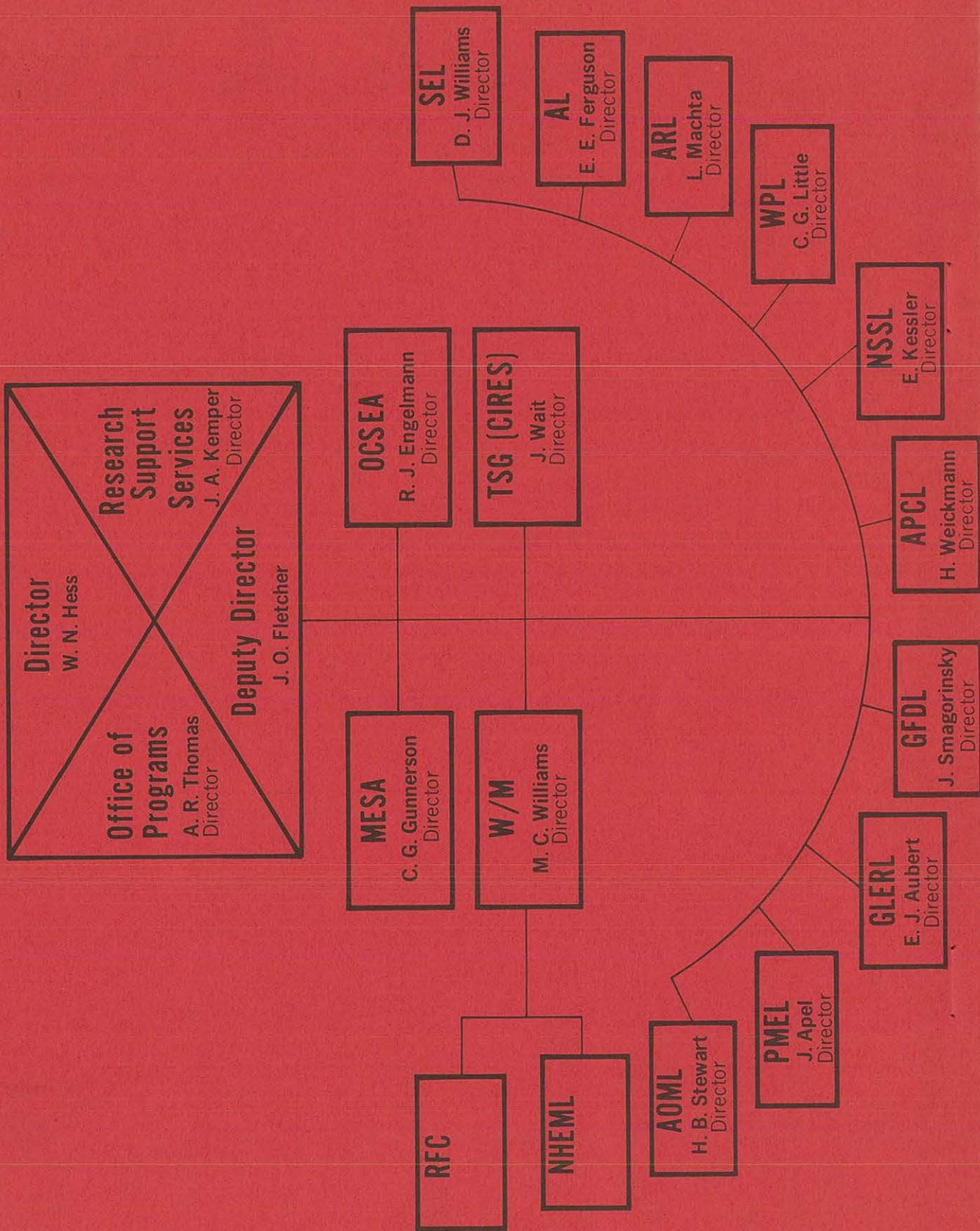
NOAA Technical Memorandum ERL MESA-12

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
Environmental Research Laboratories

AN ASSESSMENT OF THE METEOROLOGICAL STATIONS
ALONG THE STRAIT OF JUAN DE FUCA

Marine EcoSystems Analysis Program Office
Boulder, Colorado
May 1976

Environmental Research LABORATORIES



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PUGET SOUND Energy-Related Research Project
MESA Puget Sound Project Office

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AN ASSESSMENT OF THE METEOROLOGICAL STATIONS ALONG THE STRAIT OF JUAN DE FUCA

I. INTRODUCTION

The National Oceanic and Atmospheric Administration has been funded by the Environmental Protection Agency to make an environmental assessment of the potential effects of increased petroleum activities in the Puget Sound region. As a result, a five-year study, the Puget Sound Energy-Related Research Project, has been initiated, with its focus on increased petroleum transport and refinery operations in the Strait of Juan de Fuca and northern Puget Sound. Direct management of the study will be performed by the Marine Ecosystem Analysis Puget Sound Project Office in Seattle.

One of the primary objectives of this study is determination of the transport mechanisms and eventual geometry of petroleum spilled into the waters of the area. Since winds have a sizable effect upon surface currents, the wind field within the Strait of Juan de Fuca will come under close project scrutiny. Direct measurements of winds over the water will be funded as part of the physical oceanographic program in order to characterize wind-induced currents. A second long-term goal of the project is development of a capability to describe the wind field over the water on a real-time basis, so that in the event of an oil spill, optimum protection and cleanup operations can be effected. While complete realization of this capability is not anticipated within the framework of project activities, the project will initiate efforts in this direction by funding extensive land-based wind measurements simultaneously with its over-the-water measurements. It is expected that information collected by these field deployments will form a data base for further experimental work and eventual upgrading of the permanent meteorological network.

This paper represents the first effort of the projects' wind study. It will attempt to (1) provide a brief overlook of the seasonal wind flow within the area, (2) describe and analyze the permanent meteorological networks (both U.S. and Canadian), and (3) summarize initial project field activities undertaken to improve the understanding of the winds within the Strait of Juan de Fuca and northern Puget Sound.

Information describing the U.S. meteorological network was obtained through site visits and from the personnel and files of the Weather Service Forecast Office in Seattle. Canadian station descriptions were obtained from the Regional Superintendent for Observational Services, Atmospheric Environment Service, Vancouver, B.C. Additional input was acquired through the Sea Use Foundation, the Pacific Marine Environmental Laboratory, and the Environmental Data Service.

II. WIND FLOW PATTERNS IN THE STRAIT OF JUAN DE FUCA

The prevalent flow of the surface winds which occur along the western coasts of Washington and Vancouver Island is determined by circulation around large-scale pressure cells which dominate the eastern Pacific Ocean. Inland surface winds over the Strait of Juan de Fuca and northern Puget Sound, however, do not necessarily conform to the winds predicted by these pressure patterns; rather they often exhibit marked contrasts to the coastal winds, due to the effects of the pronounced local topography.

The Strait of Juan de Fuca is funnel-shaped, tapering to the western end. The Olympic Mountains to the south drop from an elevation of 5000' to the waters' edge. To the north, the mountains of Vancouver Island average 3000'. As a result, large scale air flow is funneled into predominantly an east-west mode along the axis of the Strait, with much local perturbation due to the rugged irregularity of the coastlines.

There are two prevalent wind regimes which operate within this geometry: the summer system (April - September) and the winter system (October - March). Wind vectors for each of these regimes are depicted in figure 1.

SUMMER:

In the summer months, clockwise flow around a well-developed semi-permanent high pressure cell to the north of the region causes prevailing northwesterly winds everywhere along the western coasts of Washington and Vancouver Island. These surface winds enter the Strait and are channeled eastward until they meet the mainland, where they are deflected into north and south components. Historical data from Victoria, Port Angeles, and Whidbey Island all reflect this very sharp summer predominance. Winds are generally weakest during the summer months. This is not true at Port Angeles, however, where a strong afternoon diurnal effect causes a maximum average velocity in July: winds of eighteen knots or more can be expected 2 out of every 3 days.

Summer winds at Tatoosh Island are curious. Although winds everywhere else along the coast are northwesterly, winds at Tatoosh are characterized by southerly flow. Immediate siting effects are an unlikely cause, since the instrument is well exposed. One explanation (Harris, 1954) is that a venturi effect occurs at the mouth of the Strait, causing a semi-permanent gyre at Tatoosh, and resulting in flow from the south.

WINTER:

During autumn the prevailing northwesterly coastal winds decline rapidly as the Pacific High retreats southward and weakens. The semi-permanent low pressure center found near the Aleutian Islands begins to intensify and deepen. By midwinter the prevalent flow along the coast is southerly to southwesterly, due to counterclockwise circulation around the low. Over inland waters, however, again the picture is not so simple. Historical data at Victoria show a well-defined predominance of northerly

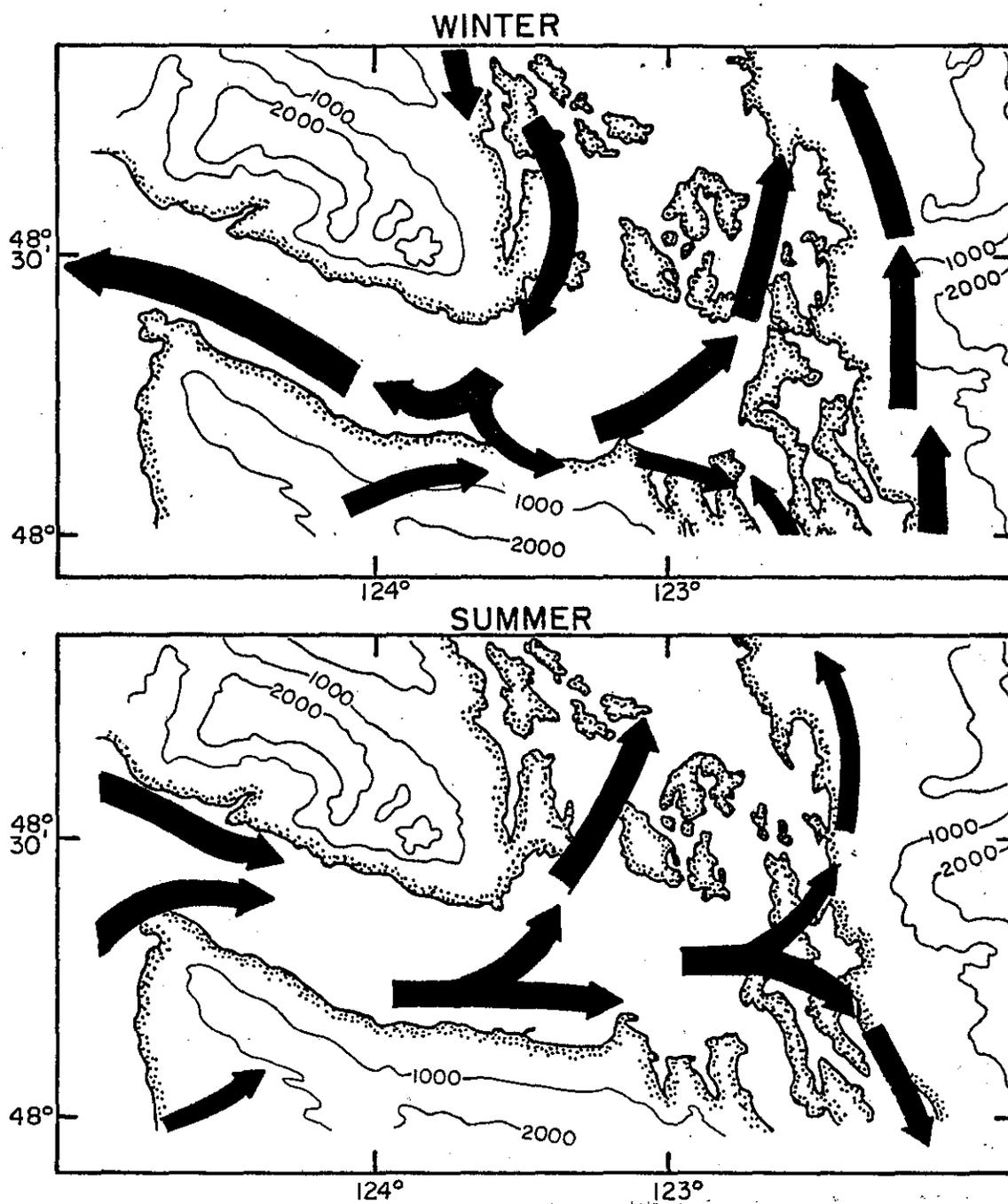
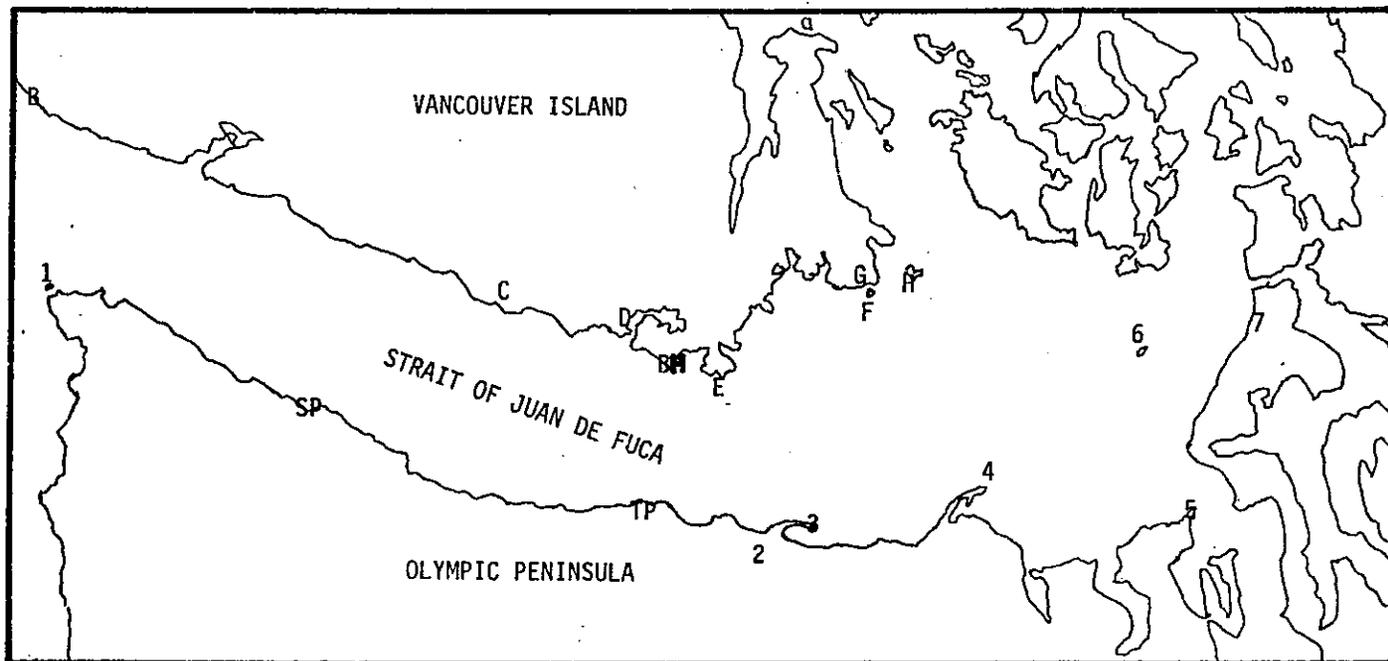


Figure 1. Seasonal wind patterns in the Strait of Juan de Fuca (after Harris, 1954).



UNITED STATES METEOROLOGICAL STATIONS

1. Tatoosh Island Light Station
2. Fairchild International Airport
3. Port Angeles USCG Air Station
4. New Dungeness Light Station
5. Point Wilson Light Station
6. Smith Island Light Station
7. Whidbey Island Naval Air Station

BH: Beechey Head
 TP: Tongue Point
 SP: Slip Point

CANADIAN METEOROLOGICAL STATIONS

- A. Pachena Point Light (off map)
- B. Carmanah Point Light
- C. Sheringham Point Light
- D. Victoria Marine Radio (Sooke)
- E. Race Rocks Light
- F. Trial Island Light
- G. Victoria Gonzales
- H. Discovery Island

Figure 2. Existing Meteorological Stations.

winds. (This station is well-exposed and is considered representative of the general flow in the area.) These winds cross the Strait and meet the Olympic Mountains west of Port Angeles where a division of flow takes place. The major stream passes westward through the Strait, while the minor stream is deflected to the east. Historical data show a strong winter predominance of easterlies at Tatoosh, and a moderate predominance of winter westerlies at Port Angeles. Because the Strait narrows to the west, the easterly winds pick up speed as they progress, and the easterly winds at Tatoosh are often quite strong.

In addition, during the winter months the Washington-Vancouver Island area lies in the path of migratory winter storms which follow the polar fronts across the country. As a result the western coasts and the mouth area of the Strait are often exposed to westerlies of gale force, and winds of 70 knots or more are not uncommon over the water.

In summary, the wind system of the Strait of Juan de Fuca cannot be predicted by large scale pressure patterns. (Indeed, winds are often discovered to be in opposition to these patterns due to the vagaries of topography.) While the regime is predominantly an east-west flow, it is not simple. It is not uncommon for the wind to be quite strong in opposite directions at points only a few miles apart. At each end of the Strait this east-west flow interacts with primarily a north-south flow to produce relatively unknown circulation patterns.

Development of a better understanding of the wind system and an ability to predict the flow will require considerable field effort. Existing data has been gathered at rather widespread stations, with large gaps in the coverage area. Almost no serious data has been taken over the water. It is not impossible that the current understanding of the wind field is a creation of the existing wind stations. If the stations were located in different areas, the vectors in Figure 1 might be shifted considerably. Following is a description of the existing meteorological stations which ring the Strait of Juan de Fuca.

III. THE EXISTING METEOROLOGICAL NETWORK

There are fifteen permanent meteorological stations along the Strait of Juan de Fuca: seven U.S. and eight Canadian stations. As is shown in Figure 2, these stations are primarily located at the eastern end of the Strait and in northern Puget Sound. There are two main reasons for this spacial bias: (1) The eastern end of the Strait is more heavily populated and hence, is of greater interest to the populace, while providing better logistic support for the stations. (2) The sites at the eastern end are lower and flatter and project farther out into the water, making them obvious candidates for meteorological stations. On the U.S. side, there are no stations between Port Angeles and Tatoosh Island in the western sector, roughly 60% of the entire length of the Strait. A similar situation exists on the Canadian side between Carmanah Point (just north of Tatoosh) and Sheringham Point (northwest of Port Angeles).

U.S. Meteorological Stations

The National Weather Service manages six of the seven U.S. meteorological stations along the Strait; the seventh is the Whidbey Island Naval Air Station, operated by naval personnel. The NWS stations all function in a similar mode: minimum instrumentation associated with an existing operation, such as a light station or airport. Observations are taken by resident personnel and relayed to the Weather Service Forecast Office (WSFO) in Seattle on a real-time basis.

Tatoosh Island Light Station is the only U.S. meteorological station in the western half of the Strait. Tatoosh Island is the most northwesterly point in the State of Washington, lying just outside of Cape Flattery in the Pacific Ocean. Since it is just off the coast, it has excellent exposure to coastal winds and westerlies which are channeled down the Strait. It has good exposure to easterlies, but is shadowed from southeasterly winds by the much higher mainland. Immediate exposure of the instrument site is good.

Although geometrically Tatoosh appears to be an excellent station for measuring winds from almost all directions, historical data lends some question as to its usefulness for gauging winds within the Strait. During the summer months the flow is predominantly southerly, a direction unmatched by winds anywhere else in the vicinity. During the winter months the station is situated at the junction of strong coastal southerlies and easterlies from within the Strait. Perhaps the wind data are most characteristic of inland winds during storms, when direct westerlies come off the ocean into the Strait.

Tatoosh is manned on a 24-hour basis by the U.S. Coast Guard contingent at the light station. Winds are measured on a standard NWS F-420 wind system, and are reported to Port Angeles every three hours via teletype circuit, for relay to the WSFO.

All the remaining U.S. meteorological stations are located on the eastern half of the Strait. Fairchild International Airport is the next most westerly. It is located about one mile from the water, south of Ediz Hook at Port Angeles. It is used chiefly for aeronautical purposes; its distance from the water and its high elevation (300') make it unlikely to be an accurate indicator of surface winds over the water. Observations there are made during daylight hours only, by a private airline company under contract to the NWS. Data are relayed to the WSFO hourly by telephone.

The Port Angeles USCG Air Station is located at the end of Ediz Hook, a low spit which extends $1\frac{1}{2}$ miles out into the waters of the Strait. The instrument is mounted atop the USCG operations building, and has good immediate exposure to winds from all directions. The station is somewhat shadowed from the main flow by several peaks and promontories to the west and by the Olympic Mountains to the south. During the summer the winds are found to be from the W and the WNW, almost to the exclusion of all other winds. Winter winds are experienced from all directions, with a moderate predominance of westerlies.

Observations at the air station are made by the Coast Guard SAR unit, which is on 24-hour duty. Measurements are made on an Aerovane wind system, a relict of the base's former meteorological capability for fixed wing aircraft. The radio watch transmits the data, as well as the data from other Coast Guard stations at Quillayute, Tatoosh Island, and Smith Island, to Coast Guard Headquarters in Seattle for relay to the WSFO on a real-time basis.

The next station (to the east) is New Dungeness Light Station. It is located on the end of New Dungeness Spit, a low flat sand spit which extends about 2½ miles out into the Strait presenting almost ideal conditions for measurement of surface winds. From scant historical data, the winds tend to be similar to those measured at Port Angeles. Unfortunately, the site is not instrumented, and only estimated winds are sent to the WSFO. The National Weather Service has for some time had priority plans to install one of its standard F-420 wind systems, but uncertainty about future logistic support has precluded such deployment. The light station is due to become fully automated in spring of 1976, and by autumn it will be unmanned. The NWS has been unable to gain guarantees that telephone service and power will still be available from the Coast Guard; the cost of providing these services for a meteorological station is prohibitive.

Estimated wind observations on New Dungeness are presently made every three hours during daylight, and are telephoned directly to the WSFO in Seattle.

The Point Wilson Light Station is located in the eastern portion of the Strait at the entrance to Puget Sound. It has good exposure to winds from all directions except the southwest, where it is shadowed by local hills. The USCG contingent there makes observations every three hours on a standard NWS F-420 wind system, and relays them directly to the WSFO via telephone.

Whidbey Island is the eastern boundary of the Strait of Juan de Fuca. The meteorological station at the Whidbey Island Naval Air Station operates primarily for naval aeronautical purposes, but because it contributes continuous hourly reports, it is a valuable cog in the area's meteorological network. Smith Island is a small triangular island just a few miles west of Whidbey. The Smith Island Light Station has excellent exposure to all directions, and reports observations every three hours to the Coast Guard base at Port Angeles, for relay to the WSFO.

Winter winds at these two stations are primarily from the SE, reflecting their exposure to the Puget Sound - Strait of Georgia geometry. Summer winds are primarily westerly, reflecting the view down the axis of the Strait of Juan de Fuca.

Canadian Meteorological Stations

When compared to the southern side of the Strait, the northern shoreline is relatively straight. Because of this lack of extension into the Strait, the Canadian stations (except for the island stations) are less

Table 1. Summary of U.S. Weather Stations - Strait of Juan de Fuca

STATION	ID	OBSERVER	OBS/DAY	HOURS	PARAMETERS	WIND EQUIP.	DATA AT NCC
New Dungeness Light Station	96S	USCG	6	04-19 3 hrs	weather, vis., wind speed, dir., sea height	none	4/32 - 6/37 M 6/73 - 12/74 M
Point Wilson Light Station	53S	USCG	8	01-22 3 hrs	weather, vis., wind speed, dir., sea height, dir., pressure, temp.	NWS:F-420	7/30 - 1/47 M 7/72 - 12/74 M
Port Angeles USCG Air Sta.	NOW	USCG	6	04-19 3 hrs	weather, vis., wind speed, dir.	USCG: UMQ5 Aerovane	6/29 - 5/42 M 12/43 - 12/74 M 1/48 - 1/53 T
Port Angeles Fairchild Int. Airport	CLM	commercial	13 ¹	04-16 1 hr	weather, vis., wind speed, dir., precip., temp.	NWS: F-420	none
Smith Island Light Station	86S	USCG	6	04-19 3 hrs	weather, vis., wind speed, dir., sea height, air temperature	NWS: F-420	6/62 - 12/74 M
Tatoosh Island Light Station	TTI	USCG	6	04-19 3 hrs	weather, vis., wind speed, dir., sea height & period air temp., pressure	NWS: F-420	7/30 - 7/66 M 1/67 - 12/73 M 9/74 - 12/74 M 1/48 - 7/66 T
Whidbey Island Naval Air Sta.	NUW	USN	24	00-23 1 hr	weather, vis., wind speed, dir., air temp., pressure	USN: UMQ5 Aerovane	1/43 - 8/75 M 4/45 - 12/73 T

1. M: archived data in manuscript form
2. T: archived data on magnetic tape
3. all observations on Smith Island are taken ½ hour before nominal record time.

Table 2. Summary of Canadian Weather Stations - Strait of Juan de Fuca

STATION	OBS/DAY	HOURS	PARAMETERS	WIND EQUIP.	ARCHIVED DATA
Pachena Point Light	3	0630, 1110 1930	weather, visibility, clouds, sea height, wind speed and dir.	none	3/39 - 11/58 (M)
Carmanah Point Light	4	0415, 0630 1040, 1440	weather, visibility, clouds, sea height, wind speed & direction	U2A	none
Sheringham Point Light	10 24(winds)	04-20 00-23(winds)	weather, visibility, clouds, sea height, wind speed & direction	U2A 45B	none
Victoria Marine Radio (Sooke)	24	00-23	weather, visibility clouds, temp., press., wind speed & direction	U2A	1/70 - present (T)
6 Race Rocks Light	10	04-20	weather, visibility, clouds, sea height, wind speed & direction	45B anemograph	7/69 - present (T)
Trial Island Light	4	daytime	weather, visibility clouds, sea height, wind speed & direction	U2A	none
Victoria Gonzales Heights	24	00-23	weather, visibility, clouds, temp, press., wind speed & direction precipitation	U2A 45B	1/53 - present (T) 8/98 - 12/74 (M)
Discovery Island Light	4	daytime	weather, visibility, clouds, sea height, wind speed and direction	none	none

likely to provide representative sites for wind-over-the-water measurements than the U.S. counterparts.

Pachena Point Light is an uninstrumented station which reports weather conditions several times per day. It lies roughly 15 miles west of the mouth of the Strait. Carmanah Point Light, the next station to the east, lies directly north of Tatoosh Island, across the mouth of the Strait. It has good exposure to the SE-S-SW, with the other directions shielded by the surrounding hills. Observations are made five times per day during daylight hours.

Sheringham Point Light is 32 miles east of Carmanah point. The station is instrumented with two sets of winds equipment, one of which reads out remotely at Victoria Marine (Sooke). Exposure is good from the east through south to the northwest.

Victoria Marine Radio (Sooke) is somewhat inset from the body of the Strait, and the meteorological instruments are sheltered by trees around the radio station reserve. It is probably not an adequate station for measuring the surface winds.

Race Rocks Light is on a small rocky island, 1.5 miles off Vancouver Island. A 45B wind instrument there is equipped with an anemograph, which provides one of the few 24-hour continuous recordings of wind in the area. Exposure is excellent to all directions, and the island is situated so as to be valuable for both the east-west regime and the winter northerlies.

The remaining three stations on the Strait of Juan de Fuca are located about Victoria, where the Strait widens and leads into the San Juan Islands. Trial Island is .7 miles SE of the southern tip of Vancouver Island. Exposure is good in all directions locally, although it is shielded from westerly flow by Vancouver Island. Victoria Gonzales Heights is located atop Gonzales Hill at the southern tip of the Saanich Peninsula. Its wind equipment is quite high (265'), and this station probably cannot give as good a coverage to surface winds as nearby Trial Island. Discovery Island, just east of the city of Victoria, is uninstrumented. It has good exposure to all directions; daylight observations are made there chiefly for the use of pleasure boaters.

Wind Instrumentation

The standard wind-measuring device used by the National Weather Service in the area is the F-420, which is similar to Canada's U2A. Both are direct reading, nonrecording, three-component systems consisting of a 3-cup anemometer, a wind direction vane, and a 2-dial panel readout. Separate transmitters for the vane and anemometer permit remote readout in living or working quarters.

The UMQ5 Aerovane wind system is in use at Port Angeles USCG Air Station and at Whidbey Island Naval Air Station. It consists of two components: a combined sensor and a remote readout. The sensor is in the form of an aircraft, with the anemometer forming the propeller and the vane forming the tail section of the aircraft. The readout is a single panel with two dials. The system is a nonrecording type.

Table 3. Selected Wind Data for U.S. Stations Along
the Strait of Juan de Fuca

DATE/TIME	TATOOSH	PA-NOW	PA-CLA	DJNG.	SMITH	WILSON
01/0400	WNW/15	---	NA	calm	SE/12	SSE/20
01/0700	WNW/30	---	NA	W/15	SW/20	S/5
01/1000	W/15	SW/15	NA	W/18	WSW/25	W/18
01/1300	W/10	SW/15	NA	W/15	---	WNW/22
01/1600	SW/11	SW/15	NA	calm	SW/15	SSE/9
01/1900	W/12	SE/6	NA	calm	SW/12	calm
02/0400	NW/8	SSW/2	NA	calm	ESE/10	SSE/5
02/0700	SW/18	calm	NA	calm	SE/12	SSE/12
02/1000	S/14	---	NA	calm	SSE/15	SSE/17
02/1300	S/35	---	NA	E/15	---	SSE/22
02/1600	SW/30	SW/10	NA	W/15	SE/25	SSE/25
02/1900	SW/35	WSW/25	NA	SE/10	SE/15	SE/12
08/0400	W/30-40	WSW/30	NA	W/30	WSW/38	W/30
08/0700	W/30-35	WSW/30	NA	W/25	WSW/30	W/25
08/1000	NW/30	SSW/15	NA	W/25	WSW/25	W/14
08/1300	WNW/18	---	NA	W/15	---	W/16
08/1600	WNW/32	---	NA	W/20	SSW/20	W/18
08/1900	W/30	---	NA	W/25	WNW/20	WSW/20
18/0400	SW/5	calm	NA	calm	N/10	calm
18/0700	SE/5	---	NA	calm	E/9	calm
18/1000	ENE/10	---	NA	N/5	NNE/8	calm
18/1300	E/10	---	NA	calm	---	calm
18/1600	ENE/8	---	NA	calm	calm	WNW/4
18/1900	E/7	calm	NA	calm	calm	calm
01/0500	E/8	calm	NA	calm	calm	W/8
01/0800	S/6	calm	NA	calm	calm	calm
01/1100	SE/6	calm	NA	calm	E/18	SE/16
01/1400	S/10	calm	NA	calm	---	SE/10
01/1700	S/8	calm	NA	calm	SE/18	SSE/10
01/2000	S/9	S/3	NA	calm	S/5	SE/10
21/0500	E/25	E/10	NA	SE/35	ESE/20	SE/18
21/0800	ENE/30	NE/30	NA	SE/40	ESE/20	SE/24
21/1100	E/10	ENE/30	NA	SE/40	ESE/22	SE/25
21/1400	E/8	E/10	NA	SE/35	---	SE/20
21/1700	SE/15	calm	NA	SE/25	ESE/20	SE/15
21/2000	SE/12	SW/5	NA	SE/25	ESE/18	SE/15
25/0500	N/20	SSW/15	NA	W/15	NW/20	NNW/30
25/0800	N/19	SSW/10	NA	W/20	NW/25	NNW/25
25/1100	NNW/12	W/8	NA	W/20	NW/25	NNW/25
25/1400	WNW/20	W/15	NA	NW/20	---	NNW/20
25/1700	WNW/30	WSW/20	NA	W/15	WNW/12	NW/20
25/2000	NW/30	WSW/20	NA	NW/25	W/15	WNW/26

Table 3. Selected Wind Data for U.S. Stations Along
the Strait of Juan de Fuca (continued)

DATE/TIME	TATOOSH	PA-NOW	PA-CLA	DUNG.	SMITH	WILSON
01/0500	SW/12	WSW/12	WNW/6	W/5	S/8	calm
01/0800	SW/10	WSW/10	NW/6	W/5	SSW/12	W/12
01/1100	SSW/10	W/7	NW/6	W/5	SW/12	NW/10
01/1400	SW/12	SW/15	WNW/11	W/5	---	WNW/6
01/1700	SW/15	WSW/15	WNW/10	W/10	SSW/8	WNW/11
01/2000	SW/12	WSW/15	---	W/15	WSW/14	WNW/10
10/0500	WSW/8	WSW/18	W/7	W/10	SW/15	WNW/15
10/0800	W/8	WSW/10	WNW/8	W/10	SW/15	W/10
10/1100	SW/5	W/12	WNW/10	W/10	SW/7	WNW/7
10/1400	SW/8	W/15	WNW/13	W/10	---	WNW/5
10/1700	SW/10	WSW/15	WNW/12	W/5	SW/12	WNW/10
10/2000	W/12	WSW/20	---	W/20	SW/15	W/15
21/0500	SW/08	SW/5	calm	calm	W/7	W/5
21/0800	calm	SW/5	W/5	calm	WSW/8	calm
21/1100	calm	WSW/5	WNW/7	W/3	SW/5	WNW/5
21/1400	W/15	WSW/10	NNW/4	calm	---	WNW/6
21/1700	SW/12	W/15	WNW/8	W/10	WSW/4	WNW/8
21/2000	S/5	W/10	---	W/10	W/6	WNW/15
29/0500	W/5	SSW/5	calm	S/10	SW/12	calm
29/0800	NE/8	SSW/5	N/6	calm	SW/10	calm
29/1100	S/5	ESE/12	ESE/7	calm	SW/5	calm
29/1400	W/10	NE/8	ENE/8	calm	---	calm
29/1700	W/5	WSW/8	WNW/6	calm	S/5	calm
29/2000	S/5	WSW/5	---	W/5	SSW/7	NW/11
31/0500	WSW/5	SSW/3	WSW/3	W/5	SW/14	W/8
31/0800	calm	SW/5	NNW/3	W/3	SW/11	NW/4
31/1100	calm	NW/5	N/5	calm	WSW/5	calm
31/1400	W/8	NW/3	N/5	calm	---	SSE/6
31/1700	SW/10	W/8	---	calm	W/6	calm
31/2000	W/8	W/15	---	SW/3	S/5	WNW/11

JULY 1975

All times are Pacific Daylight Time (PDT).

All recordings made on the hour, except Smith Island, whose recordings were made on the half hour before each indicated time.

--- denotes no observations made

A 45B anemometer is in operation at Race Rocks Light, Sheringham Point, and Victoria Gonzales Heights. The sensor is a combined vane and anemometer. At Race Rocks the winds from the 45B are recorded on an anemograph - a step recorder which measures wind direction and total miles of wind per hour.

IV. ASSESSMENT OF THE EXISTING METEOROLOGICAL NETWORK

Readily available wind data were obtained for the U.S. meteorological stations in the area, in an attempt to get a feel for the value of the existing data-recording modes for characterizing the winds. From a quick scan of the data, it appears that the information conveyed is inadequate for project needs. Observations are made (generally) at three hour intervals, with most stations having at least one period per day with an interval of six hours between observations. Port Angeles USCG Air Station is often missing for many hours at a time. In general, the data interval seems too great to allow interpretation of a wind history at any station, and correlations between various stations would be difficult.

While not suggested by these data, another potential problem is error in the data due to the mode of recording. Because most of these sites exist primarily for another purpose (airport, light station, SAR unit...), only minimum training is given to the observers, and time is available for making measurements only when the primary duties allow. Since each of the instruments is of the direct-reading, nonrecording type, a conscious effort is required at each observation to obtain a representative value of speed and direction over a suitable time period. It is doubtful that this time and effort can be devoted at each observation.

Conversations with the personnel at the WSFO confirm that the existing meteorological network in the Strait does not provide an adequate data base for making good forecasts; hourly reports by trained meteorologists would be much preferred. (Wind strength forecasts within the Strait are made chiefly on the pressure differentials between Bellingham and Tatoosh Island, as well as by wind information from Sheringham Point and Whidbey Island.) The system is the best possible, however, with the resources available to the respective weather services, and it does provide valuable insight into real-time conditions within the Strait.

A. Spatial Distribution: In general, the existing stations occupy the best possible sites for surface wind observations within each local area. Overall coverage is good in the eastern Strait. The western Strait is poorly covered, and additional sites will have to be occupied (at least temporarily) in order to gain an understanding of the wind regimes in this area. Coverage over the water is nonexistent, except for passing ships. Temporary recording will have to be performed over the water so that a correlation can be made between these winds and those measured at shoreline stations. Should such a correlation not exist, permanent over-the-water reporting stations would be necessary to report surface winds.

B. Instrumentation: Actual wind measuring equipment is excellent and an adequate calibration program is performed by the respective weather services. The present non-recording systems, however, permit errors by nonmeteorologist observers. A valuable addition to each of these stations would be a strip chart recorder (or some form of electronic averaging) so that appropriate direction and speed averages could more easily be obtained.

C. Observation intervals: In order to make effective use of data from the meteorological stations, consistent hourly reports on a real-time basis are required by the Weather Service Forecast Office. Since there is presently no significant need for precise wind predictions for the Strait, the existing report schedule is adequate. Should such predictions become needed in the future, observational modes in the field will have to be upgraded accordingly.

An entirely different type of data recording will be necessary to develop correlations between winds over the water and the winds observed by the shoreline stations: continuous recording on a medium which lends itself easily to computer processing. The data, however, need not be reported in real time, but may be recorded locally for later processing.

D. Dungeness Spit, is the site most likely to be representative of winds over the western segment of the Strait. Should project research find this to be true, the site should be instrumented with a data-link to a manned station.

V. PROJECT FIELD ACTIVITIES

The Puget Sound Energy-Related Research Project is presently funding the first of a three-part oceanographic study in the western Strait. The other two studies will be in the eastern Strait and the San Juan Islands. Fieldwork will be performed chiefly by NOAA's Pacific Marine Environmental Laboratory.

In this first phase of the study, one surface mooring and three subsurface moorings will be deployed in a transect between Beechey Head on Vancouver Island, and Tongue Point, on the Olympic Peninsula. (See Figure 2.) The surface mooring will be established in mid-February in the center of the channel. It will be instrumented topside with a vector averaging wind recorder (VAWR - a vector averaging current meter which has been modified to measure winds).

A second VAWR will be deployed at Beechey Head on the Canadian side of the transect, and a third will be installed on Ediz Hook at the USCG Air Station. The University of Washington has been contracted to measure winds at Tongue Point, on the U.S. side of the transect, and at Slip Point, farther west. The National Ocean Survey has deployed an Aanderaa wind recorder on Smith Island, and the MESA program will provide a second Aanderaa for deployment on New Dungeness Spit. Data from each of these instruments (all

are continuous-recording devices) will be combined with data from the existing meteorological network to give a comprehensive coverage of the wind field over the coasts.

Since the array will be in place from late February through mid-May, observations should be collected from both the winter and summer regimes, as well as the transition period. Valuable input will be forthcoming concerning deployment sites for the subsequent phases of the meteorological program. The obvious shortcoming of the first array is that there is but one over-the-water data source. In subsequent phases, three or more over-the-water deployments will be made in an effort to characterize longitudinal and cross-sectional variations of the surface winds within the Strait. Consideration is being given to deployment of pressure-recording devices and also for over-the-water horizontal wind profiling during these future deployments.

REFERENCES

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APPENDIX: STATION DESCRIPTIONS

STATION DESCRIPTION: TATOOSH ISLAND LIGHT STATION

Type Station: MARS

Wind Instrumentation: NWS F-420

Latitude: 48-23N
Longitude: 124-44W
Elevation: 129' above sea level
28' above gnd level

Parameters Recorded
weather and visibility
wind speed and direction
sea height and period
air temperature and pressure

The light station is located on Tatoosh Island, a small island (.2 miles in diameter) about .4 miles off Cape Flattery, the northwestern most point of the State of Washington. Maximum elevation is 108'. The station is also called Cape Flattery Light Station.

The wind station is located on the northwest side of the island, mounted on a 28' Rohn tower. The lighthouse is the closest obstruction (65' high); it bears SW at approximately 40'. The USCG residence building, a 2-story structure is approximately 60' south.

Four USCG personnel are stationed on the island, and they provide the meteorological observations.

Observations: MARS-type observations are taken daily between the hours of 0400 and 1900 PST (0500-2000 PST). These are sent real-time to Group HQ at Port Angeles for retransmittal to the 13th District HQ. The 13th District HQ sends the information to WSFO, Seattle.

Observations are recorded on NOAA Form 72-5a and mailed once each month to WSFO, Seattle. WSFO forwards them annually to NCC at Asheville, N.C. for archival.

Future Plans: The wind sensors were relocated in April, 1974. No further changes are anticipated.

Data Archived at NCC:

Manuscript Form: 7/30 - 7/66
1/67 - 12/73
9/74 - 12/74

Magnetic Tape: 1/48 - 7/66

STATION DESCRIPTION: FAIRCHILD INTERNATIONAL AIRPORT, PORT ANGELES

Type Station:	Commercial aviation	Wind Instrumentation:	NWS F-420
Latitude:	48-07N	<u>Parameters Recorded</u>	
Longitude:	123-30W		weather, visibility, and ceiling
Elevation:	310' above sea level		wind speed and direction
	20' above gnd level		temperature and dewpoint
			pressure

Fairchild International Airport is sited on top of a 300' hill above the city of Port Angeles, about one mile south of the Strait of Juan de Fuca. The NWS has contracted with Pearson Aircraft Inc. to make meteorological observations at the airport.

The F-420 wind sensors are located just north of the east-west runway on a 20' Rohn tower. There are no nearby obstructions and exposure to winds is excellent in all directions.

Observations: Meteorological observations are made daily every hour during the operating day of Pearson Aircraft Inc., generally from 0400 to 1600 PST. Observations are logged on WB Form 1130A (WBAN 10A) and sent to the WSFO, Seattle. WSFO forwards these records to NCC for archival as they receive them. The WSFO, Seattle telephones the aircraft company every three hours for the data on a real time basis.

Future Plans: No changes are anticipated.

Data Archived at NCC:

None

STATION DESCRIPTION: PORT ANGELES USCG AIR STATION

Type Station:	MARS	Wind Instrumentation:	USCG UMQ5 Aerovane
Latitude:	48-08N		
Longitude:	123-24W	<u>Parameters recorded</u>	
Elevation:	40' above sea level 30' above gnd level	weather and visibility wind speed and direction	

The Port Angeles USCG Air Station is located about $\frac{1}{2}$ mile from the eastern end of Ediz Hook, a low spit about three miles long which extends eastward into the Strait of Juan de Fuca. The spit forms the outer boundary, and a natural breakwater for the Port Angeles harbor.

Port Angeles has excellent exposure for winds from all directions. The Aerovane wind system is attached to the roof of the USCG Group HQ Building. The closest obstruction to the wind sensors is another building of similar height which bears magnetically west of the HQ Building at approximately 100 feet.

The meteorological observations are taken by the SAR unit at the base, which maintains a 24-hour watch.

Observations: MARS-type observations are collected daily once each three hours between 0400 and 1900 PST (0500-2000 PDT). The radio watch takes these observations (plus those from Smith Island, Quillayute, and Tatoosh) and sends them to the 13th District HQ. The 13th District relays this information to the WSFO, Seattle. The data are also documented on NOAA Form 72-5a at the air station and sent in to the WSFO monthly. WSFO forwards the data annually to NCC at Asheville, N.C. for archival.

Future Plans: No changes are anticipated.

Data Archived at NCC:

Manuscript Form: 6/29 - 5/42
12/43 - 3/75

Magnetic Tape: 1/48 - 1/53

STATION DESCRIPTION: NEW DUNGENESS LIGHT STATION

Type Station:	MARS	Wind Instrumentation:	none
Latitude:	48-10N		
Longitude:	123-06W	<u>Parameters Recorded</u>	
Elevation:	15' (est.)	weather and visibility	
		wind speed and direction	
		sea height	

The station is located on the tip of New Dungeness Spit which extends east-northeast from the shore near Dungeness, Washington into the Strait of Juan de Fuca.

Exposure is excellent in all directions. Five Coast Guard buildings are the only obstructions (one 2-story dwelling, three 1-story structures, and the lighthouse-dwelling).

The station is manned by 3 USCG personnel and families, who live on the spit. The men perform maintenance on the light equipment, and do not keep a 24-hour watch.

Observations: This station is not instrumented with meteorological equipment. MARS-type observations are taken daily once each three hours between 0400 and 1900 PST (0500-2000 PDT). These are documented on NOAA Form 72-5a and mailed each month to WSFO, Seattle. WSFO forwards them annually to the National Climatic Center at Asheville, N.C. for archival.

From April through October WSFO collects the observations via telephone. During the winter months the reports are available on an "on call" basis for real time use: observations continue to be documented throughout the winter for archival purposes.

Future Plans: The USCG plans to fully automate the light station late in spring 1976. The new system will be checked out through fall, 1976, upon which time the station will be unmanned. The WSFO has been unable to make plans for an alternate system, because future logistics support from the USCG is uncertain.

Data Archived at NCC

Manuscript Form: 4/32 - 6/37
6/73 - 12/74

Magnetic Tape: none

STATION DESCRIPTION: POINT WILSON LIGHT STATION

Type Station: MARS

Wind Instrumentation:
NWS F-420

Latitude: 48-08.7N
Longitude: 122-45.2W
Elevation: 30' above sea level
20' above gnd level

Parameters Recorded
weather and visibility
wind speed and direction
sea height and direction
air temperature
pressure

Point Wilson is at the intersection of the Strait of Juan de Fuca and Puget Sound - just north of Port Townsend, Washington. The Coast Guard light station is at the end of the point.

Point Wilson has good exposure to winds from all directions except the southwest quadrant, where higher terrain creates obstructions at distances varying from one half to three miles. Visibility is excellent from the WNW through N to the SSW.

The F-420 wind system is mounted on a 20' Rohn tower which is approximately 20 feet south of the breakwater protecting the station against the Strait of Juan de Fuca. The sensors are approximately 10 feet higher than the top of the breakwater. The nearest obstruction to the sensors is the USCG residence building which is approximately 50 feet southwest of the tower and is approximately 15 feet higher. The light house is 100 feet to the ESE.

The USCG mans the station with a complement of 4 men. A 24-hour watch is maintained at this station.

Observations: MARS-type observations are collected daily once each three hours. The Seattle WSFO collects the data by telephone on a real-time basis. The data are also documented on NOAA Form 72-5A at the station, and sent to the WSFO monthly. WSFO forwards them annually to NCC at Asheville, N.C. for archival.

Future Plans: The USCG has plans for eventual automation of this light station. No particulars are known at this time.

Data Archived at NCC:

Manuscript Form: 7/30 - 1/47
7/72 - 12/74
Magnetic Tape: none

STATION DESCRIPTION: WHIDBEY ISLAND NAVAL AIR STATION

Type Station: Military aviation

Wind Instrumentation:

USN UMQ5

Aerovane

Latitude: 48-21N

Longitude: 122-40W

Elevation: 34' above sea level

Parameters Recorded

weather, visibility,
and ceiling

wind speed and direction

air temperature and
pressure

The air station is located on the western side of Whidbey Island about five miles from the northern end. The wind sensors are mounted at the intersection of the runways, a site about 1/2 mile from the eastern end of the Strait of Juan de Fuca. Instrument elevation is 34' above sea level. There are no nearby obstructions and exposure is good to winds from all directions, especially the west.

Naval personnel are on duty 24 hours per day at the air station. Navy meteorological technicians take the observations and the meteorological instruments are serviced by naval personnel on a routine basis.

Observations: Observations are made daily on a 24-hour basis. The information is documented on WBAN-10AB; these forms are sent monthly to NCC at Asheville, N.C. for archival. Data are relayed hourly to WSFO in Seattle.

Future Plans: No changes in activity are anticipated.

Data Archived at NCC:

Manuscript Form: 1/43 - 8/75

Magnetic Tape: 4/45 - 12/73

STATION DESCRIPTION: SMITH ISLAND LIGHT STATION

Type Station: MARS

Wind Instrumentation:
NWS F-420

Latitude: 48-19N
Longitude: 122-51W
Elevation: 86' above sea level
26' above gnd level

Parameters Recorded
weather and visibility
wind speed and direction
sea height
air temperature

Smith Island is a small low triangular-shaped island at the eastern end of the Strait of Juan de Fuca, about 8 miles west of Whidbey Island and 16 miles north of Point Wilson. The Coast Guard station is at the east side of the island, at an elevation of about 60'.

Smith Island has good exposure to all directions, and is particularly exposed to westerly winds. The F-420 wind sensors are attached to the roof of the generator building at the USCG station.

Four men are stationed at the light house station. No 24-hour watch is maintained.

Observations: MARS-type observations are taken daily once each three hours between 0400 and 2200 PST. (0500-2300 PDT) No observations are taken, however, at 1300 PST (1400 PDT). Data is sent on a real time basis to USCG Group HQ at Port Angeles via radio, who forwards it to the 13th District via teletype. The District relays the data to the Seattle WSFO.

At the light station, the data are recorded on NOAA Form 72-5a and mailed each month to WSFO, Seattle. WSO forwards them annually to NCC at Asheville, N.C. for archival.

Future Plans: The USCG has plans to automate this light station by late 1977 according to the published plan. However, implementation is lagging behind schedule, and automation may not be realized until some time thereafter.

Data Archived at NCC:

Manuscript Form: 6/62 - 12/74

NOTE: Data are recorded on the half hour before the data is actually sent.

STATION DESCRIPTION: PACHENA POINT LIGHT

Type Station:	Supplementary	Wind Instrumentation:	none
Latitude:	48-43N	<u>Parameters Recorded</u>	weather, visibility,
Longitude:	125-06W		clouds
Elevation:	150' above sea level		wind speed and direction
			combined sea height

The station is located in a small flat clearing at Pachena Point, which is on the southwest coast of Vancouver Island, about 15 miles outside of the mouth of the Strait of Juan de Fuca. The surrounding area is mountainous and the only good wind exposure is towards the coast (SW-S-SE). There is no wind instrumentation.

Observations: Estimated wind observations are made daily at 0630, 1110, and 1930 PST. Reports are transmitted to Victoria Marine (Sooke) where they are relayed to Vancouver for the marine weather summary.

Data Archived: 3/39 - 11/58 (manuscript form only)

STATION DESCRIPTION: CARMANAH POINT LIGHT

Type Station: Supplementary

Wind Instrumentation:
U2A (nonrecording)

Latitude: 48-37N

Longitude: 124-45W

Elevation: 205' above sea level
30' above gnd level

Parameters Recorded

weather, visibility,
cloud cover
wind speed and direction
combined sea height

The Carmanah Point Light is located at the mouth of the Strait of Juan de Fuca on Vancouver Island. The station is in a small clearing on steeply sloping land. The wind sensors are located atop a mast at the south end of the power house. Exposure is good to the SE-S-SW quadrant, and is poor to the remaining directions due to the mountainous forested terrain.

Observations: Observations are made daily at 0415, 0630, 1040, 1440, and 1930 PST. Reports are transmitted to Victoria Marine and are relayed to Vancouver for the marine weather summary.

Data Archived: none

STATION DESCRIPTION: SHERINGHAM POINT LIGHT

Type Station: Supplementary

Wind Instrumentation:
U2A & 45B (nonrecording)

Latitude: 48-23N

Longitude: 123-55W

Elevation: 60' above gnd level
90' above sea level

Parameters Recorded
weather, visibility,
clouds
wind speed and direction
combined sea height

The lighthouse is on the southern tip of Sheringham Point on the southwest coast of Vancouver Island. There are two sets of wind equipment which are installed on 20' masts attached to a catwalk near the top of the lighthouse. Exposure is good E through S to NW. The N-NE exposure is shielded by mountainous woody terrain.

Observations: Wind data are remotely monitored at Victoria Marine (Sooke) and are reported hourly in the hourly weather collection on the teletype circuit. Local observations of other parameters are made 10 times per day.

Data Archived: none

STATION DESCRIPTION: VICTORIA MARINE RADIO (SOOKE)

Type Station:	Marine radio	Wind Instrumentation:	U2A (nonrecording)
Latitude:	48-22N	<u>Parameters Recorded</u>	weather, visibility,
Longitude:	123-45W		clouds
Elevation:	30' above gnd level		temperature, pressure
	129' above sea level		wind speed and direction

The station is located on the southwestern tip of Vancouver Island on the north side of the entrance to Sooke Harbor. The surrounding country is hilly and heavily wooded. The wind sensors are on a 30' mast and are somewhat sheltered by trees in the vicinity.

Observations: Observations are made hourly and are teletyped to Vancouver for the marine weather summary. Victoria Marine Radio (VAK) transmits local marine weather from the lighthouse stations five times per day on 1630kHz and 161.9MHz.

Data Archived: January 1970 - present

STATION DESCRIPTION: RACE ROCKS LIGHT

Type Station: Supplementary
Latitude: 48-18N
Longitude: 123-32W
Elevation: 59' above sea level
43' above gnd level

Wind Instrumentation:
45B (with anemograph)

Parameters Recorded
weather, visibility,
clouds
wind speed and direction
combined sea height

The light station is on a small rocky island 1.5 miles southeast of Rocky Point on the southeast coast of Vancouver Island. Wind sensors are located on a knoll on a 40' mast. Exposure is good in all directions.

Observations: Observations are taken 10 times daily and are transmitted to Victoria Marine (Sooke) where they are relayed to Vancouver for the marine weather summary. The winds are recorded on an anemograph, which records direction and total miles run. The daily charts are sent to the Regional Climate Data Centre in Victoria on a monthly basis.

Data Archived: July 1969 - present

STATION DESCRIPTION: TRIAL ISLAND LIGHT

Type Station: Supplementary

Wind Instrumentation:
U2A (nonrecording)

Latitude: 48-24N

Longitude: 123-18W

Elevation: 110' above sea level
55' above gnd level

Parameters Recorded
weather, visibility,
clouds
wind speed and direction
combined sea height

The station is on the southern tip of the Trial Islands in the Strait of Juan de Fuca, .7 miles SE of the southern tip of Vancouver Island. The wind sensors are on a 20' mast located on a catwalk near the top of the lighthouse, with good exposure in all directions.

Observations: Observations are made four times per day, and are transmitted to Victoria Marine (Sooke) where they are relayed to Vancouver for the marine weather summary.

Data Archived: none

STATION DESCRIPTION: VICTORIA GONZALES HEIGHTS

Type Station: weather station

Wind Instrumentation:
U2A & Dines pressure
tube anemometer
with strip chart
recorder

Latitude: 48-25N
Longitude: 123-19W
Elevation: 265' above sea level
63' above gnd level

Parameters Recorded
weather, visibility,
clouds
wind speed and direction
temperature, pressure
precipitation

This station is located on top of Gonzales Hill at the southern tip of the Saanich Peninsula on Vancouver Island, 25 miles ESE of the city center (Victoria). The U2A wind sensors are on a 30' mast on the flat roof of the old observatory building. A Dines wind gust recording anemometer is on a second 30' mast similarly located. Wind exposure is good to all directions.

Observations: Automatic weather reporting system. Wind data is abstracted from hourly recordings.

Data Archived: January 1953 - present (magnetic tape)
8/98 - 12/74 (manuscript)

STATION DESCRIPTION: DISCOVERY ISLAND LIGHT

Type Station: Supplementary

Wind Instrumentation:
None

Latitude: 48-25N

Longitude: 123-13W

Elevation: 50' above sea level

Parameters Reported: local
marine weather and winds

The lighthouse is on the eastern extremity of Discovery Island in Haro Strait, about 3 miles east of Vancouver Island. From the light the land slopes upward toward the NW to the top of Pandora Hill (100'). The station is uninstrumented.

Observations: Local marine weather is reported 3 or 4 times daily to Victoria Marine (Sooke) for relay to Vancouver for the Marine Weather Summary.