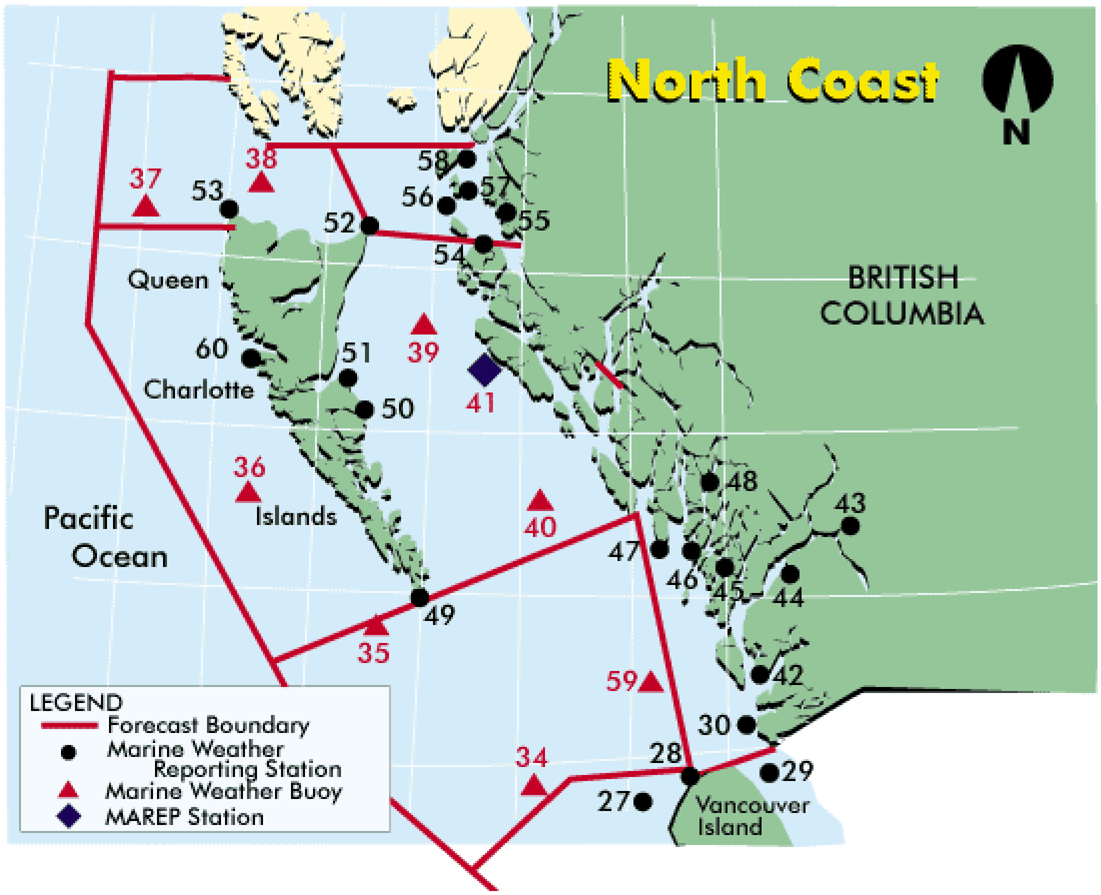

Figure 4.5 **Locations of land-based marine weather reporting stations (including MAREP station) and marine weather buoys in northern British Columbia waters.**

Table 4.2 **Parameters Reported at Marine Weather Observation Stations (after AGRA 1998)**

Met-Ocean Parameter	**Station Type**	
	Marine Weather Reporting Station	**Marine Weather Buoy**
Air Temperature	T	T
Pressure	T	T
Wind Speed and Direction	T	T
Wave Height		T
Wave Period		T
Sea Temperature		T
Limited readings from some stations:	T	
Visibility	T	
Sky Cover/Precipitation	T	

Although the wind speeds in northern British Columbia waters are high, similar conditions are also experienced in other areas of the world where offshore hydrocarbon exploration and development activities are currently active. In the Gulf of Mexico, tropical cyclones reaching hurricane speed (exceeding 120 kmh^{-1}) are the largest factor leading to weather-related shut-downs; most companies include 5 to 7 days of weather-related production losses each year in their business plans (Epps 1997).

Extreme winds over Canadian waters have been estimated as part of the wave hindcasting projects described in the next section (Canadian Climate Centre 1992). A brief comparison of the regional distributions of 50- and 100-year return period wind speeds for each coast shows that extreme wind speeds are roughly 10% higher for the eastern continental shelves, with six-hour values reaching 119 kmh^{-1} in areas where hydrocarbon production activities are already in progress. In comparison, the offshore facilities in the Gulf of Mexico are regularly exposed to wind speeds that exceed the maximum values estimated for both the east and west coasts of Canada.

4.4.2 Surface Waves

Given the close relationship between storm winds and surface waves, wave conditions in the northern British Columbia waters can also be considered relatively severe. Extreme wave conditions are typically estimated from a combination of historic record analyses and numerical modelling of previous extreme storm events (hindcasting).

In addition to the buoy locations shown on Figure 4.5, AES and DFO maintain weather buoys offshore from the coast of British Columbia. Of the total of 17 buoys, eight are shown in Figure 4.5, three are located in the Strait of Georgia, two off of the west coast of Vancouver Island, and three offshore buoys are located about 400 km to the west of the British Columbia coast. All buoys were installed between 1987 and 1993; in general, the period of record is longer for the offshore buoys than for the coastal network. Short-term, historical data are also available for a number of primarily nearshore sites (e.g. Prince Rupert, Kincolith, Kitimat, Port Simpson).

Marine observations of wind conditions and sea state are also available from platforms of opportunity, including both ships and fixed platforms such as drilling rigs. Although this database can be extensive in areas close to major shipping lanes, this type of observation is considered to be significantly less reliable than those obtained from the weather buoys.

Wave hindcasting is relied on world-wide to estimate extreme wave conditions for engineering design purposes (e.g. the 100-year return period wave) in areas where the measurement database is insufficient for this purpose (most offshore areas). In wave hindcasting, sea state conditions are estimated for historic extreme storm events using a combination of numerical modelling and other analysis techniques. Extreme storm events are typically identified using a variety of criteria, and, in the absence of direct wind measurements, wind fields are developed from atmospheric charts for each storm event. These wind fields are then used to estimate site-specific wave conditions in the area of interest for each storm event. The resulting long-term simulated database is then used to estimate extreme wave parameters. Available wind and wave measurements are used to calibrate and verify the numerical modelling and analysis procedures.

A wave hindcasting study for the British Columbia coast was completed in 1992 for the Atmospheric Environment Service (Canadian Climate Centre 1992). This study was part of a multi-part project to estimate extreme wind and wave conditions for Canadian offshore waters. Project results indicated that extreme wave conditions are similar for the west coast of Canada and for the eastern continental shelves, with 100-year return period significant wave heights on the order of 13 m for both the Grand Banks of Newfoundland and the exposed areas of the west coast. It should be noted that the methodology used in these studies predicts deep-water wave conditions only; the effects of shallow water and strong currents on wave heights were not considered.

Since the early 1990's when the extreme wave studies were completed for Canadian waters, the impacts of several extreme storm events on both coasts of North America have prompted the re-assessment of wind and wave hindcast procedures. This re-assessment has focused on the accuracy of the wind fields used to predict wave conditions. The development of wind fields from atmospheric pressure charts uses a combined quantitative and qualitative approach, and thus relies on the expertise of the hindcaster.

In recent years, wind prediction methods have been improved and new wind fields developed for historic storm events (e.g. NCEP-NCAR Renalysis Project (NRA)). These wind fields have recently been used to produce a 40-year wind and wave hindcast for the North Atlantic (http://www.oceanweather.com/aes40). High quality wave measurements allowed evaluation of the accuracy of the wind fields. Although the NRA wind fields were found to produce wave hindcasts of good quality, wind fields still required reanalysis and enhancement using analyst-interactive techniques (Swail and Cox 2000).

For the B.C. coast, the 1992 estimates of wind and wave extremes could be updated based on the improved wind and wave climate databases, and also considering advancements in techniques for predicting wind fields in addition to inclusion of the effects of shallow water and strong currents. Given the large grid size of the NRA wind fields (2°), it is not clear if they will be appropriate for predicting wave conditions in coastal B.C. waters.

4.4.3 Wind-Driven Currents

In addition to creating surface waves, storm winds have several impacts on ocean currents and circulation patterns. In open ocean conditions, winds will create surface currents flowing in the downwind direction at a few percent of the wind speed. In shallower waters, interactions between the wind forcing and the bathymetry can lead to considerably more complex circulation patterns. In nearshore waters where freshwater inputs can lead to density stratification of the water column, the response to wind forcing is yet more complicated.

Several modelling efforts have contributed to our understanding of ocean currents and circulation patterns in the waters surrounding the Queen Charlotte Islands. In addition to the studies mentioned in

Section 4.2, Crawford et al. (1999) have modelled the response of these waters to wind forcing. For this exercise, the local winds measured at the AES buoys (Section 4.4.1) were used to drive the model, and comparisons were made with the summer drifter studies. Limited data were available to verify model predictions for the more extreme winter storms.

4.4.4 West Coast Marine Weather Forecasting

The state of marine forecasting for the west coast of British Columbia, particularly the north coast, has significantly improved since the mid-1980's. Specific improvements were sought at that time in the areas of storm event forecasting and advance warning time. The occurrence of a "marine bomb" event, or rapidly developing low pressure system, in October 1984 in which several fishing vessels were lost was a contributing factor to this need for improvement, as was the direct observation of wave conditions reaching or exceeding the 100-year return period event during several other storms.

The Environment Canada weather office and forecast operations for the Pacific and Yukon regions are based in Vancouver. The west coast marine weather forecast areas presently served are illustrated in Figure 4.6 *(http://www.weatheroffice. ec.gc/NatMarine/BC/index.html). A dedicated marine forecast desk, for both nearshore (coastal and 50-100 km out) and offshore marine areas, has been in operation since 1985 and considerable experience has been accumulated since that time. The forecasting unit operates on a 24 hour, seven days a week basis, and issues wind and sea state forecasts every six hours which cover the subsequent 24 hours with an outlook for the following 24 hours.*

Marine forecasts consist of two parts: a descriptive synopsis of the prevailing weather patterns, plus a detailed weather forecast. A sample for Hecate Strait is listed below.

> **Synopsis:**
> A ridge of high pressure along the coast will move inland tonight.
> A rapidly deepening low will track northwards to lie about 250 miles west of the Charlottes tonight. The associated front will sweep over the Charlottes Monday afternoon and reach the lower mainland Tuesday morning. A trough of low pressure will follow across the Charlottes Monday night.
> Over northern waters winds will rise to gale force southeast tonight. A brief period of storm force winds is expected Monday morning in advance of the front. Winds will ease to strong southerly with the passage of the front. Southerly gales ahead of the trough will shift to strong to gale force westerlies in its wake.
> Over southern waters winds will back into the southeast and rise to strong to gale as the front nears Monday.