LAURENTIAN SUB-BASIN EXPLORATION DRILLING PROGRAM ENVIRONMENTAL ASSESSMENT: SUPPLEMENT 2009

Prepared by

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1.0 Introduction

This document is a supplement to the environmental assessment (EA) and related addendum of an exploration/appraisal drilling program prepared on behalf of ConocoPhillips Canada Resources Corporation and BHP Billiton Limited (Buchanan et al. 2006, 2007). The purpose of this supplement is to provide relevant and up-to-date information as it pertains to the 2009 drilling program and its potential effects on the environment.

2.0 Project Overview for 2009

The name of the 2009 program is East Wolverine – G-37. The Study Area for the drilling program was defined in Buchanan et al. (2006) and is shown in Figure 2.1; however, the Project Area has been modified slightly from that defined in Buchanan et al. (2006) due to reconfiguration of the Exploratory Licences (EL). One new drill site in EL 1087R is proposed for fall 2009, located in waters ~2000 m deep (Figure 2.1). A summary of the 2009-2010 drilling program is provided in Table 2.1. The same drilling techniques described in Subsection 2.3 of Buchanan et al. (2006) will be employed in 2009-2010.

Table 2.1 Summary of the 2009 Drilling Program in the Laurentian Sub-Basin.

Program Details	Summary
Exploration License (EL)	1087R
Location	See Figure 1
Drilling Platform	Dynamically positioned (DP) drillship *Stena Carron*
Duration of Program (approx. days)	> 110 days
Approx. Water Depth (m)	1900 m
Start Date	Fall, winter 2009-2010
End Date	Spring, summer 2010

Note: The program could extend later into 2010 if logistical, technical or weather delays are encountered.

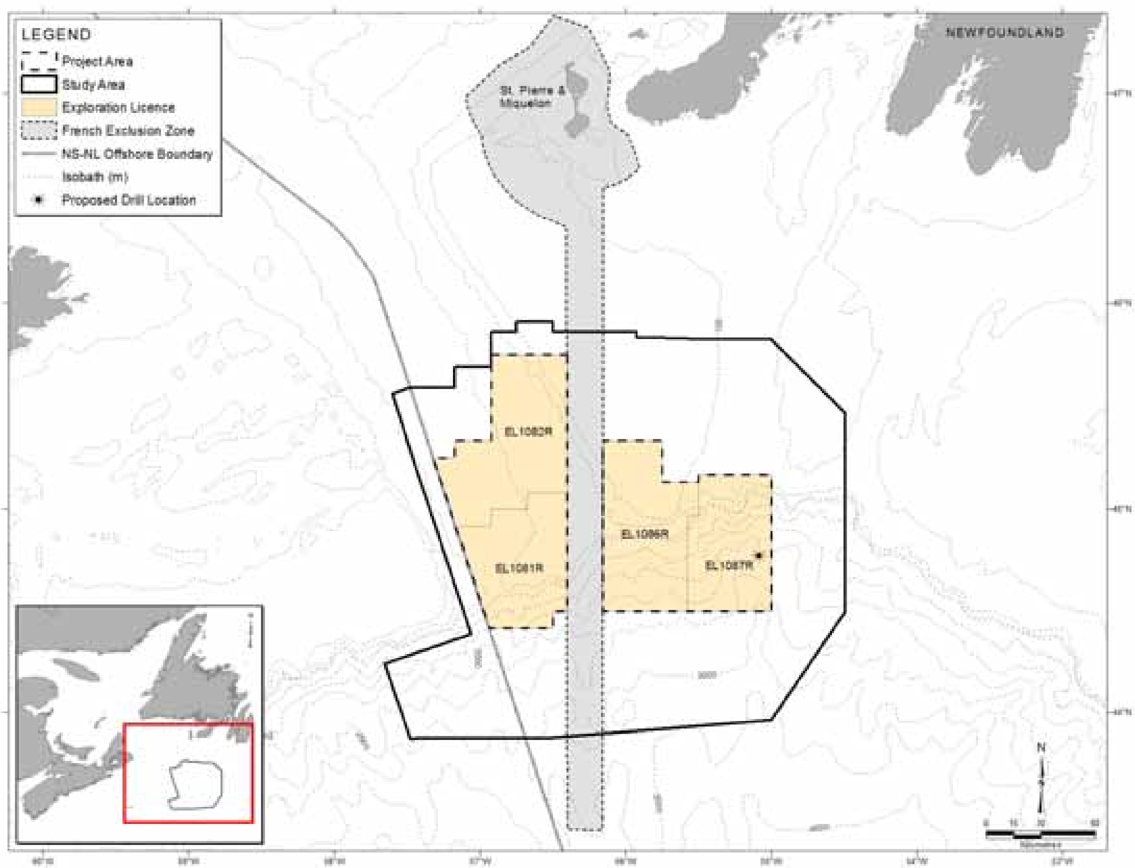

Figure 2.1 Location of the Study Area, Project Area and Proposed 2009 Drill Location.

2.1 Consultations

Consultations will be conducted with various stakeholders during and after the preparation of this EA supplement, likely in August-September 2009, in order to provide information about the 2009-2010 drilling program. ConocoPhillips wishes to identify any potential issues and concerns stakeholders may have regarding the program and will provide contact information for additional questions that may arise following consultations. Consultations will be undertaken with the following agencies and interest groups, as well as any other interested party:

- Fisheries and Oceans (DFO)
- Environment Canada
- Natural History Society
- One Ocean
- Marystown Fishers
- Fish, Food, and Allied Workers Union (FFAW)
- Association of Seafood Producers
- Groundfish Enterprise Allocation Council (GEAC) (Ottawa)
- Clearwater Limited Partnership
- Icewater Seafoods
- Others, as identified

3.0 Physical Environment

The physical environment of the Study Area was described in Section 3 of Buchanan et al. (2006). The predictions contained in the original EA and addendum (Buchanan et al. 2006, 2007) that concern the effects of the environment on the Project remain unchanged.

The following subsections provide updated information concerning climatology data, seismicity, and geology in the Study Area.

3.1 Climatology

An updated climatology report, using the most recently available data, was prepared for the purposes of this EA supplement (see Appendix 1). Updates to the information presented in Buchanan et al. (2006) include:

- Improved spatial and temporal resolution for wind and wave climatology;
- Additional information on the frequency of tropical storms, including the severe tropical storm season in 2005;
- A discussion of natural climate variability and analysis of the effects of the winter North Atlantic Oscillation index on wind and waves, based on the availability of higher resolution data, and
- An analysis of wind and wave extremes based on higher resolution data.

The reader is directed to Appendix 1 for a review of the most recent data available on climatology.

3.2 Seismicity

A single earthquake has been recorded since 2006 in Newfoundland and areas of Atlantic Canada near the Laurentian Sub-basin. On 28 April 2009, an earthquake of 3.3 magnitude occurred 28 km southwest of Bay Roberts, Newfoundland at 47.4ºN, 53.5ºW (NRCan 2009).

3.3 Geology

New information on the geologic processes of the Laurentian Fan and the southwest slope of the Grand Banks is available since the preparation of Buchanan et al. (2006, 2007), including the following recently published information:

- Five major phases describe the late Cenozoic evolution of the Laurentian Fan, as outlined in Skene and Piper (2006). This paper suggests that coarse-grained bed load flowed down the Eastern Valley as hyperpycnal inflows due to ice margin flow separation as opposed to the Western Valley that was fed by finer-grained sediment from meltwater plumes.

- Stratigraphic and sedimentological evidence for late Wisconsonian sub-glacial outburst floods to the Laurentian Fan (Piper et al. 2007). Large scale meltwater discharge caused large-scale catastrophic erosion and the transport of coarse sediments to the abyssl plain while smaller scale discharges created principally muddy sediment. At least one major sediment transport event, presumably pre-dating the 1929 "Grand Banks" turbidity current and dated to 16.5 ^{14}C ka, eroded the upper slope and major fan valleys of the Laurentian Fan; a gravel bed at least three metres thick was deposited in the wide fan valleys and thick sand of the Sohm Abyssal Plain. This event may have also created giant flute-like scours.
- Ledger-Piercy and Piper (2007) described a reconnaissance survey of late Quaternary stratigraphy and geohazards on the deep continental margin seaward of Green Bank, Haddock Channel, and Whale Bank. Hunter Sparker lines were used to show that five regional reflections were correlated throughout these regions and map the distribution of major mass-transport deposits, evacuation surfaces, and head scarps. Using piston cores, mostly mud was recovered, although cores adjacent to Haddock Valley contained abundant thin sand bed layers. There is evidence for active salt tectonics in the area, but the frequency of seabed sediment failures is similar to other areas of the southeastern Canadian margin and indicates that there are no unusual geohazards in these regions.
- Mosher and Piper (2007) interpreted multibeam bathymetric sonar data of the 1929 landslide area as showing canyons, valleys, and gullies typical of the continental slope in the region, with no major head scarp. It appeared to be a relatively shallow (top 5-100 m) landslide but laterally extensive and presumably changing into turbidity currents flowing along the existing canyon and valleys, supporting earlier theories that the landslide was thin-skinned and dispersed over a large area.

Unpublished research has also been made available for summary purposes in this EA supplement (David Piper, Bedford Institute of Technology, Geological Survey of Canada, pers. comm.), and include:

- A description of erosional and depositional features of glacial meltwater discharges on the eastern Canadian continental margin. From Hudson Strait to the Scotian margin, there is evidence of important glacial meltwater processes seaward of all transverse troughs on the continental shelf. Glacigenic debris flows, turbidity current deposition of channel-levee complexes, and blocky mass-transport deposits resulting from debris avalanches are identified as three major end-member processes on submarine fans seaward of the transverse troughs. It appears that glacigenic debris flows are dependent on gradient, and the importance of meltwater appears to be greater at lower latitudes.
- Armitage et al. (In Review) investigated the development of canyons and intercanyon ridges as well as the sedimentary processes affecting glacially influenced slopes in the southwest Grand Banks slope region. Canyons apparently resulted from Quaternary ice-related processes along the continental margin (e.g., ice stream outwash and proglacial plume fallout). Near the shelf-break, levee-like deposits occur. The authors suggest that the principal turbidity current generating mechanism in the region is likely turbulent subglacial outwash from tunnel valleys; these currents are important to the amount of upper slope sedimentation, slope morphology, and distribution of coarse-grained materials.

- Mosher et al. (In Prep.) discuss the near-surface geology of the Halibut Channel region of the southwest Newfoundland slope. In the eastern Laurentian area in particular, sedimentation appears to be predominantly pro-glacial above Q50 and has steep local gradients, suggesting that this area may be subject to failure. However, large-scale failures (such as that of the 1929 landslide) do not seem more frequent in this area than other regions of the eastern Canadian margin and are likely rare.

4.0 Biological Environment

The biological environment, including "Species at Risk", of the Study Area was overviewed in Section 4 of Buchanan et al. (2006). The following subsections provide updates on Species at Risk, cetacean and sea turtle sightings, cold water corals, recently proposed and accepted sensitive areas, DFO research vessel surveys, and DFO fisheries data.

4.1 Species at Risk

Species listed under the federal *Species at Risk Act* (*SARA*) are provided in Table 4.1 of Buchanan et al. (2006). Since the preparation of Buchanan et al. (2006), four species that could occur in the Study Area have been listed by the Committee on Species of Endangered Wildlife in Canada (COSEWIC): the roundnose grenadier, roughhead grenadier, American plaice, and killer whale (COSEWIC 2008). However, none of these species have yet to be listed under any schedule of *SARA*. One *SARA*-listed species (as *endangered* on Schedule 1) not previously profiled, the roseate tern (*Sterna dougalii*), may occasionally occur in the Study Area and is briefly described below. Several other species are categorized as candidate species under COSEWIC (see Table 4.1). Table 4.1 presents a list of Species at Risk updated from Buchanan et al. (2006).

Although not listed on Schedule 1 of *SARA*, the roundnose grenadier is currently listed as *endangered* under COSEWIC. Distributed in the NW Atlantic from Cape Hatteras to Greenland, the roundnose grenadier is a deepwater, demersal fish found in continental slope areas at depths of 200 to over 2000 m (Atkinson 1995). This species is thought to undergo seasonal migrations with individuals in northeast Newfoundland waters occupying deep water in winter and shallower water in late summer. Diurnal vertical migrations also occur that may carry them more than 1000 m off the bottom (COSEWIC 2004). The long-lived, late-maturing, slow-growing species has a low fecundity and is potentially vulnerable to overfishing (Devine and Haedrich 2008). The roundnose grenadier harvest has been under a moratorium in Canadian waters in Northwest Atlantic Fisheries Organization (NAFO) Subareas 2 and 3 since the 1990s, but may be harvested as by-catch in other fisheries (Power 1999). Roundnose grenadier spawning grounds are largely unknown and suspected to be in waters deeper than 850 m. Spawning is believed to occur in different areas throughout the NW Atlantic (COSEWIC 2004) or predominately in Icelandic waters with the passive eggs and larvae carried to other areas in the Northwest Atlantic by currents (Scott and Scott 1988). The spawning time is uncertain, but believed to occur throughout the year with more intense spawning occurring during particular periods. These periods appear to vary between areas (Atkinson 1995). The roundnose grenadier feeds on a variety of small crustaceans and euphasiids, squid, and small fishes. This slow swimming species, in turn, is possibly consumed by other fishes (Scott and Scott 1988).

Although not listed on Schedule 1 of *SARA*, roughhead grenadier is currently listed as *special concern* under COSEWIC. The roughhead grenadier occurs in deep water along coasts in subarctic to temperate waters on both sides of the North Atlantic Ocean. In the NW Atlantic, this grenadier occurs from Davis Strait along the continental slope, off Newfoundland, off Nova Scotia on Banquereau, Sable Island and

Table 4.1. *SARA*- and COSEWIC-Listed Marine Species Potentially Occurring in the Study Area.

SPECIES		*SARA*[a]			COSEWIC[b]					
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**	**High-priority Candidate**	**Mid-priority Candidate**	**Low-priority Candidate**
Blue whale	*Balaenoptera musculus*	Schedule 1			X					
North Atlantic right whale	*Eubalaena glacialis*	Schedule 1			X					
Northern bottlenose whale (SS[c] population)	*Hyperoodon ampullatus*	Schedule 1			X					
Leatherback sea turtle	*Dermochelys coriacea*	Schedule 1			X					
Atlantic salmon (Inner Bay of Fundy population)	*Salmo salar*	Schedule 1			X					
Roseate tern	*Sterna dougalii*	Schedule 1			X					
Beluga whale (StLE[d] population)	*Delphinapterus leucas*		Schedule 1			X				
Northern wolffish	*Anarhichas denticulatus*		Schedule 1			X				
Spotted wolffish	*Anarhichas minor*		Schedule 1			X				
Fin whale	*Balaenoptera physalus*			Schedule 1			X			
Atlantic wolfffish	*Anarhichas lupus*			Schedule 1			X			
Ivory Gull	*Pagophila eburnean*			Schedule 1	X					
Harbour porpoise	*Phocoena phocoena*		Schedule 2				X			
Sowerby's beaked whale	*Mesoplodon bidens*			Schedule 3			X			
Atlantic cod (LN[e] population)	*Gadus morhua*			Schedule 3		X				
Atlantic cod (NL[f] population)	*Gadus morhua*			Schedule 3	X					
Atlantic cod (M[g] population)	*Gadus morhua*			Schedule 3			X			
Porbeagle	*Lamna nasus*				X					
White shark	*Carcharodon carcharias*				X					
Winter skate (SGStL[h] population)	*Raja ocellata*				X					
Roundnose grenadier	*Coryphaeoides rupestris*				X					
Winter skate (ESS[i] population)	*Raja ocellata*					X				
Cusk	*Brosme brosme*					X				
Shortfin mako	*Isurus oxyrinchus*					X				

SPECIES		***SARA***[a]			**COSEWIC**[b]					
Common Name	**Scientific Name**	**Endangered**	**Threatened**	**Special Concern**	**Endangered**	**Threatened**	**Special Concern**	**High-priority Candidate**	**Mid-priority Candidate**	**Low-priority Candidate**
American plaice (Maritimes and NL[j] populations)	*Hippoglossoides platessoides*					X				
American eel	*Anguilla rostrata*						X			
Blue shark	*Prionace glauca*						X			
Roughhead grenadier	*Macrourus berglax*						X			
Killer whale (Arctic and Atlantic populations)	*Orcinus orca*						X			
Ocean pout	*Zoarces americanus*							X		
Spiny eel	*Notocanthus chemnitzi*								X	
Pollock	*Pollachius virens*								X	
Spinytail skate	*Bathyraja spinicauda*								X	
Alewife	*Alosa pseudoharengus*								X	
Capelin	*Mallotus villosus*								X	
Haddock	*Mellanogrammus aeglefinus*								X	
Red-necked phalarope	*Phalaropus lobatus*								X	
Sperm whale	*Physeter macrocephalus*									X
Hooded seal	*Cystophora cristata*									X
Harp seal	*Phoca groenlandica*									X
Red phalarope	*Phalaropus fulicarus*									X

Sources: [a] *SARA* website (http://www.sararegistry.gc.ca/default_e.cfm)
[b] COSEWIC website (http://www.cosepac.gc.ca/index.htm)
[c] Scotian Shelf
[d] St. Lawrence Estuary
[e] Laurentian North
[f] Newfoundland and Labrador
[g] Maritimes
[h] Southern Gulf of St. Lawrence
[i] Eastern Scotian Shelf
[j] Maritimes and Newfoundland and Labrador

Browns Bank, and on Georges Bank (Scott and Scott 1988). The roughhead grenadier is predominant at depths ranging from 800 to 1500 m, although they may inhabit depths between 200 and 2000 m (Murua and De Cardenas 2005 *in* Gonzalez-Costas and Murua 2007). Catches tend to be highest at water temperatures ranging between 2.0 and 3.5ºC (Scott and Scott 1988). The roughhead grenadier is an abundant and widespread species in the NW Atlantic. This fish generally occurs both on the continental shelf and slope at depths ranging from 400 to 1200 m. It has been found at depths as shallow as 200 m and as deep as 2700 m. Spawning is thought to occur during the winter and early spring. Little is known about the spawning grounds of this fish off Newfoundland although some believe that some spawning does occur on the southern and southeastern slopes of the Grand Banks (Scott and Scott 1988). Food of the roughhead grenadier consists of a variety of benthic invertebrates including bivalve molluscs, shrimp, seastars, polychaetes and some fish. This grenadier has been found in the stomachs of Atlantic cod. This species is quickly becoming an important commercial fish in the NW Atlantic. Presently its fishery is unregulated since it is usually taken as bycatch in the Greenland halibut fishery.

Two populations of American plaice are being considered as Species at Risk: the Newfoundland and Labrador population and the Maritimes population. While neither population is currently listed on Schedule 1 of *SARA*, both are listed as *threatened* under COSEWIC. American plaice is a bottom-dwelling flatfish that resides on both sides of the Atlantic (DFO 2006). American plaice that reside in the western Atlantic region range from the deep waters off Baffin Island and western Hudson Bay southward to the Gulf of Maine and Rhode Island (Scott and Scott 1988). In Newfoundland waters, plaice occurs both inshore and offshore over a wide variety of bottom types (Morgan 2000). They are tolerant of a wide range of salinities and have been observed in estuaries (Scott and Scott 1988; Jury et al. 1994). Plaice are typically found at depths of approximately 90 to 250 m, but have been found as deep as 713 m. Most commercially harvested plaice are taken at depths of 125 to 200 m. They are a coldwater species, preferring water temperatures of 0°C to 1.5°C (Scott and Scott 1988). Tagging studies in Newfoundland waters suggest that, once settled, juveniles and adults are rather sedentary and do not undertake large scale migrations (DFO 2008). However, older plaice have been known to move up to 160 km (Powles 1965). Migrations have been observed in Canadian waters to deeper offshore waters in the winter, returning to shallower water in the spring (Hebert and Wearing-Wilde 2002 *in* Johnson 2004). In Newfoundland waters, American plaice spawn during the spring (Scott and Scott 1988). Within the Study Area, there are limited data with respect to the actual spawning times. American plaice in the Newfoundland Region have no specific spawning areas; rather spawning occurs over the entire range (DFO 2008) with the most intense spawning coincident with areas where the higher abundance of adults are found (Busby et al. 2007). Limited data indicate that spawning occurs in April (and possibly other months) on Burgeo Bank, St. Pierre Bank and along the slopes of the Laurentian Channel and Hermitage Channel (Ollerhead et al. 2004). Spawning on the St. Pierre Bank typically occurs in water temperatures of 2.7°C (Scott and Scott 1988). Large quantities of eggs are released and fertilized over a period of days on the seabed (Johnson 2004). Eggs are buoyant and drift into the upper water column, where they are widely dispersed, allowing for some intermingling of stocks. Intermingling of adults is minimal. Hatching time is temperature-dependant, occurring in 11 to 14 days at temperatures of 5°C (Scott and Scott 1988). Larvae are 4 to 6 mm in length when they hatch and begin to settle to the seabed when they reach 18 to 34 mm in length and their body flattens (Fahay 1983).

Three species of wolffish are the only fishes currently listed on Schedule 1 of *SARA*. Both the northern wolffish (*Anarhichas denticulatus*) and spotted wolffish (*Anarhichas minor*) are currently listed as *threatened* on Schedule 1 of *SARA* and under COSEWIC. The Atlantic wolffish (*Anarhichas lupus*) is currently listed as *special concern* on Schedule 1 of *SARA* and under COSEWIC. A Recovery Strategy for northern and spotted wolffishes and a Management Plan for Atlantic wolffish was recently published (Kulka et al. 2007).

Killer whales (*Orcinus orca*) found in the NW Atlantic and Arctic were re-examined by COSEWIC in November 2008, resulting in a classification of *special concern* based on an updated status report. The killer whale is a year-round resident of Newfoundland waters, presumably occurring year-round in relatively small numbers in the Laurentian Sub-basin (Lien et al. 1988; Lawson et al. 2007). Globally, killer whales are not considered endangered (IUCN 2009), and there are currently no population estimates for the NW Atlantic. However, Lawson et al. (2007) individually identified a minimum of 63 individuals in Newfoundland and Labrador. No killer whales were observed during the 2005 marine mammal monitoring program in the Laurentian Sub-basin (Moulton et al. 2006). However, there were three records of killer whales in the Study Area from a recently available DFO Cetacean Sightings Database and several in adjacent areas (see Section 4.2 and Figure 4.4).

A Recovery Strategy for the *SARA*-listed (*endangered* on Schedule 1) North Atlantic right whale (*Eubalaena glacialis*) was recently finalized (Brown et al. 2009). Critical habitat was proposed for Grand Manan Basin in the Bay of Fundy, but insufficient data were available to propose critical habitat elsewhere. The Recovery Strategy also recommended a schedule of studies to further investigate critical habitat for North Atlantic right whales, including research to determine whether Roseway Basin on the Scotian Shelf constitutes critical habitat. The NW Atlantic right whale minimum population size was estimated at 325 individuals in 2003 based on individual photo-identification (Waring et al. 2009). Historically, right whale populations were severely depleted by commercial whaling. More recently, the lack of population recovery has been attributed to direct and indirect effects of anthropogenic activities, particularly ship collisions and entanglement with fishing gear (IWC 2001). At least some right whales may move through the Project Area during north-south migrations (Knowlton et al. 1992), and there have been rare sightings off southern Newfoundland and in the Laurentian Sub-basin (Sergeant 1966; Gaskin 1991). A recently available DFO Cetacean Sightings Database includes three records of North Atlantic right whales off Newfoundland's south coast (see Section 4.2 and Figure 4.2). However, as noted in Buchanan et al. (2006), North Atlantic right whales could potentially occur in the Project Area between late spring and early fall, but their presence is likely to be rare. The majority of the population can be found on feeding grounds in New England and Bay of Fundy waters from spring to fall before migrating to winter calving areas off the southeastern United States (Brown et al. 2009).

There are no new recovery plans or status updates for blue whales (*Balaenoptera musculus*) in Atlantic Canada. However, monitoring data collected during the 2005 ConocoPhillips seismic program indicated that a relatively high number of blue whales were present in the Laurentian Sub-basin Study Area (Moulton et al. 2006). In total, there were 49 sightings comprised of 53 individuals in or near the Study Area (see Figure 4.1); sighting rates were highest during August (0.09 sightings/h) and in water depths of 2000-2500 m (also 0.09 sightings/h). There were an additional 38 sightings totalling 42 individuals of unidentified baleen whales during the survey, the majority of which were presumed to be blue whales (V. Moulton, LGL Marine Biologist, 2009, pers. comm.) However, the Study Area has not previously been identified as a known area of concentration for blue whales in the North Atlantic (COSEWIC 2002). Given their *endangered* status under Schedule 1 of *SARA*, it is worth noting that blue whales are likely to occur in the Study Area during summer and perhaps may occur there on a regular basis.

A species not previously profiled, the Roseate Tern, is listed as *endangered* on Schedule 1 of *SARA*. A few pairs nest in areas near the Study Area, including Sable Island and the mainland Nova Scotia coast (see JWEL 2003). At Sable Island, the site closest to the Study Area, the number of breeding pairs dwindled to one pair in 2001 (detailed in JWEL 2003). It forages by plunge diving in inshore waters (Kirkham and Nettleship 1986). This species occasionally occurs on the south coast of Newfoundland during migration, so it has the potential to occur in the Study Area on rare occasions (B. Mactavish, LGL Biologist, 2009, pers. comm.).

Of the candidate species, most were profiled in Buchanan et al. (2006), and the reader is directed there for detailed descriptions. However, for those not previously described, a brief profile is provided here. The ocean pout is a bottom dweller that uses a wide variety of habitats and typically spawns in protected habitats, such a rock crevices, where it lays eggs in a nest and subsequently guards the eggs as they develop. Scott and Scott (1988) reported that adult ocean pout typically occur at depths ranging from 55 to 110 m. The spiny eel is also a bottom-living fish that typically occurs over a depth range of 250 to 1000 m, but has been caught in waters as shallow as 125 m on the Grand Bank to more than 3000 m off the coast of Ireland (Scott and Scott 1988). Data suggest that spiny eels migrate northward as individuals become older and larger. The alewife is an anadromous planktivorous species that spends the majority of its adult life at sea, only entering freshwater to spawn (Scott and Scott 1988). When at sea, alewifes are thought to frequent coastal waters and is most often caught at depths less than 100 m. The capelin is a small pelagic species that has a circumpolar distribution in the northern hemisphere; they are found along the coasts of Newfoundland and Labrador and on the Grand Banks.

4.2 DFO Cetacean and Turtle Observations

A new database of cetacean observations has become available since the writing of Buchanan et al. (2006). The Department of Fisheries and Oceans in St. John's (J. Lawson, DFO Marine Mammal Research Scientist, 2009, pers. comm.) has compiled a database of cetacean observations in Atlantic Canada, including those from the Laurentian Sub-basin Study Area from 1979-2007. Records in the Study Area originate from several sources, including incidental sightings during research cruises or aerial surveys, dedicated cetacean vessel or aerial surveys sponsored by DFO, and reports from members of the public. These data can be used to indicate what species may occur in the region, but cannot provide fine-scale descriptions of abundance or distribution.

Buchanan et al. (2006) included a summary of marine mammal observations collected in the Study Area during the 2005 ConocoPhillips seismic program in the Laurentian Sub-basin. There were a total of 624 cetacean sightings in or near the Study Area during the 2005 program, including 367, 133, 35, and 69 sightings of dolphins, baleen whales, large toothed whales, and unidentified whales (Figure 4.1;

Moulton et al. 2006). These 2005 sightings were provided to DFO for inclusion in the Cetacean Sightings Database and comprise ~75% of the cetacean sightings that occur within the Study Area. Since these data were previously described relative to the Study Area, they will not be included in the following summary of recently available sightings.

There were a total of 184 new cetacean sightings (of an estimated 854 individuals) within the Study Area, most often of unidentified whales (~19% of sightings), humpback whales (~15% of sightings), and unidentified dolphins (~15%) (Table 4.2). Atlantic white-sided dolphins and long-finned pilot whales were the most frequently identified toothed whales and dolphins (Table 4.2). Cetaceans were most often observed in water depths less than 500 m (n = 134 or 73% of sightings), and dolphins or porpoises contributed ~45% (n = 82) of the cetacean sightings (Table 4.2). Approximately 88% of cetacean sightings (n = 162) occurred from May to October, although there was likely greater observer effort in the Study Area during these months. Figures 4.2-4.5 show the distribution of baleen whales, large toothed whales, dolphins and porpoises, and unidentified cetaceans in and near the Study Area. Baleen whale sightings were most common in the northeast portion of the Study Area, and typically occurred in water depths shallower than the proposed drill location (Figure 4.2). Sperm and northern bottlenose whales were sighted in slope areas throughout the Study Area (Figure 4.3), similar to many dolphin species (Figure 4.4). Dolphin sightings also often occurred over shallow banks in the Study Area. There were several unidentified cetacean sightings in the Study Area, particularly in the northeast portion (Figure 4.5). It should be noted that there was a single sighting in the Study Area of a pygmy sperm whale in waters 1001-1500 m deep during June 2001 (Table 4.2); this species was not profiled in Buchanan et al. (2006), and it is considered to be a rare visitor to the Study Area.

DFO has also compiled a database of sea turtle sightings and fishing gear entanglements in Newfoundland and Labrador waters (J. Lawson, DFO Marine Mammal Research Scientist, 2009, pers. comm.), including observations from 2001-2007 in and near the Laurentian Sub-basin Study Area (Figure 4.6). These data were not available for earlier EAs (i.e., Buchanan et al. 2006, 2007). A total of seven leatherback sea turtles were sighted, all as free-swimming individuals, within the Study Area. Most were sighted in August (n = 5), but one was sighted in an unknown month and another in June. Two sightings occurred in waters 0-100 m deep, three in waters 101-200 m deep, one in waters 501-1000 m deep, and one in waters 2001-2500 m deep. All sightings occurred in the eastern portion of the Study Area (Figure 4.6).

A number of *caveats* should be noted when considering the sea turtle and cetacean DFO data, and include:

1. The sighting data have not yet been completely error-checked.
2. The quality of some of the sighting data is unknown.
3. Most data have been gathered from platforms of opportunity that were vessel-based. The inherent problems with negative or positive reactions by cetaceans to the approach of such vessels have not yet been factored into the data.
4. Sighting effort has not been quantified (i.e., the numbers cannot be used to estimate true species density or abundance for an area).

Table 4.2. Number and Depth Distribution of Cetacean Sightings within the Study Area.

	Depth (m)											
Species	**0-100**	**101-200**	**201-300**	**301-400**	**401-500**	**501-1000**	**1001-1500**	**1501-2000**	**2001-2500**	**>2500**	**Total**	**% of Total**
Baleen whales												
Blue whale	1	1	0	0	1	0	0	0	0	0	**3**	1.6
Fin whale	4	4	0	0	1	0	0	0	0	0	**9**	4.9
Humpback whale	9	12	0	5	0	0	1	0	1	0	**28**	15.2
Minke whale	1	2	0	0	0	1	1	0	0	0	**5**	2.7
Sei whale	0	0	0	0	0	0	0	0	0	0	**0**	0
Unidentified baleen whale	1	0	0	0	0	1	0	0	0	0	**2**	1.1
Toothed whales												
Northern bottlenose whale	0	0	0	0	0	0	1	0	1	0	**2**	1.1
Sperm whale	3	0	0	2	0	2	0	0	0	0	**7**	3.8
Pygmy sperm whale	0	0	0	0	0	0	1	0	0	0	**1**	0.5
Dolphins & Porpoises												
Atlantic white-sided dolphin	6	5	0	0	1	0	1	1	0	0	**14**	7.6
Bottlenose dolphin	0	0	0	0	0	0	0	0	0	0	**0**	0
Common dolphin	0	1	0	0	0	3	0	1	0	0	**5**	2.7
Killer whale	1	0	0	0	0	0	0	0	0	2	**3**	1.6
Long-finned pilot whale	3	2	0	5	0	1	6	2	0	0	**19**	10.3
Risso's dolphin	0	0	0	0	0	0	0	0	0	0	**0**	0
Striped dolphin	0	0	0	0	0	0	0	0	0	0	**0**	0
White-beaked dolphin	2	0	0	0	0	0	0	3	0	0	**5**	2.7
Harbour porpoise	1	3	0	1	0	1	0	0	0	0	**6**	3.3
Unidentified dolphin	4	7	0	2	1	4	3	6	0	0	**27**	14.7
Unidentified dolphin or porpoise	1	0	0	0	0	1	2	0	0	0	**4**	2.2
Other Cetaceans												
Unidentified whale	10	14	0	6	2	1	1	0	0	0	**34**	18.5
Unidentified large whale	3	4	0	2	0	1	0	0	0	0	**10**	5.4
Total	**50**	**55**	**0**	**23**	**6**	**16**	**17**	**13**	**2**	**2**	**184**	

Source: DFO Cetacean Sightings Database, Records from 1979-2007 and excluding sightings during the 2005 ConocoPhillips Seismic Program in the Laurentian Sub-Basin.

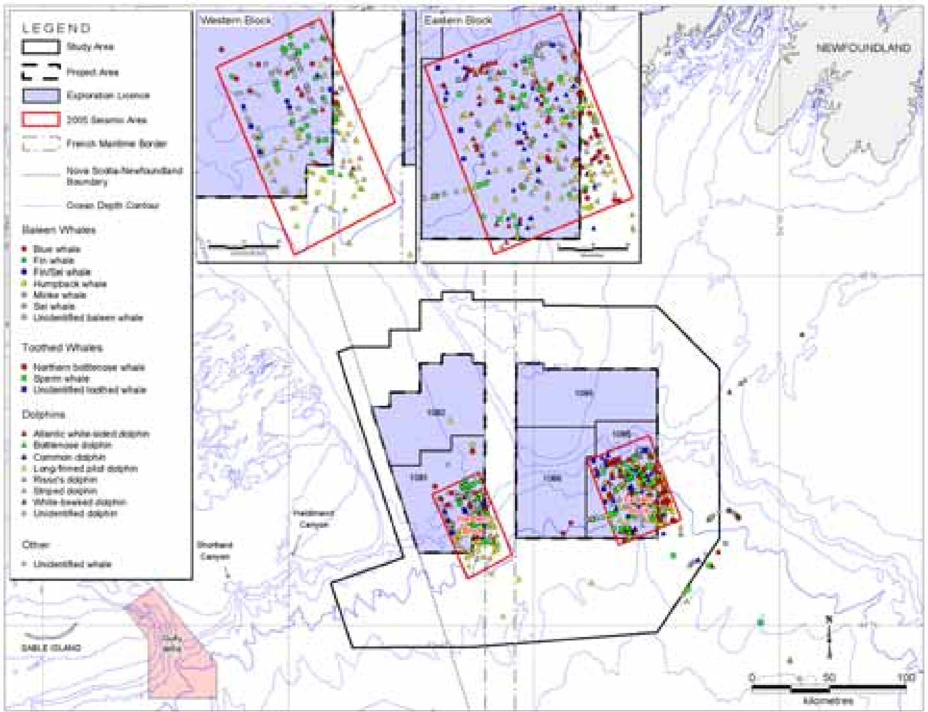

Figure 4.1. Cetacean Sightings from June-September during the 2005 ConocoPhillips Seismic Program (Moulton et al. 2006) and Summarized in Figure 4.56 of Buchanan et al. (2006). Locations of Relevant Marine Mammal Areas are Included.

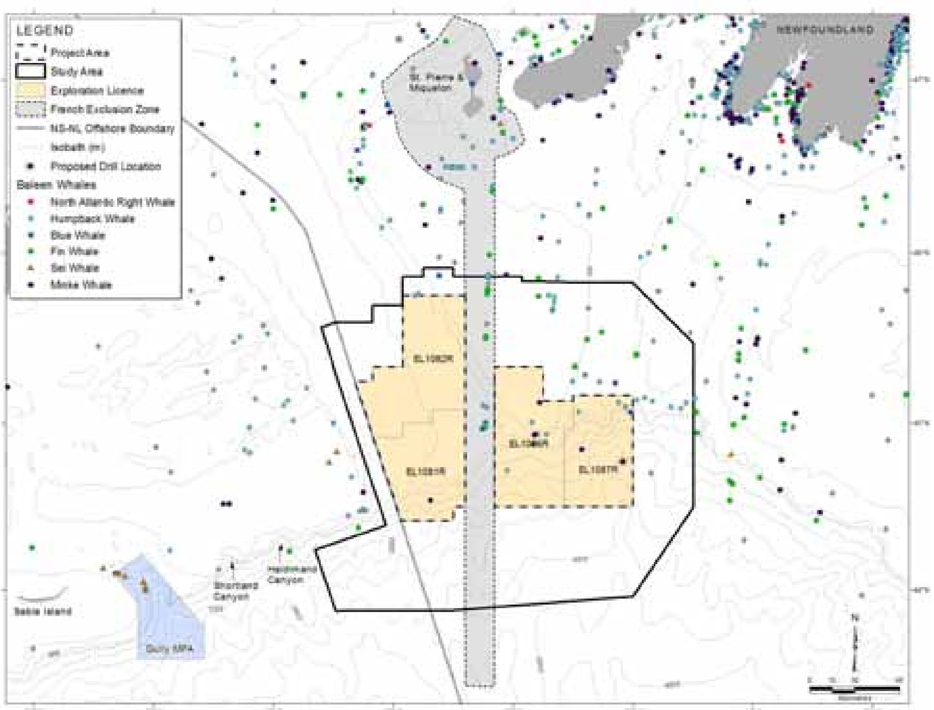

Figure 4.2. Sightings of Baleen Whales in and Near the Study Area, from the DFO Cetacean Sightings Database Including Records from 1979-2007.

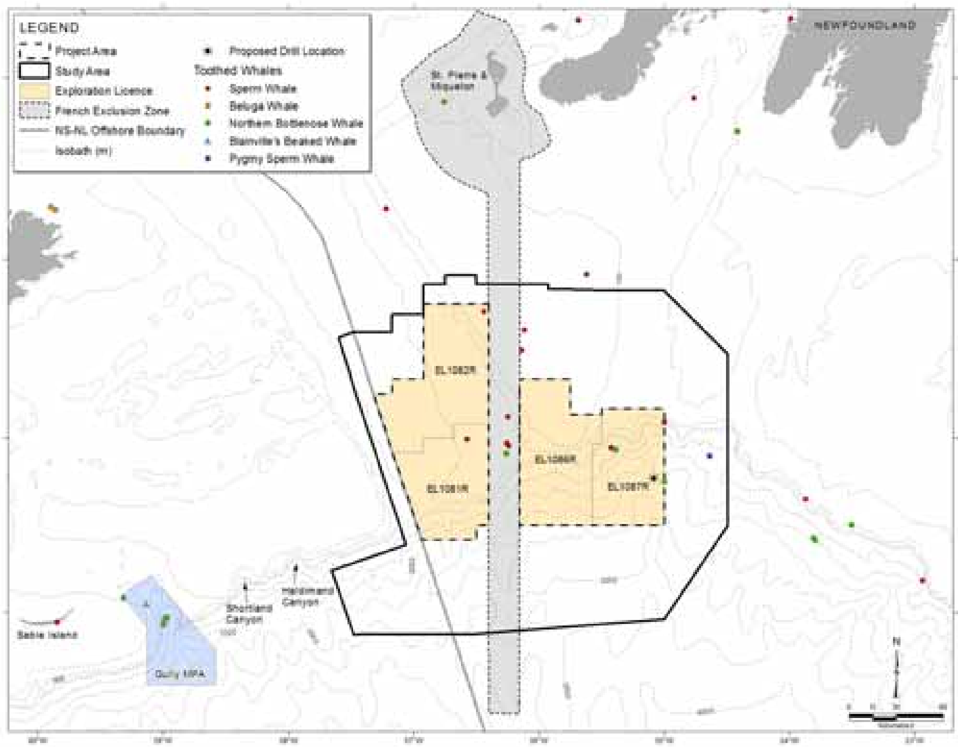

Figure 4.3. Sightings of Large Toothed Whales in and Near the Study Area, from the DFO Cetacean Sightings Database Including Records from 1979-2007.

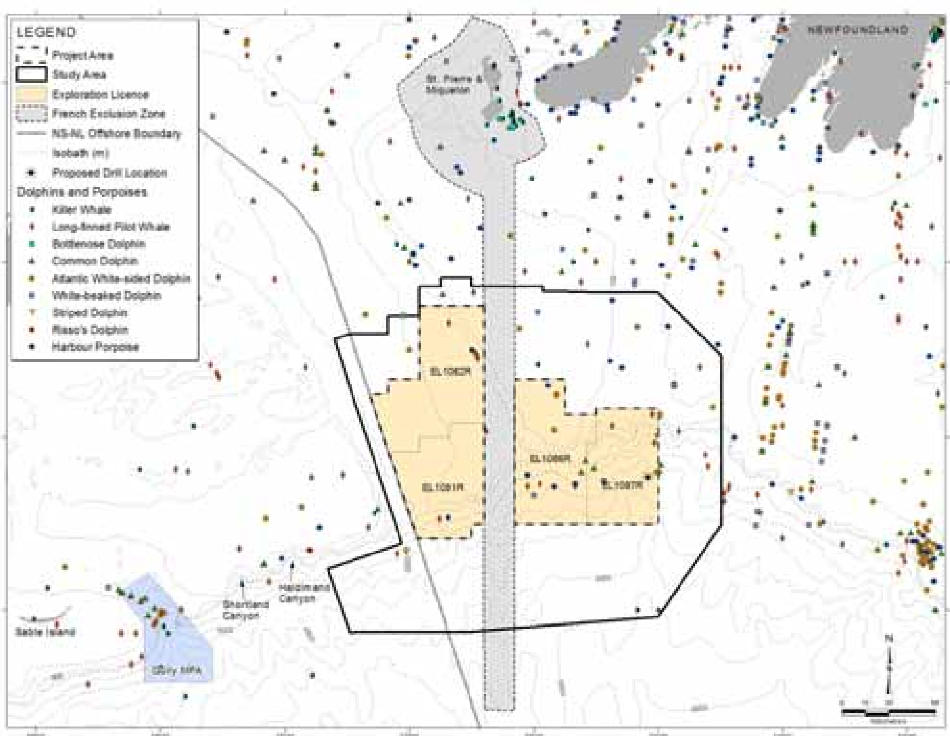

Figure 4.4. Sightings of Dolphins and Porpoises in and Near the Study Area, from the DFO Cetacean Sightings Database Including Records from 1979-2007.

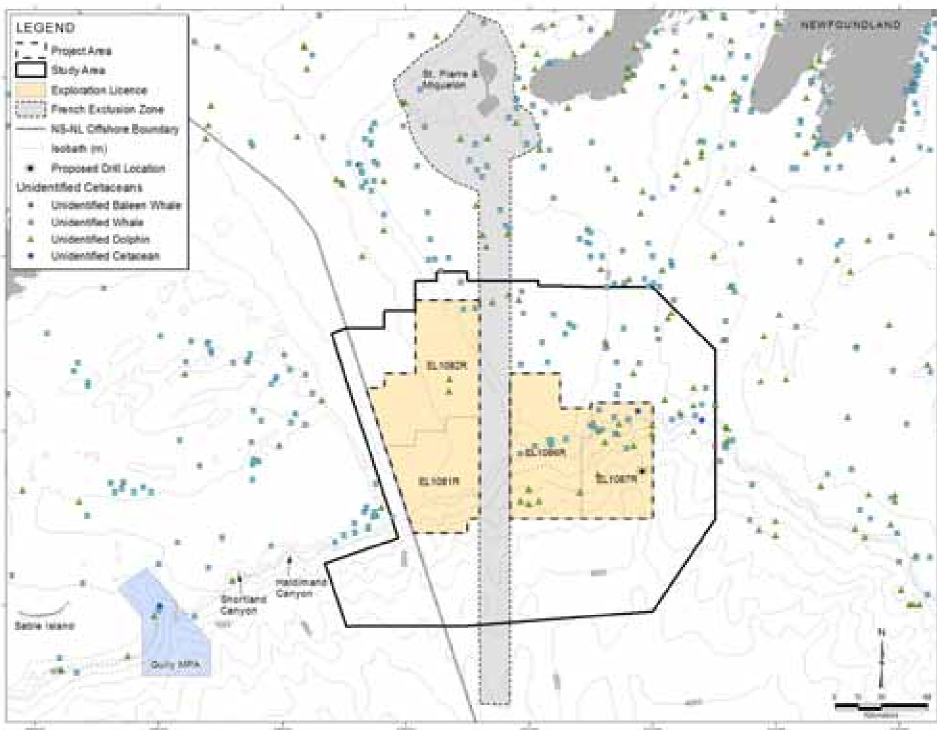

Figure 4.5. Sightings of Unidentified Cetaceans in and Near the Study Area, from the DFO Cetacean Sightings Database Including Records from 1979-2007.

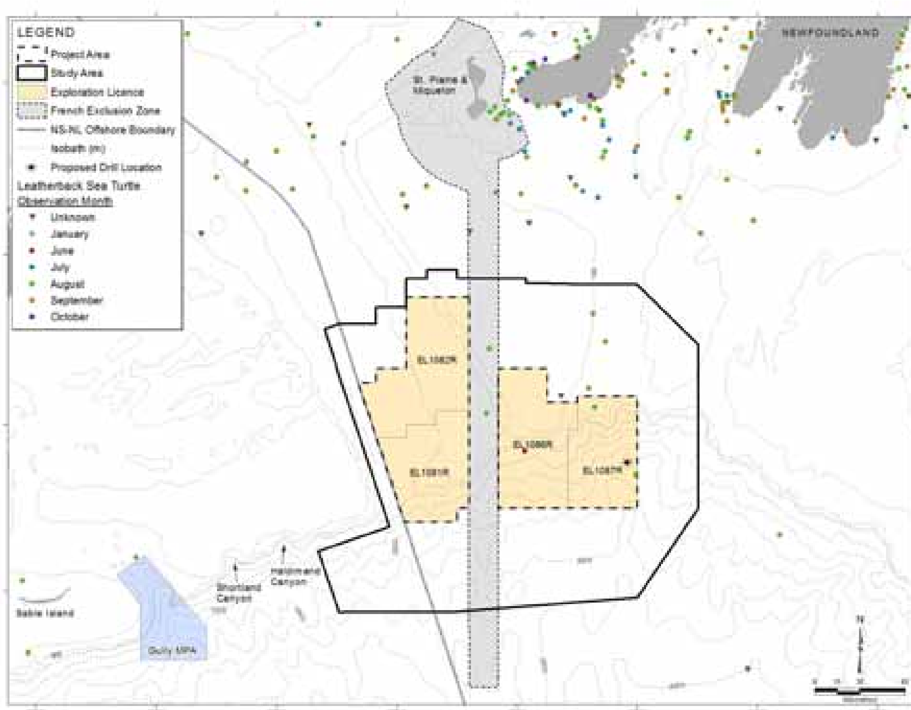

Figure 4.6. Sightings of Leatherback Sea Turtles in and Near the Study Area, from the DFO Sea Turtle Sightings and Entanglements Database, Including Records from 2001-2007.

5. Both older and some more recent survey data have yet to be entered into this database. These other data will represent only a very small portion of the total data.
6. Numbers sighted have not been verified (especially in light of the significant differences in detectability among species).
7. For completeness, these data represent an amalgamation of sightings from a variety of years and seasons. Effort (and number of sightings) is not necessarily consistent among months, years, and areas. There are large gaps between years. Thus seasonal, depth, and distribution information should be interpreted with caution.
8. Many sightings could not be identified to species, but are listed to the smallest taxonomic group possible.

4.3 Coldwater Corals

Wareham (2009) presented updated information on the distribution of cold water corals (also termed deep-sea corals) in Newfoundland and Labrador, including data collected in and near the Study Area since 2006. Data included the 2005 Northern Shrimp Multispecies Survey, 2000-2007 multispecies scientific surveys, and 2004-2007 commercial fishing vessels by Fisheries Observers. Preliminary results from a July 2007 deep-water remotely-operated vehicle survey (ROPOS) conducted in the Stone Fence area, Haddock and Halibut channels, and Desbarres Canyon (Mercier et al. 2009) were also included. Sets with corals were distributed along and beyond the continental shelf, with concentrations occurring along the southwest Grand Banks edge/slope area from southern St. Pierre Bank to the Tail of the Grand Banks. Relatively dense sets with corals occurred at the northwest St. Pierre Bank slope and Laurentian Channel area. Soft coral were caught in the region of Rose Blanche Bank/Burgeo Bank/northeast Laurentian Channel. Multiple species of antipatharian corals, large and small gorgonians, solitary stony corals, and sea pens were also surveyed or caught within 50 km of the proposed drill site, and particularly in the nearby Haddock and Halibut channels, Stone Fence area, and Desbarres Canyon (see Figures 4.1-4.7 in Wareham 2009). Thickets of *Keratoisis omata* were also observed during the 2007 ROPOS survey in an area close to the proposed drill site, located between the southern entrances to Halibut and Haddock channels (however, no coordinates were given; see Figure 4.7 in Wareham 2009).

Edinger and Gilkinson (2009) described five broad areas of high deep-sea coral diversity and abundance along the continental margin of Newfoundland and Labrador, including one area directly to the west of the Study Area, the southwest Grand Banks slope. A CAD-NAFO Coral Protection Zone was created along the southwest Grand Banks slope on 1 January 2008 as a mandatory temporary closure area to fishing between the 800 and 2000 m (see Figure 4.7). This closure remains in effect until 31 December 2012. The areas around Haddock and Halibut channels contain particularly high coral diversity per survey trawl and has a unique habitat type; species include golden bamboo coral (*Keratoisis omata*) and other associated corals (i.e., *Acanthogorgia armata*, *Anthomastus grandiflorus*, and soft corals), *Acanella arbuscula*, *Radicipes gracilis*, and sea pens (Edinger and Gilkinson (2009). The southwest slope of the Grand Banks was also identified as a priority area for coral conservation by Edinger et al. (2007). The Stone Fence, located about 20 km to the southwest of the western boundary of the Project

Area and ~168 km from the proposed drill site, is the only known Canadian location of the reef-building coral *Lophelia pertusa* (see Figure 4.7).

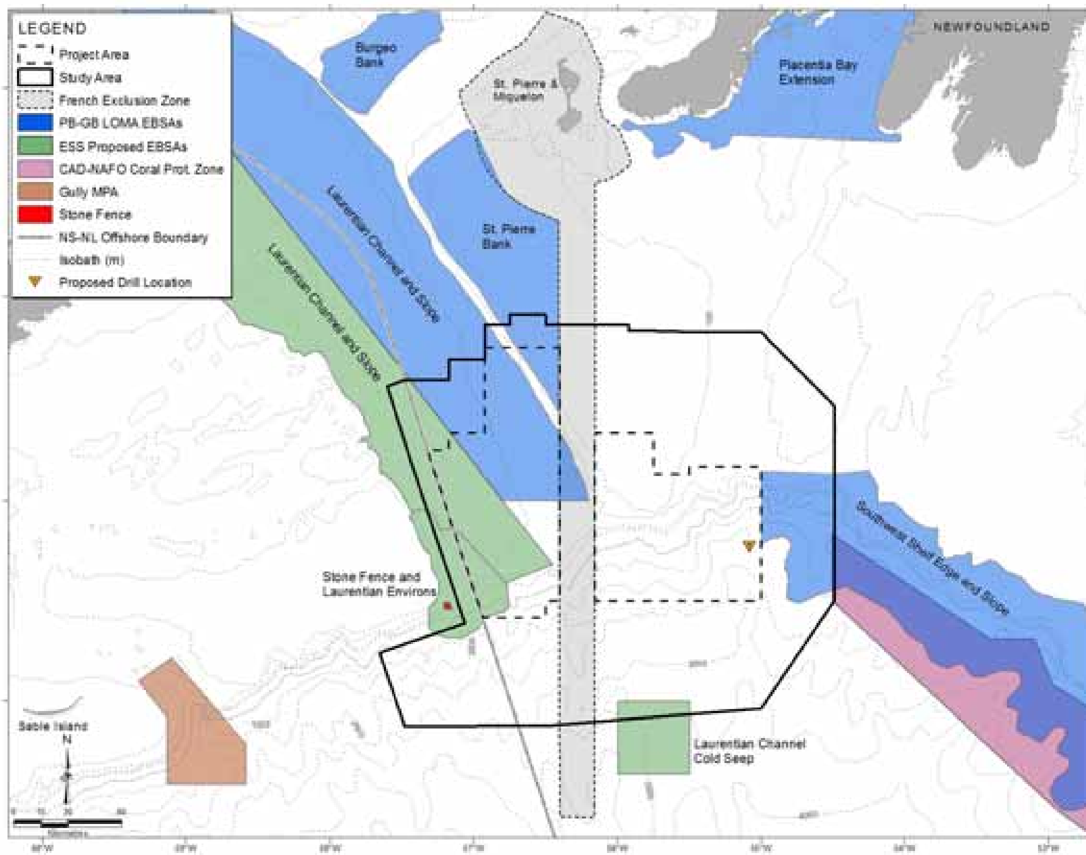

Figure 4.7. Proposed and Accepted Sensitive/Special Areas Within and Nearby the Proposed Drill Site and Study Area, Including Those Within the Placentia Bay-Grand Banks Large Ocean Management Area (PB-GB LOMA) and Proposed on the Eastern Scotian Shelf (ESS). Note that the Gully and Stone Fence were Previously Identified in Buchanan et al. (2006, 2007).

4.4 Sensitive/Special Areas

Several regions along the eastern Scotian Shelf and southern Newfoundland coast have recently been identified as sensitive or special areas. Canada's *Oceans Act* authorizes DFO to provide special protection to portions of the oceans and coasts considered to be ecologically or biologically important. Nearby or within the Study Area, a number of "Ecologically or Biologically Significant Areas" (EBSAs) have been designated or proposed by DFO (Figure 4.7). Special areas that overlap with the Study Area include three EBSAs associated with the Placentia Bay-Grand Banks Large Ocean Management Area (LOMA) and three proposed EBSAs associated with the eastern Scotian Shelf. Other proposed or designated EBSAs are found nearby in the Gulf of St. Lawrence, eastern Newfoundland, and the Grand Banks. Additional information regarding each of these areas are provided in various DFO documents (DFO 2007; Doherty and Horseman 2007; Templeman 2007). Table 4.3 provides an estimate of the distance between the proposed drill site and each proposed or existing protected area that is nearby the Study Area.

Table 4.3. Estimated Closest Distances (km) Between Proposed and Existing Sensitive Areas and the Proposed Drilling Location.

Sensitive Area	Closest Distance to Proposed Drill Site (km)
General Areas	
Gully	300
Stone Fence	168
CAD-NAFO Coral Area	46
PBGB LOMA	
St. Pierre Bank	127
Southwest Shelf	7
Laurentian Channel/Slope	92
ESS Proposed Areas	
Stone Fence/Laurentian Channel	137
Laurentian Channel/Cold Seep	92
Laurentian Channel/Slope	109

The EBSA designation has no legal implications *per se*. However, such areas have potential to become areas of interest (AOI) which may eventually lead to marine protected area (MPA) status with restrictions or conditions on use of the area. Attaining MPA status would likely require extensive public consultations. In any event, ConocoPhillips will continue to follow these issues and will conduct their operations accordingly in order to minimize any adverse effects on potentially sensitive areas.

4.5 Commercial Fisheries in 2006

The Study Area supports a variety of commercial fisheries, involving fishing vessels largely based in Newfoundland and Nova Scotia, and to a lesser extent, Quebec and New Brunswick. These are primarily groundfish fisheries, though snow crab and whelk are also important harvests. The area's fisheries are conducted using both fixed and mobile gear. This section describes the commercial fisheries in the area of the proposed survey for the period of 2006-2008. Biological characteristics and status of the main commercial fish and invertebrate species are described in preceding sections or in Buchanan et al. (2006).

4.5.1 Data Sources

An historical overview using DFO datasets (1986-2005) and NAFO datasets (1984–2001) is provided in Buchanan et al. (2006). The DFO data used in that EA represented all catch landed within the DFO Maritimes Region and for all Newfoundland and Labrador landed catch. The NAFO datasets capture harvest by Canadian fishers and non-Canadian NAFO states, which in this area is primarily France, harvesting species in association with the French territorial waters and exclusive economic zone (EEZ) extending from St. Pierre et Miquelon. Buchanan et al. (2006) also conducted a detailed analysis of fishing activity in the Study Area focussing on DFO data for the years 2003-2005 because fishing activities in the area had changed significantly in the previous 10 to 15 years.

Data derived from the DFO Newfoundland Region (Newfoundland and Labrador), Maritimes Region (Nova Scotia), Gulf Region (New Brunswick and Prince Edward Island), and Quebec Region catch and effort datasets (DFO 2006-2008) were used for the fisheries maps and the catch analysis in this supplement. The data for these years are still classified by DFO as "preliminary" although the data are not likely to change significantly when finalized.

Much of the DFO catch data for the Study and Project Area in recent years are georeferenced,[1] which allows plotting of past harvesting locations. Areas farther from shore tend to have a great proportion of their catch georeferenced, while those closer to shore have less, though this may vary from year to year in the DFO datasets. For instance, >99% (by quantity) of the recorded catch from offshore Unit Area 3Psh was georeferenced in 2008, while roughly 50% of the catch was georeferenced in that year in 3Psc (Placentia Bay), which is inshore, northeast of the Study Area.[2] However, in the 2005 dataset provided by DFO, 56% of the 3Psh harvest was georeferenced, and just over 2% of the 3Psc quantities. Consequently, when characterizing the historical domestic fisheries, this report also describes the fisheries in Unit Areas 3Psf, 3Psg, 3Psh, 4Vsc and 4Vsb. These "Adjacent Unit Areas" are those within which some part of the Study Area is located.

In addition to the databases and consultations described, this supplement also draws on a variety of published sources, mainly from DFO, such as species management plans, status reports and research documents. These are listed in Section 6.0.

4.5.2 Overview

The Study Area and Project Areas in relation to marine features and fisheries management zones (Unit Areas) and other boundaries are shown in Figure 4.8. As the map indicates, these areas straddle parts of NAFO Subareas 3 and 4.

The fisheries in the southern Laurentian Channel and on the south western Grand Banks, over many decades, have been dominated by groundfish harvesting. Today, the harvest is primarily redfish species (ocean perch) and cod, although skates, white hake, halibut (Atlantic and Greenland), and American plaice also account for important commercial landings. A little farther north on the western Grand Banks, the snow crab is extensively harvested, and some large pelagic species (swordfish, tunas and sharks) are also important (though to a much lesser extent) within certain parts of this area.

To the west, on the Scotian Shelf and beyond the Study Area, snow crab, shrimp and – since the mid-1990s in particular – various deep-sea clams have become very important commercial species. The latter fishery, mainly for Stimpsons surf clams, propeller clams and quahaugs, accounted for 63% to 70% of

[1] The location given is that recorded in the vessel's fishing log, and is reported in the database by degree and minute of latitude and longitude; thus the position is accurate within approximately .5 nautical mile of the reported co-ordinates. It should be noted that for some gear, such as mobile gear towed over an extensive area, or for extended gear, such as large pelagic longlines, the reference point does not represent the full distribution of the gear or activity on the water. However, over many data entries, the reported locations create a fairly accurate indication of where such fishing activities occur.

[2] A general exception to this is the offshore clam harvest from 4Vsc, where much of the harvest of those species is not georeferenced in the dataset provided, though this occurs outside the Study area on the Scotian Shelf.

the 4Vsc harvest by quantity from 2006-2008. However, this is pursued by one harvesting company (Clearwater Limited Partnership) on specific beds in 4Vsc well outside of the Study Area.

Running north-south through the Project Area is the "French Corridor", a portion of France's EEZ extending southward from the French islands St. Pierre et Miquelon off Newfoundland's south coast. This 10.5-mile wide zone was awarded by an international court of arbitration in 1992, settling an offshore boundary dispute between Canada and France. Within this corridor, which extends through NAFO 3Ps into 4Vs, France has quota for most commercial species. However, Canada's DFO manages fisheries in the zone and French quotas in and around the EEZ are set under a treaty signed in 1994 (JWEL 2003).

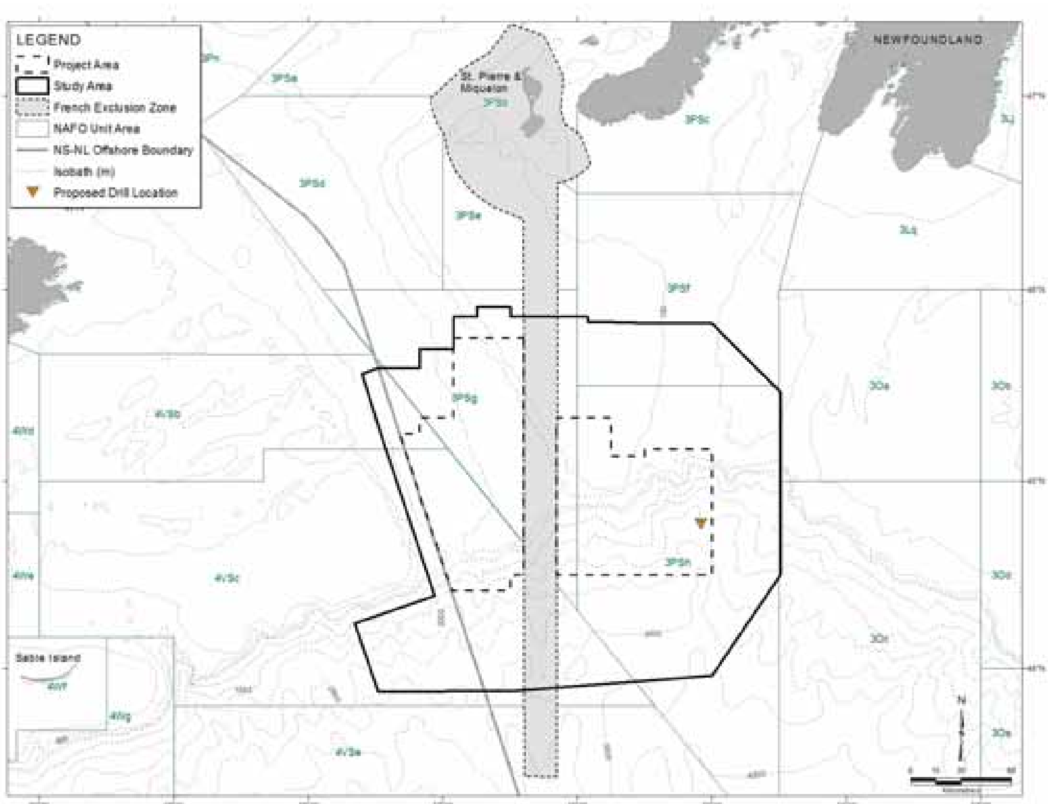

Figure 4.8. Study and Project Areas in Relation to Fishing Zones, Boundaries and Marine Features.

As JWEL (2003) notes, both NAFO and DFO manage fisheries in the general area, with DFO assuming primary responsibility for stocks that do not usually cross (straddle) the 200-mile EEZ limit, and those that are sedentary (e.g., snow crab). While NAFO has the primary responsibility for stocks outside the 200-mile EEZ and for straddling stocks, DFO provides scientific and management advice. The large pelagic species are managed by the International Commission for the Conservation of Atlantic Tunas (ICATT). Within the Canadian management system, DFO's Newfoundland Region is generally responsible for 3Ps, and DFO Maritimes Region for fisheries in 4Vs.

The composition of the catch in recent years in the Adjacent Unit Areas (3Psf, 3Psg, 3Psh, 4Vsb and 4Vsc; see discussion above) is shown in Table 4.4.

Table 4.4. Adjacent Unit Areas Domestic Harvest, 2006-2008 Average.

Species	Tonnes	% of Total
Deep sea clams	18,987	47.5%
Groundfish	9,539	23.9%
Snow crab	5,873	14.7%
Shrimp	2,314	5.8%
Whelks	1,996	5.0%
Small pelagics	778	1.9%
Large pelagics (includes swordfish, tunas, and sharks)	158	0.4%
Scallops	87	0.2%
All other	210	0.5%
Total	**39,942**	**100.0%**

Excluding the clam fishery, groundfish species continue to compose the majority of the harvest as they have in the past, though today this occurs almost exclusively in the 3Ps portions of this area. During 2006-2008, redfish, cod, white hake, skate, pollock, Atlantic halibut, haddock, and American plaice have accounted for roughly 94% on average of the domestic groundfish harvest in the Adjacent Unit Areas (Table 4.5).

Table 4.5. Adjacent Unit Areas Domestic Groundfish Harvest, 2006-2008 Average.

Species	Tonnes	% of Total
Redfish	3,164	33.2%
Atlantic cod	2,819	29.6%
White hake	986	10.3%
Skate	642	6.7%
Pollock	588	6.2%
Atlantic halibut	320	3.4%
Haddock	250	2.6%
American plaice	207	2.2%
Hagfish	181	1.9%
Monkfish	140	1.5%
Greenland halibut (turbot)	93	1.0%
All other groundfish	241	1.6%
Groundfish Total	**9,538**	**100.0%**

The NAFO commercial fisheries dataset available through the organization's website only provides information on catches occurring in different divisions or subdivisions (i.e., 3Ps), not unit areas (i.e., 3Psf). In addition, georeferenced catch locations are not provided and catch weights are provided as ranges, not absolute numbers. Because of the limitations of the datasets, only the species targeted and fishing gear used will be described with the NAFO data in this section.

According to NAFO commercial fisheries data from 2000-2009, groundfish species are also important harvests for Canadian and French (St. Pierre et Miquelon) vessels fishing in Subdivision 3Ps. Some important groundfish species, in order of decreasing catch abundance, are Atlantic cod, unspecified groundfish, redfish, white hake, skate, Atlantic halibut, witch flounder (greysole), Greenland halibut, winter flounder, and pollock. Small pelagics, such as Atlantic herring and Atlantic mackerel, as well as invertebrates, such as unspecified crab, sea scallop, unspecified mollusc, and shrimp, are also important target species. French vessels primarily targeted Atlantic cod, redfish, and mixed species. The main gear types used to target these species include fixed gear (gillnets, longlines, pots, and pound nets) and mobile gear (bottom otter trawl, handlines, Danish seines, and dredges).

In Subdivision 4Vs, the main species targeted by Canadian vessels include, in order of decreasing catch abundance, unspecified groundfish, redfish, swordfish, mixed species, Atlantic halibut, unspecified crustaceans, shrimp, and American plaice. From 2000-2009, harvesting by foreign vessels was limited to a small abundance of swordfish by Spanish vessels in 2005. The main gear types include longlines, bottom otter trawls, dredges, and Danish seines.

4.5.3 Historical Fisheries (Adjacent Unit Areas)

As mentioned above, an historical overview using DFO and NAFO datasets is provided in Buchanan et al. (2006). The EAs for the 2004-5 ConocoPhillips seismic programs (Buchanan et al. 2004; Christian et al. 2005) contain additional historical graphs based on catch data from NAFO and DFO. The NAFO recorded data are for 1984-2001, and the Canadian (DFO) data are for 1984-2003. The NAFO data presented in that report include harvests from all NAFO nations, though these are primarily Canadian (4Vs and 3Ps) and Canadian and French (within 3Ps). While some other European nations and Japan recorded relatively smaller catches to about 1988, there have been virtually none in 4Vs and 3Ps since then.

Since the Atlantic cod moratoria were declared in most east coast waters during 1992 and 1993, 3Ps has been one of the few open cod fisheries remaining, though quotas are now lower than in previous decades. Within the 4Vs, the once extensive cod fishery has been closed to directed fishing since 1993, though small catches have been allowed as by-catch in other fisheries and, since 1996, in a sentinel commercial index fishery. For example, the 4Vsc cod harvest in 1986 was more than 29,000 tonnes; in 2008 it was 51 tonnes. After groundfish, snow crab has been the next most important species over the past decade, though catches have been declining somewhat in recent years.

4.5.4 Study Area Commercial Fisheries

Table 4.6 shows the quantity of the domestic harvest by species recorded within the Study from 2006-2008. The last column of Table 4.6 indicates the percentage of the total harvest each species represents, by quantity, averaged over the three year period.

During this period nearly 74% of the catch was groundfish species (including skates) (Table 4.6. Redfish and Atlantic cod made up roughly half of the overall harvest from 2006-2008, while white hake, pollock, skates, haddock, and Atlantic halibut constituted approximately a further 23% of the total. Hagfish catches were also important within the Study Area in those years.

Of the non-groundfish species, the whelk harvest made up the largest catch by quantity, particularly in 2008 when it was the largest catch of all species. Snow crab and, to a lesser extent, Stimpson's surf clam are also important invertebrate harvests within the Study Area. Although the large pelagic harvests (swordfish, tunas and sharks) are not large, they are of relatively high value. Further information on the important commercial species fisheries in the Study Area, including seasonality and the fishing gear employed, are provided in following sections.

The majority of the catch (roughly 66% by quantity) in the Study Area was taken by vessels less than 65' in length from 2006-2008. The remainder was by vessels up to 200'.

Table 4.6. Study Area Harvest by Species, 2006–2008 (January – December).

Species	2006		2007		2008		2006-08
	Tonnes	% of Total	Tonnes	% of Total	Tonnes	% of Total	% overall
Redfish	3,476.8	30.1%	2,487.5	21.5%	1,801.3	17.9%	23.4%
Atlantic cod	2,689.9	23.2%	3,139.4	27.1%	1,884.9	18.8%	23.2%
Whelk	1,110.3	9.6%	1,440.3	12.4%	2,625.3	26.2%	15.6%
White hake	1,310.8	11.3%	1,052.1	9.1%	517.8	5.2%	8.7%
Snow crab	790.5	6.8%	863.4	7.5%	959.9	9.6%	7.9%
Pollock	443.2	3.8%	807.5	7.0%	415.1	4.1%	5.0%
Skate	513.7	4.4%	706.5	6.1%	366.9	3.7%	4.8%
Haddock	122.5	1.1%	343.9	3.0%	259.3	2.6%	2.2%
Atlantic halibut	265.1	2.3%	189.0	1.6%	184.1	1.8%	1.9%
Hagfish	184.9	1.6%	175.7	1.5%	180.7	1.8%	1.6%
Stimpson's surf clam	0.0	0.0%	7.7	0.1%	460.7	4.6%	1.4%
Monkfish	313.1	2.7%	30.0	0.3%	25.5	0.3%	1.1%
American plaice	104.3	0.9%	119.8	1.0%	88.9	0.9%	0.9%
Greenland halibut (turbot)	110.5	1.0%	62.9	0.5%	65.9	0.7%	0.7%
Witch flounder (greysole)	33.4	0.3%	11.9	0.1%	119.7	1.2%	0.5%
Yellowtail flounder	2.4	0.0%	14.8	0.1%	59.9	0.6%	0.2%
Swordfish	1.7	0.0%	53.0	0.5%	2.5	0.0%	0.2%
Atlantic herring	0.0	0.0%	49.1	0.4%	0.0	0.0%	0.1%
Sea scallop	45.0	0.4%	2.9	0.0%	0.0	0.0%	0.1%
Sea cucumber	29.0	0.3%	0.0	0.0%	7.3	0.1%	0.1%
Cusk	10.1	0.1%	5.5	0.0%	6.8	0.1%	0.1%
All Others	12.8	0.1%	19.3	0.2%	2.8	0.0%	0.1%
Total	11,570.0	100.0%	11,582.3	100.0%	10,035.2	100.0%	100.0%

4.5.4.1 Harvesting Locations

Figures 4.9 to 4.11 indicate the georeferenced domestic fishing locations in relation to the Study and Project areas, and the proposed 2009-2010 drilling site, for 2006-2008. As these maps indicate, most of the fish harvesting in the general area is concentrated on the Scotian Shelf and the Grand Banks, particularly on the shallower shelf banks (e.g., St. Pierre Bank, Banquereau Bank) and on the shelf edge and upper slope. Within the Laurentian Channel, most activity is focused north of the Project Area, or at the Channel mouth, and near the Stone Fence, while the deeper waters (>1,000-m depth) to the south see relatively less fishing activity.

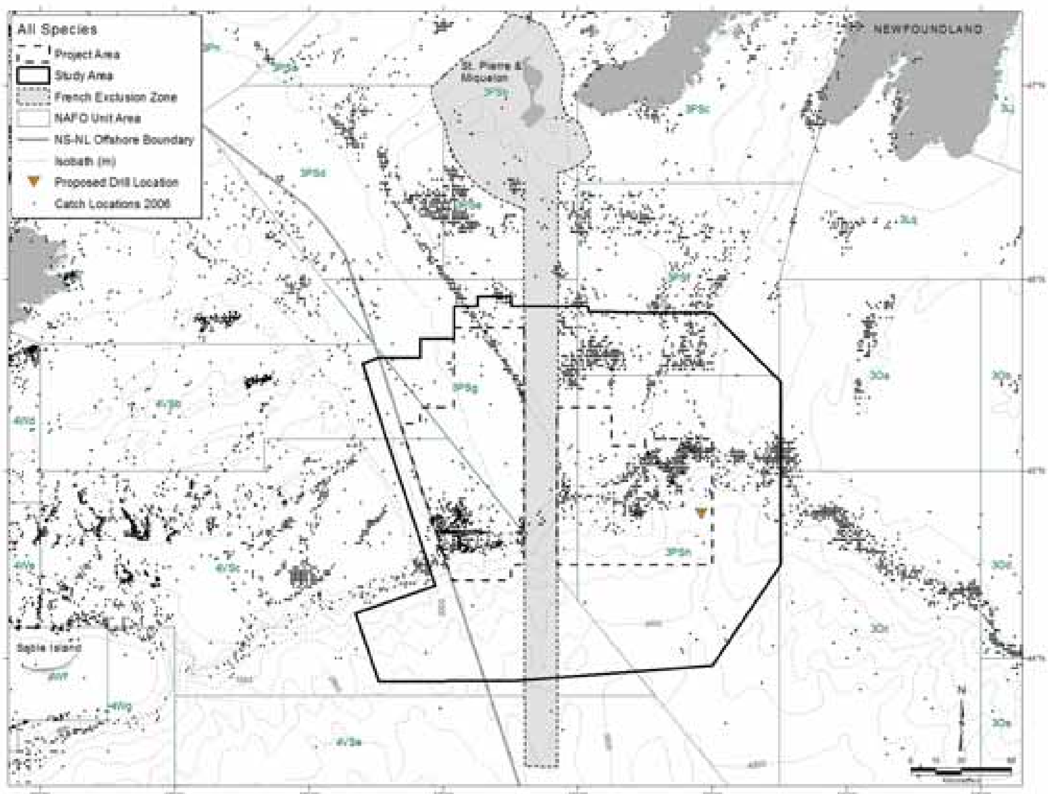

Figure 4.9. Harvesting Locations, All Species, January–December 2006.

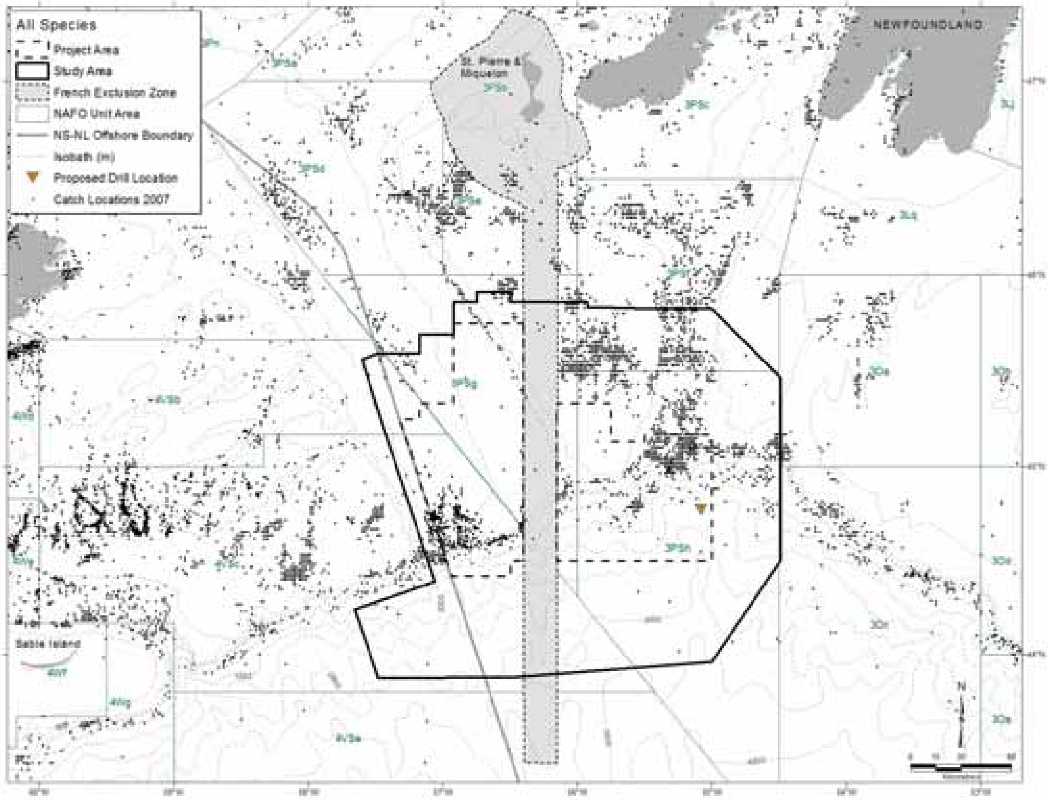

Figure 4.10. Harvesting Locations, All Species, January–December 2007.

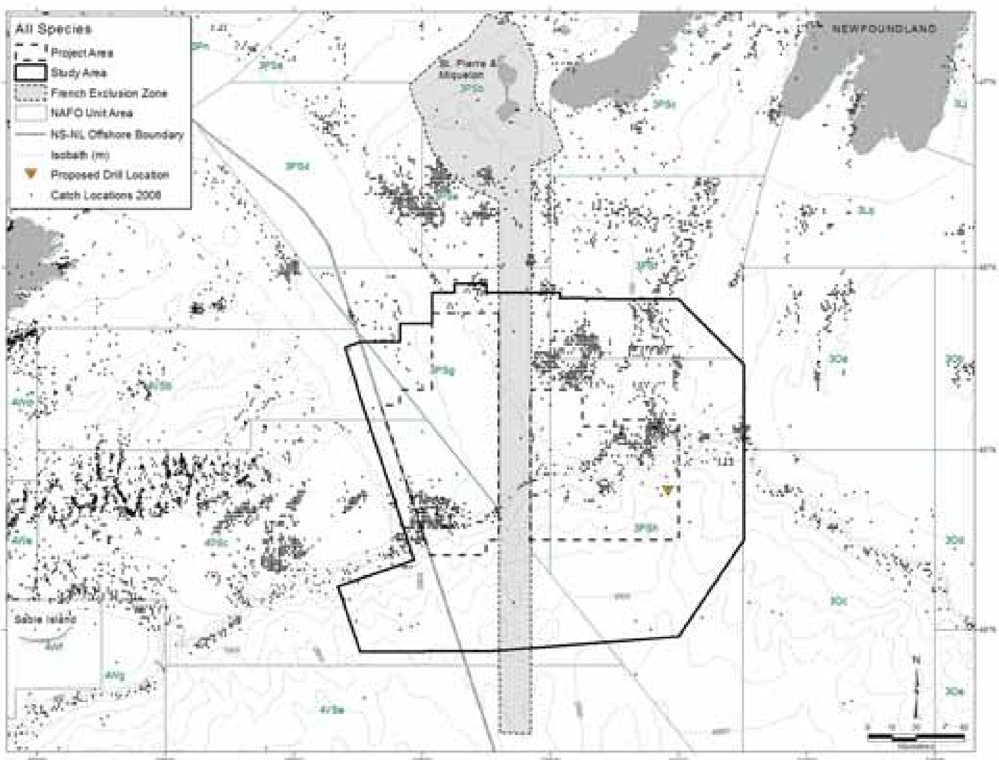

Figure 4.11. Harvesting Locations, All Species, January–December 2008.

As the maps indicate, the locations of activities from year to year have been generally consistent especially within the Study Area, where they are concentrated in fairly specific zones.

4.5.4.2 Seasonal Distribution

Fishing seasons may change depending on regulations set by DFO, the harvesting strategies of fishing enterprises, or on the availability of the resource itself. Figure 4.12 shows the 2006–2008 catch by month from the Study Area. As the data indicate, the earlier months of the year are generally productive in terms of quantity of harvest, though there has been a fair amount of variability. In recent years, the overall harvest appears to be more concentrated in the summer.

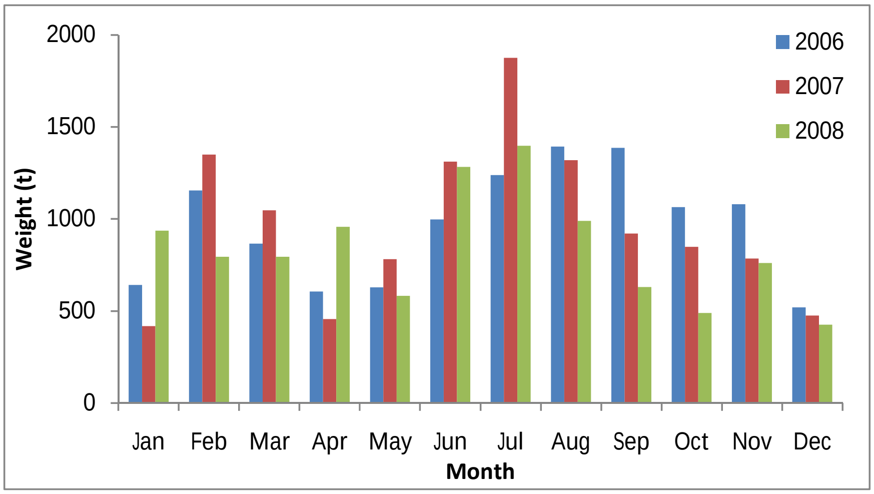

Figure 4.12. Study Area Harvest by Month, All Species, 2006-2008.

The following maps (Figures 4.13 to 4.24) show the reported domestic harvesting locations, all species, by month for January to December 2008, in relation to the Study Area, the Project Area and the potential initial drilling site.

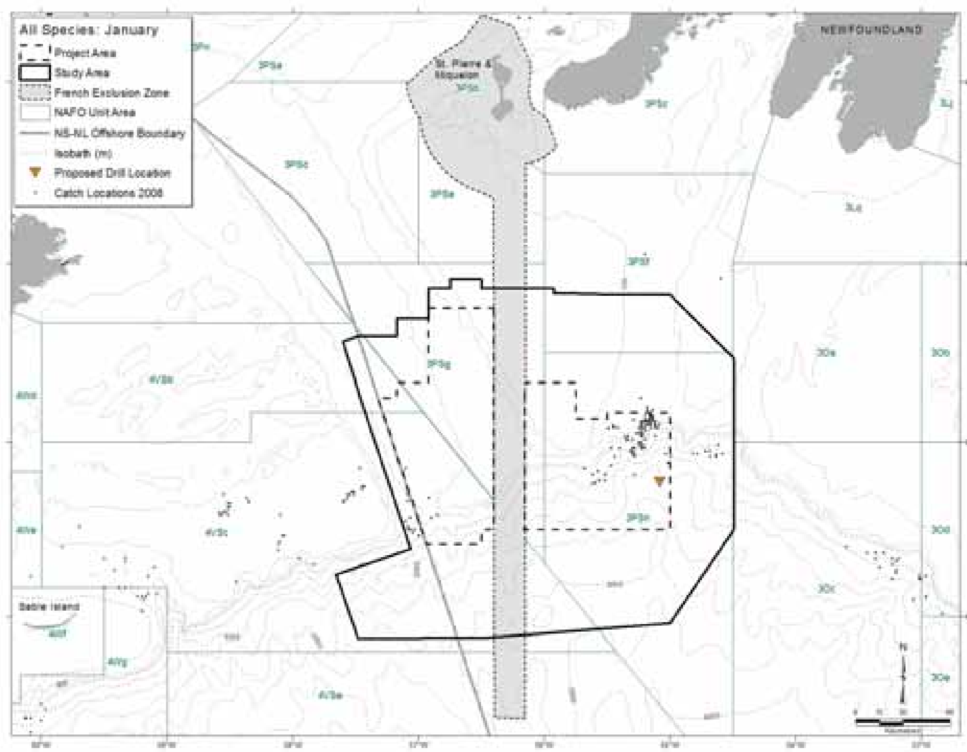

Figure 4.13. All Species Harvesting Locations, January 2008.

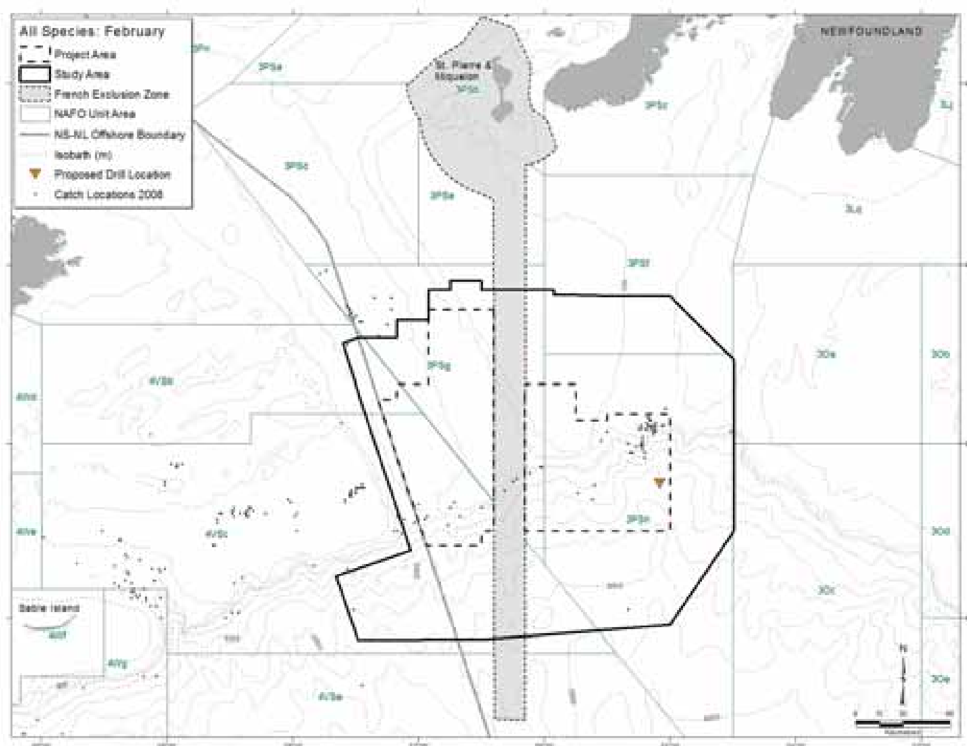

Figure 4.14. All Species Harvesting Locations, February 2008.

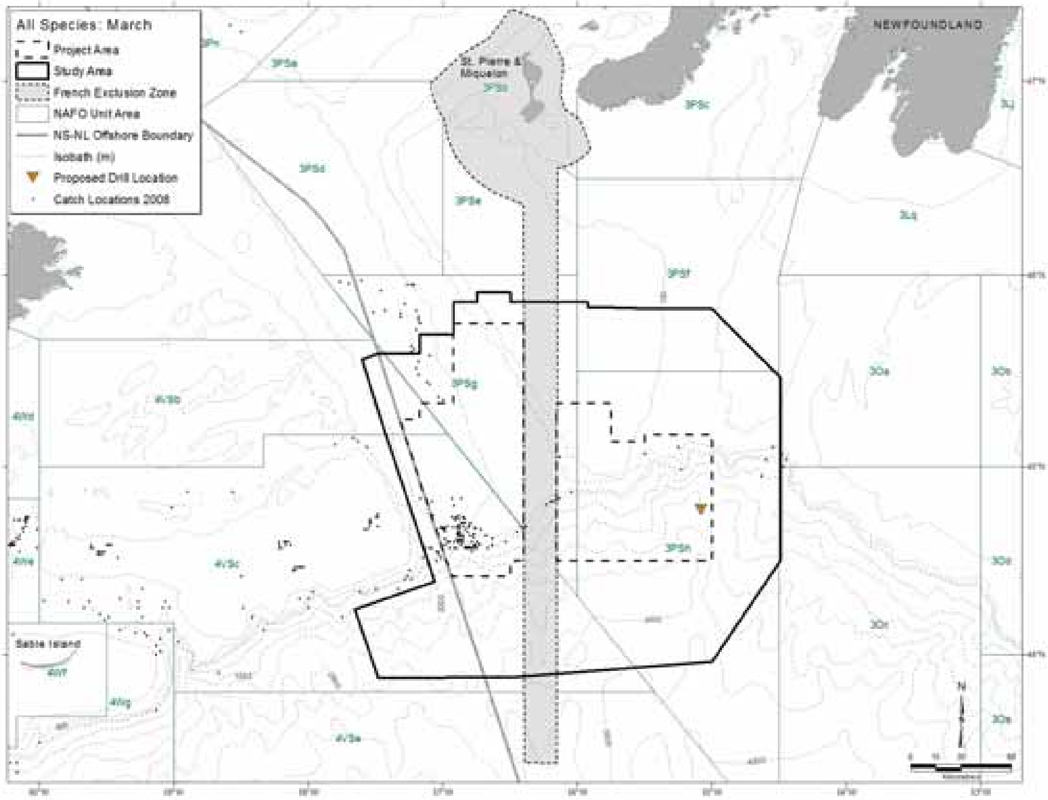

Figure 4.15. All Species Harvesting Locations, March 2008.

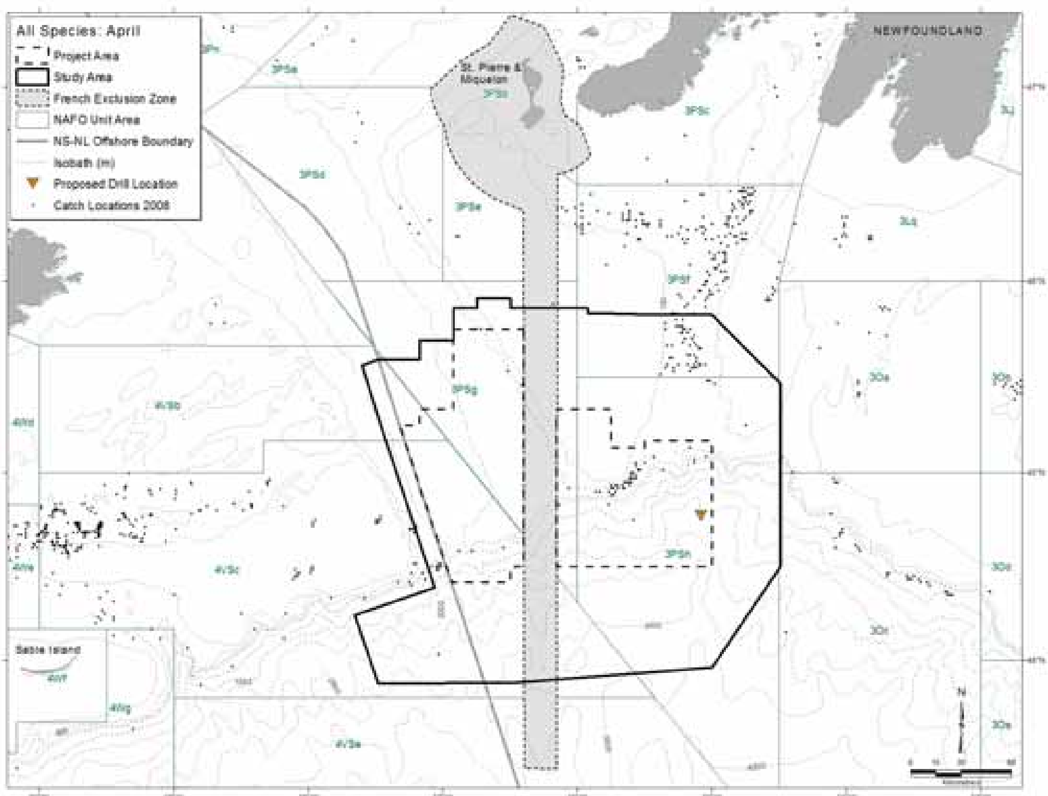

Figure 4.16. All Species Harvesting Locations, April 2008.

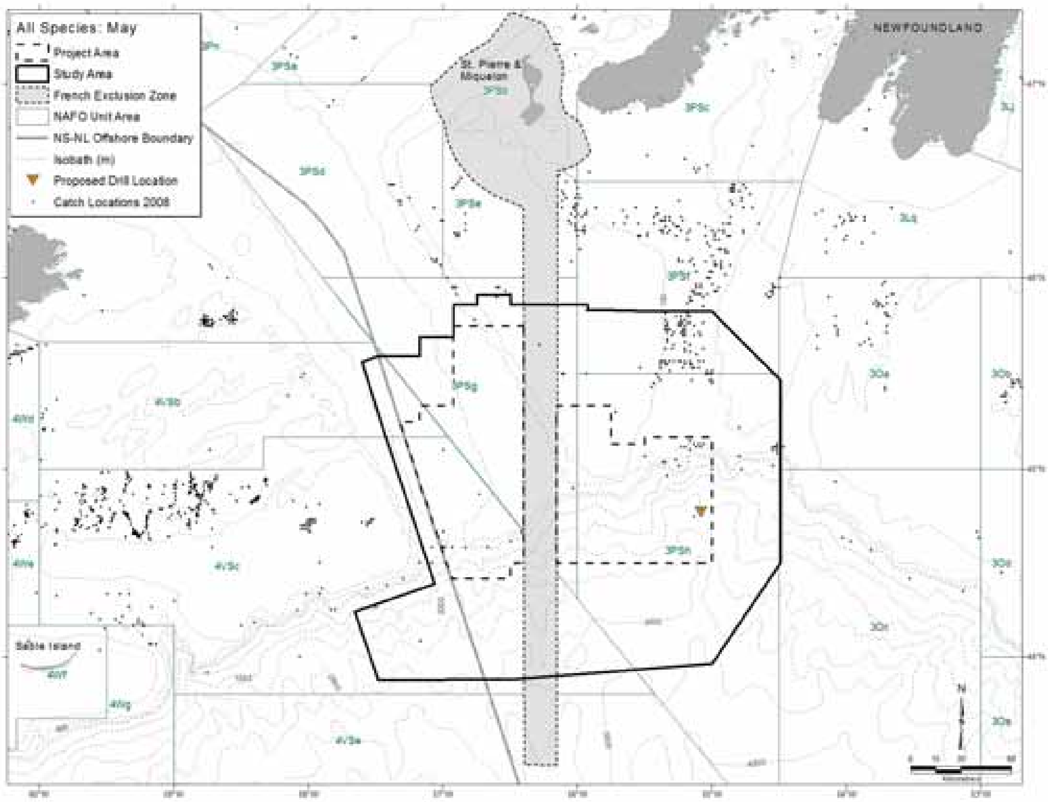

Figure 4.17. All Species Harvesting Locations, May 2008.

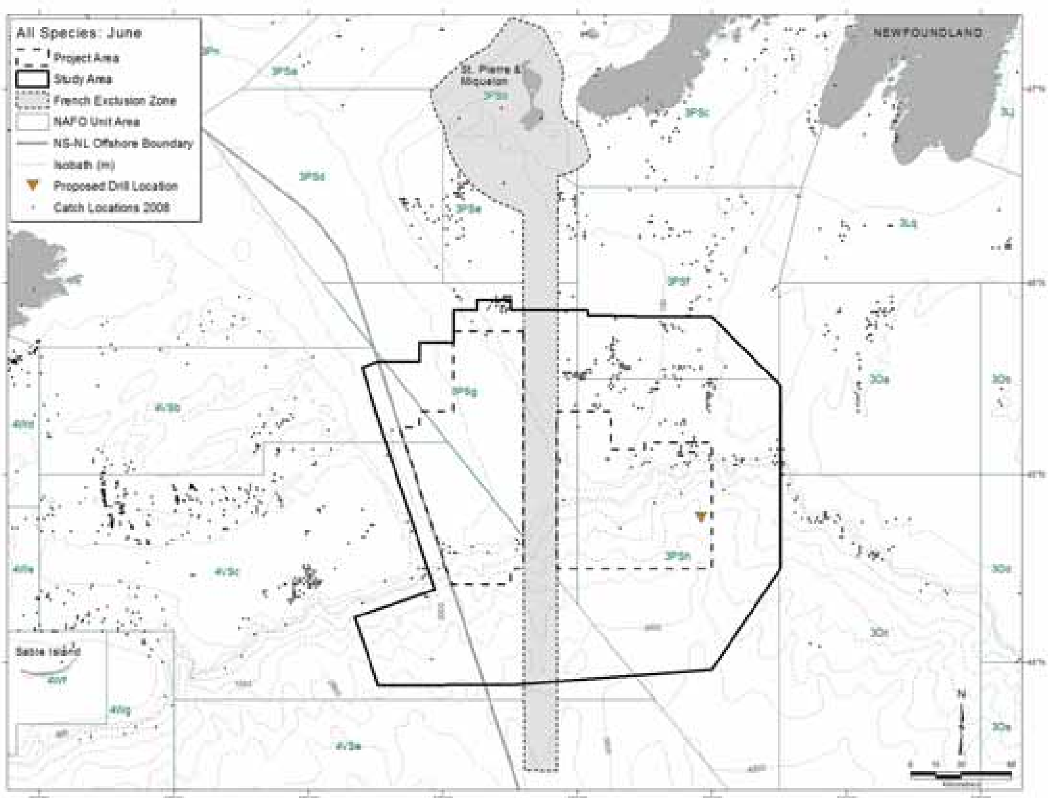

Figure 4.18. All Species Harvesting Locations, June 2008.

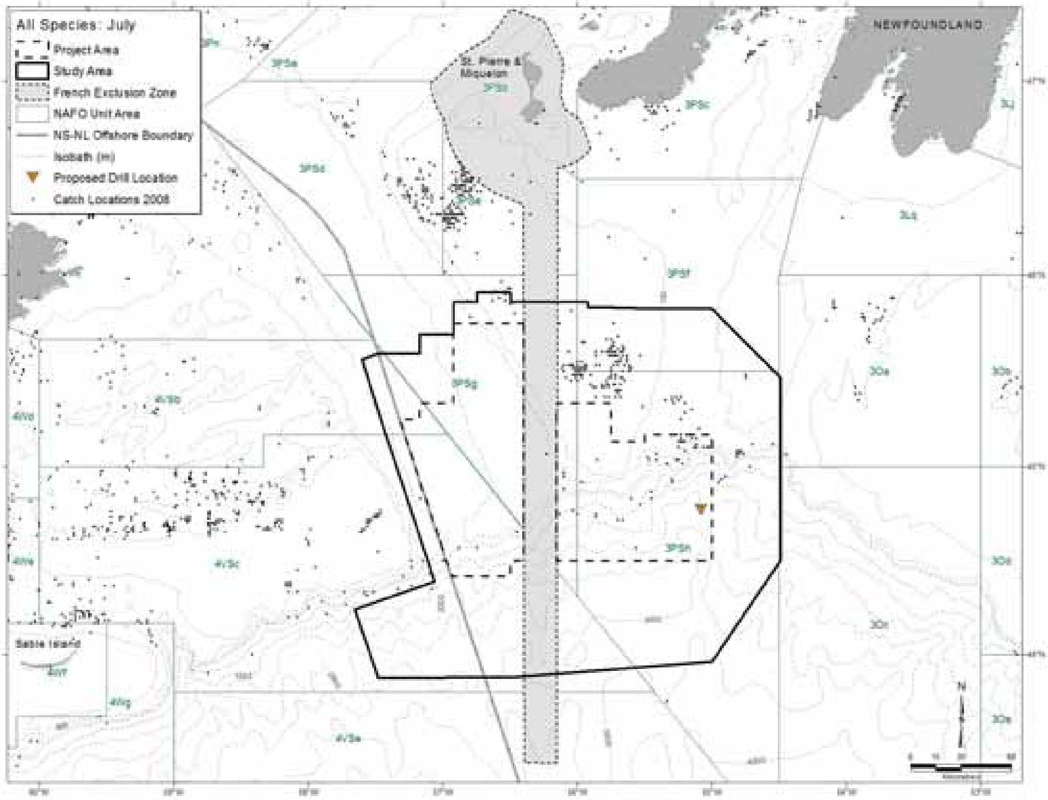

Figure 4.19. All Species Harvesting Locations, July 2008.

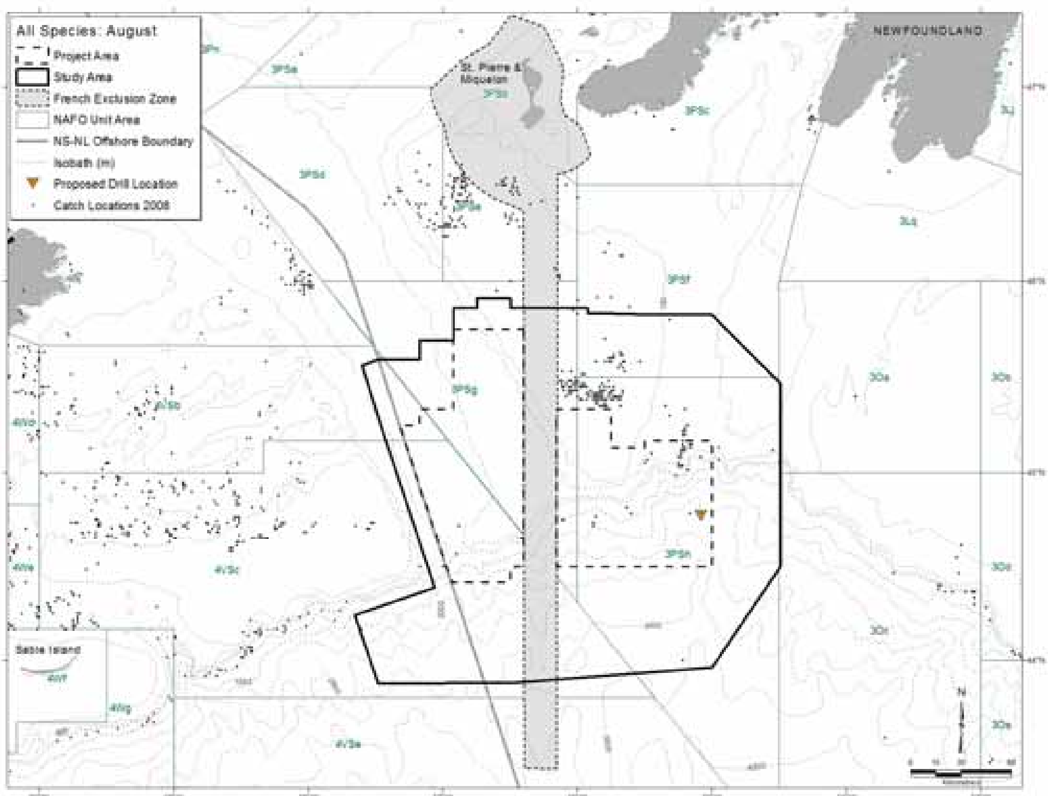

Figure 4.20. Species Harvesting Locations, August 2008.

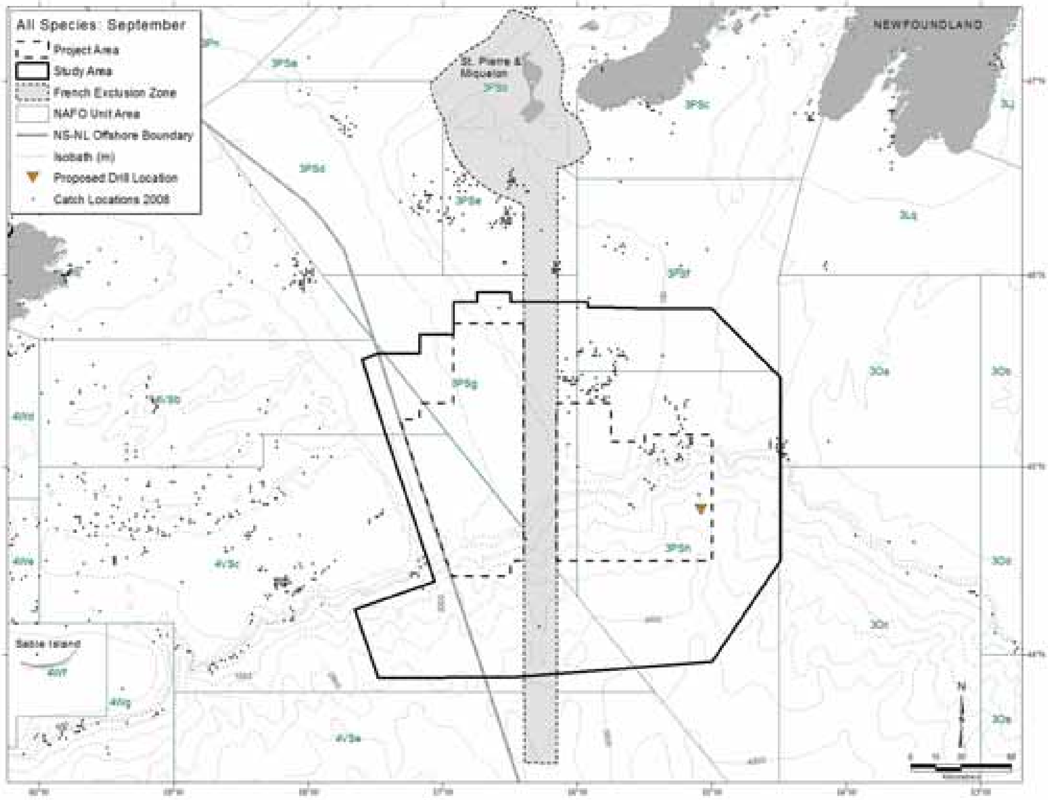

Figure 4.21. All Species Harvesting Locations, September 2008.

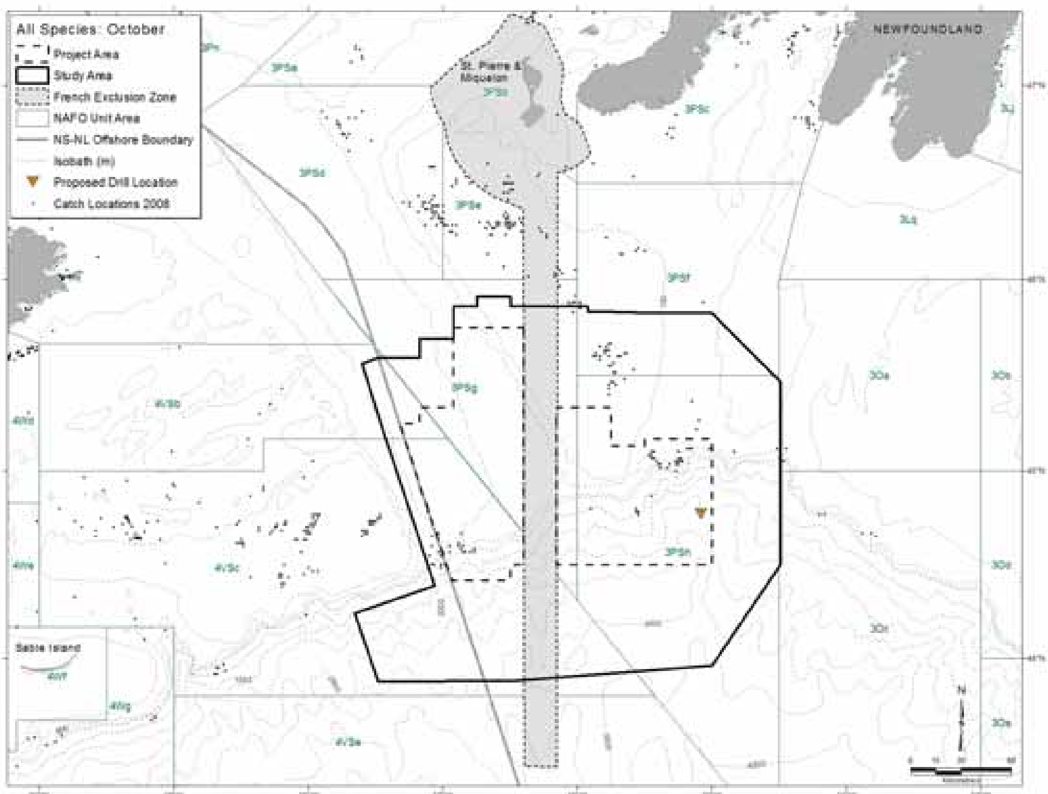

Figure 4.22. All Species Harvesting Locations, October 2008.

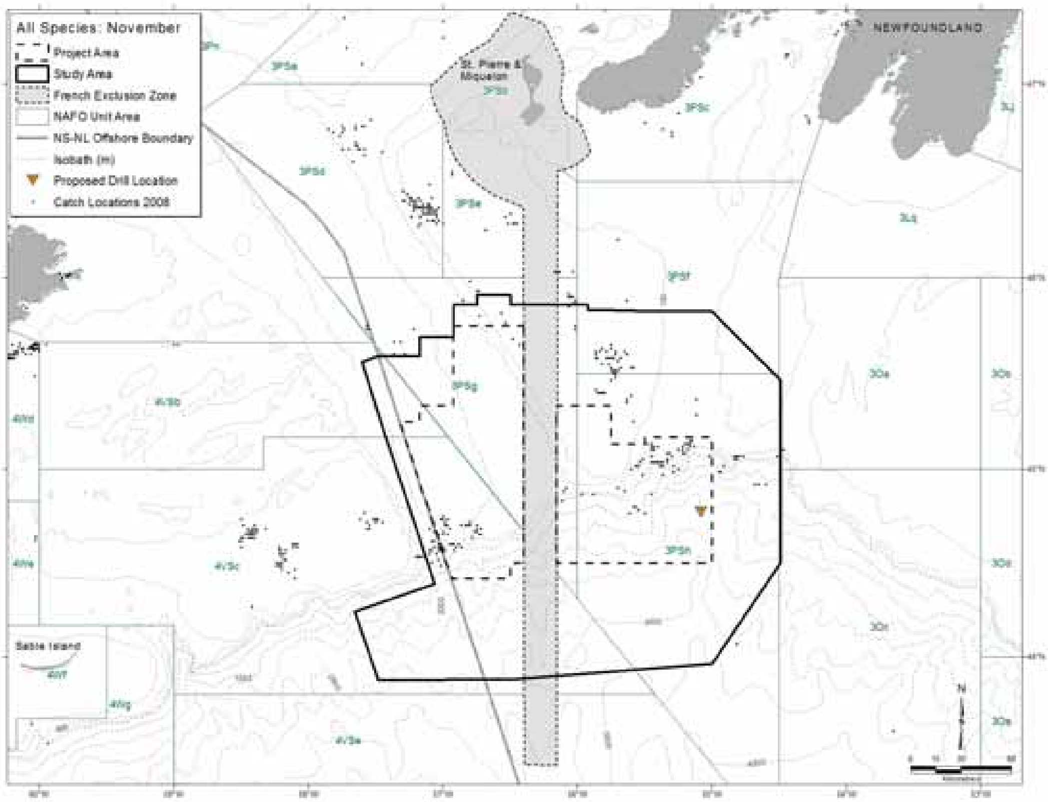

Figure 4.23. All Species Harvesting Locations, November 2008.

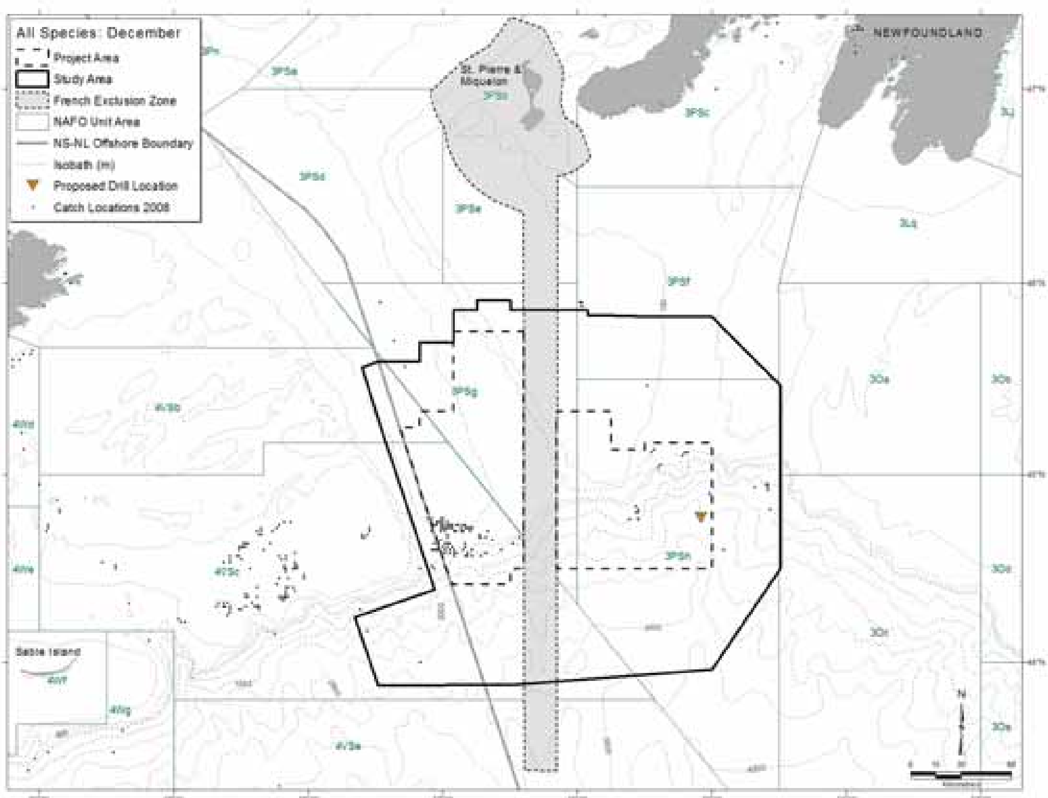

Figure 4.24. All Species Harvesting Locations, December 2008.

4.5.4.3 Principal Species

This section describes the principal groundfish and invertebrate fisheries that are expected to be active in the areas of interest over the next few years.

As described above, the groundfisheries within both the Study Area and the Project Area have composed the great majority of the catch by quantity for many years. The following maps (Figures 4.25 to 4.27) show the groundfishing locations (including skates) for the past three years. As these maps indicate, there is a high level of consistency in the preferred harvesting locations from year to year.

The following sections provide more detailed information on the groundfish species, such as redfish, Atlantic cod, white hake, pollock, skate, haddock, Atlantic halibut, and hagfish, harvested in the Study Area. Important invertebrate fisheries (whelk, snow crab, surf clams are further detailed in the following sections. In addition, highly valuable fisheries for large pelagics, namely swordfish, tunas, and sharks, are collectively described.

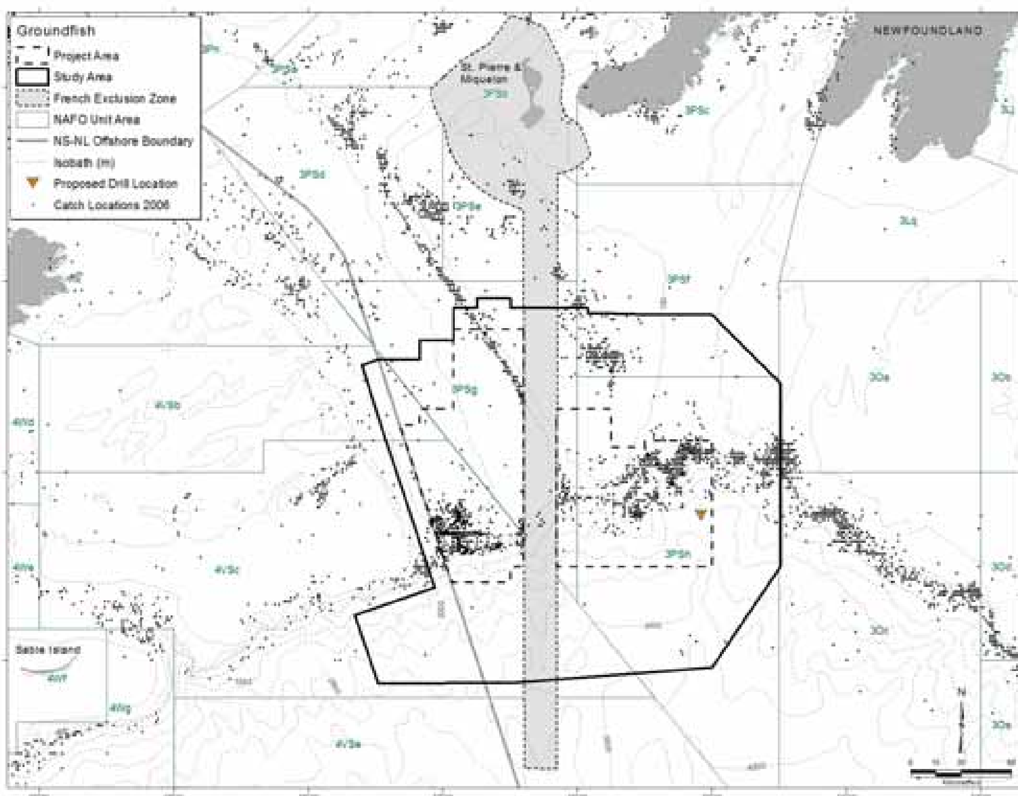

Figure 4.25. Groundfish Harvesting Locations 2006.

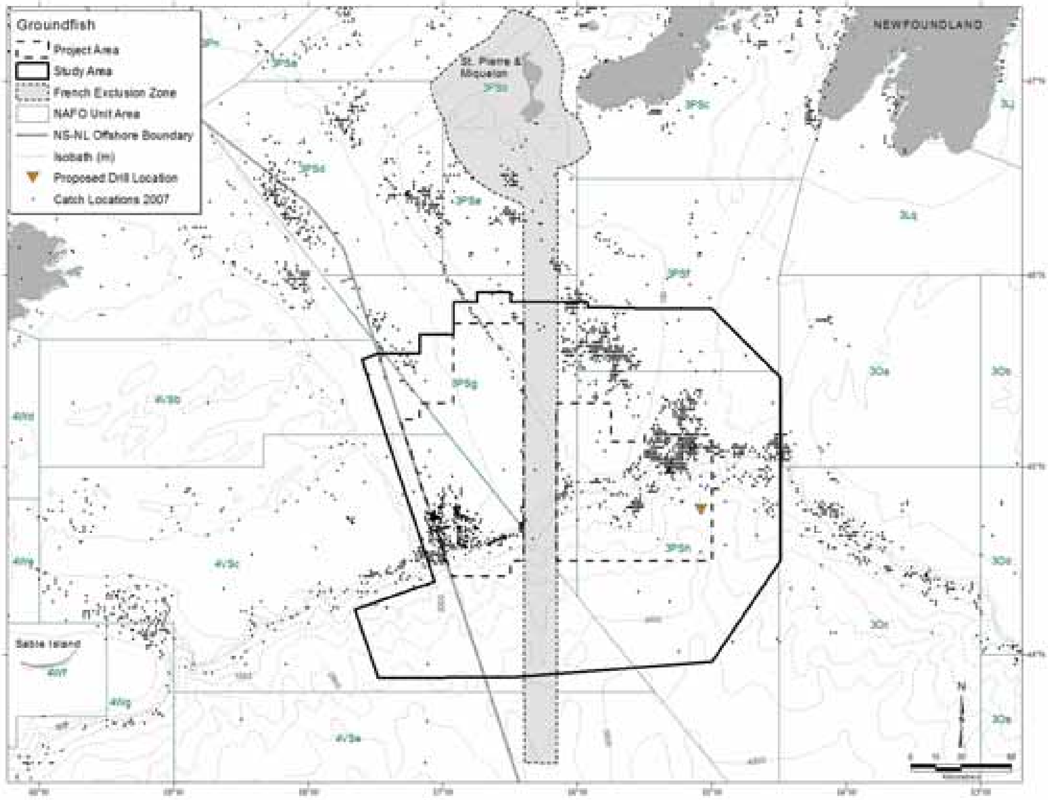

Figure 4.26. Groundfish Harvesting Locations 2007.

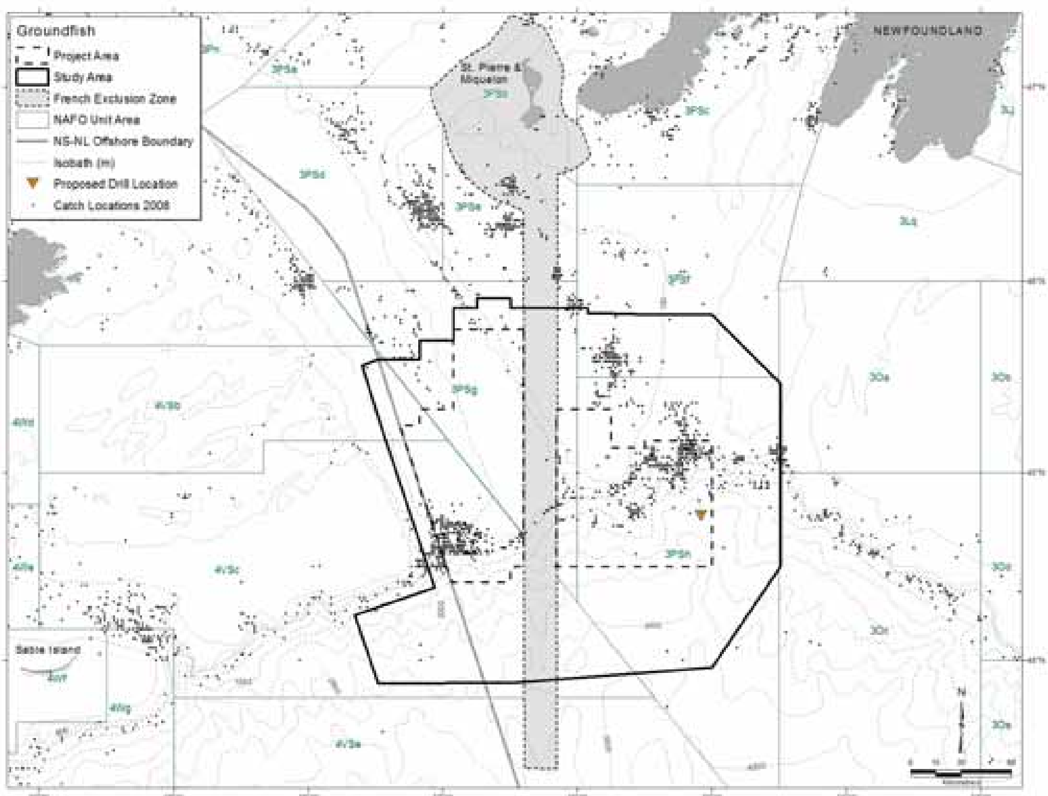

Figure 4.27. Groundfish Harvesting Locations 2008.

4.5.4.3.1. Redfish (spp.) (Ocean Perch)

Similar to previous years, the redfish fisheries were very important within the Study Area and Project Area during 2006-2008. In these years they made up 18% to 30% of the harvest during the year. Though the fishery involves three species of redfish (Acadian, golden and deepwater), they are harvested as one.

The following map (Figure 4.28) indicates the recorded harvesting locations during 2008. The season for this species is 1 July to 31 March. There is no directed fishery for this species during the spawning (pupping) period, 1 April to 30 June, which is reflected in Figure 4.29. From 2006-2008, the harvest within the Study Area was largely taken by bottom otter trawls (stern), with a smaller proportion harvested using Danish seine, gillnet, and longline.

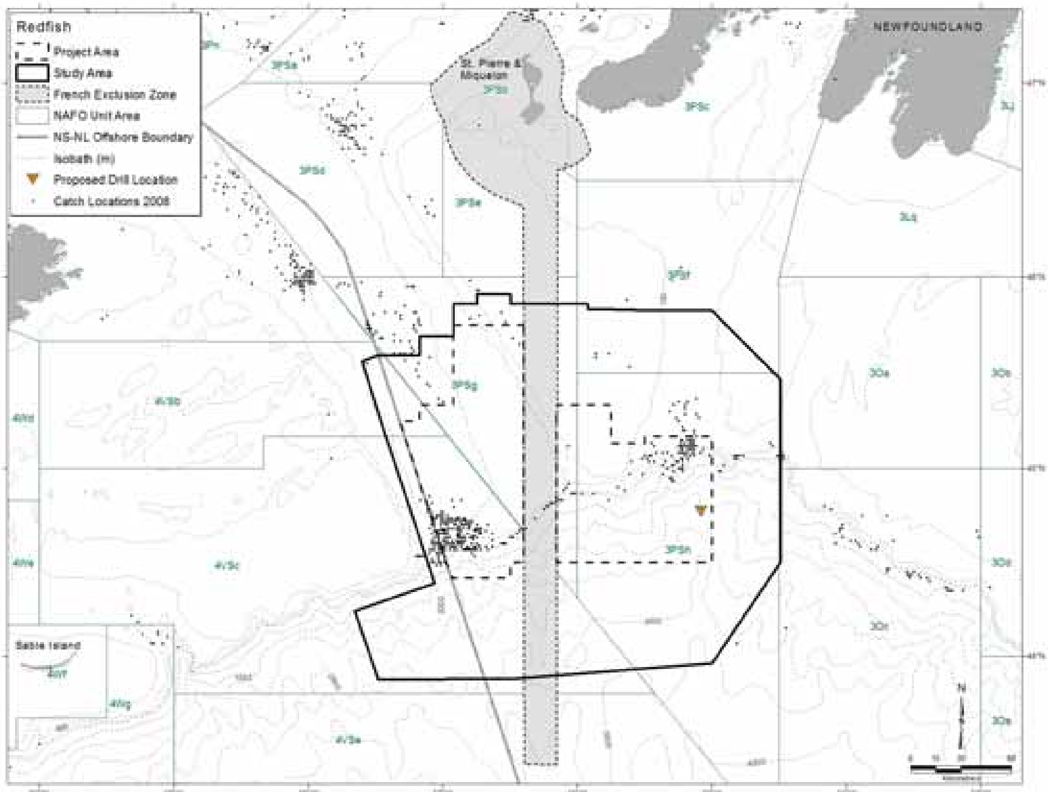

Figure 4.28. Redfish (spp.) Harvesting Locations, 2008.

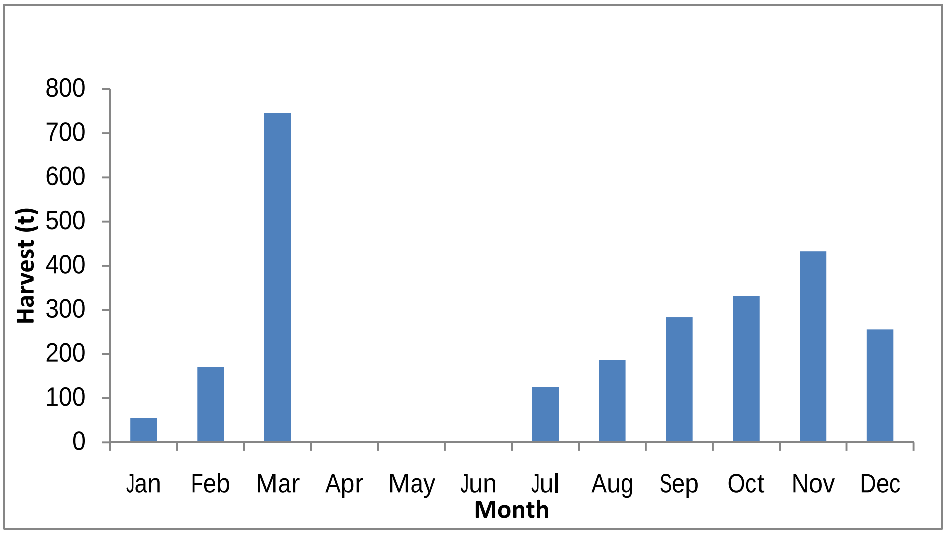

Figure 4.29. Study Area Redfish (spp.) Harvest by Month, 2006-2008 Average.

4.5.4.3.2. Atlantic Cod

Cod was again one of the main species harvested in the Study Area (Table 4.7), accounting for just over 23% of the total harvest by quantity during 2006-2008. It is also a major species within the 3Ps part of the Adjacent Unit Areas.

Table 4.7. 2009 3Ps Atlantic Cod Quotas and Harvesting by License Category to 1 June 2009.

License Category / Quota Definition	Quota (t)	Harvested (t)	% Harvested
Mobile Gear < 65', based in 3Ps	218	0	0
Mobile Gear < 65', based in 3KL (overlaps)	191	0	0
Mobile Gear < 65' based in 4R3PN (overlaps)	58	0	0
Fixed Gear <65', based in 3KL (overlaps)	304	0	0
Fixed Gear <65', based in 3KL (equivalents)	168	0	0
Fixed Gear <65', based in 3PN (Overlap)	168	6	4
Fixed Gear < 65', Area 9 Overlaps	141	0	0
Fixed Gear < 65', based in Branch / Point Lance	85	0	0
Fixed Gear <35', Placentia Bay - Area 10	2,663	701	26
Fixed Gear 35'-64', Placentia Bay - Area 10	1,010	102	10
Fixed Gear <35', Fortune Bay & West - Area 11	2,308	452	20
Fixed Gear 35'-64', Fortune Bay & West - Area 11	613	16	3
Sentinel Fishery	153	0	0
Fixed Gear 65'-100'	191	0	0
Mobile Gear 65'-100'	0	4	undefined
Vessels >100'	1,408	19	1
Total 3Ps	9,679	104	1

Source: DFO Quota Reports accessed 8 July 2009 (http://nfl02.nfl.dfo-mpo.gc.ca/publications/reports_rapports/cod_2009_clf2.htm).

At present, within the Study Area, a directed fishery for cod is permitted in the 3Ps portion only (DFO 2009a). Within 4Vs, the cod fishery has been closed to directed commercial fishing since 1993 (DFO 2003a) though cod catches do occur as bycatch or during the Sentinel program. In some years, cod catches in 4Vs in January to April are attributed to the Southern Gulf of St. Lawrence Stock (DFO 2009b).

The quota year for 3Ps cod is from 1 April to 31 March of the following year, but the fishery is closed during March because it is the spawning season. Table 4.7 shows how the 2009 quota for 3Ps is distributed over the various license categories in Newfoundland and Labrador Region.

Figure 4.30 maps the locations of cod fishing activity (georeferenced dataset) for 2008. As the maps show, the harvest was focused within 3Ps on and near the shelf edge and St. Pierre Bank.

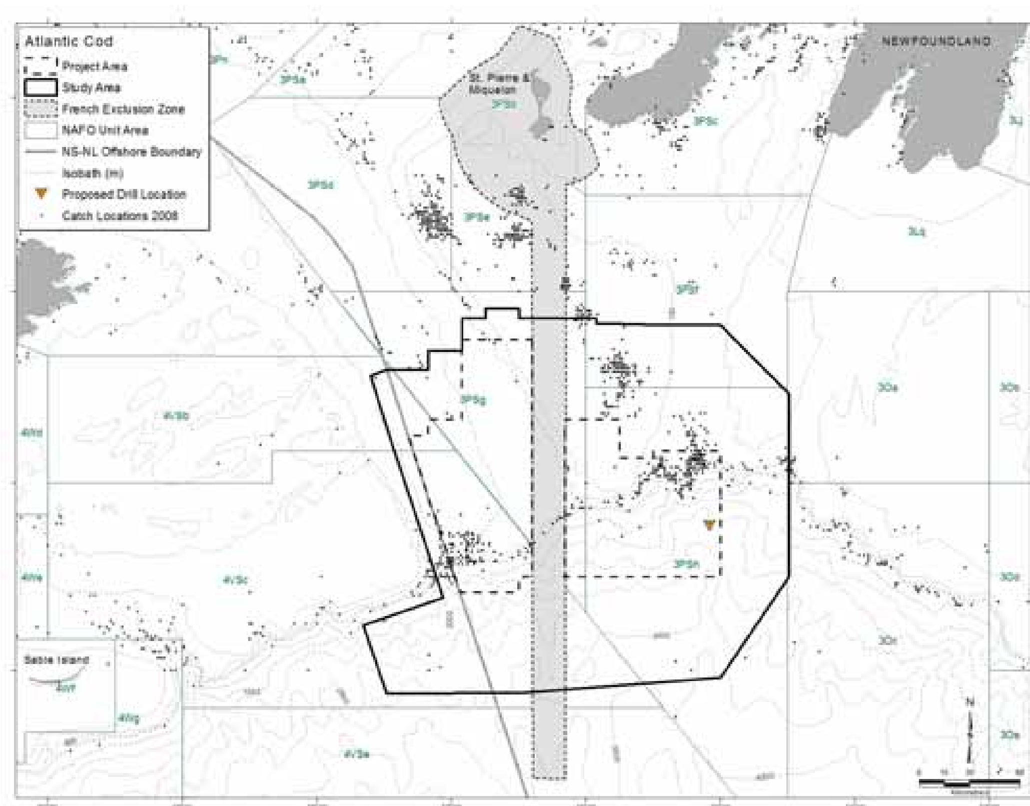

Figure 4.30. Atlantic Cod Harvesting Locations, 2008.

The timing of the fishery in the Study Area was fairly consistent during 2006-2008, with relatively little harvesting occurring after February until late summer and fall (Figure 4.31).

The cod harvest is taken primarily by fixed gear in the Study Area (60% over the past three years combined). Roughly 33% and 27% of the harvest was caught with gillnet and longline while <1% was captured using pot. The remainder (40%) was harvested with mobile bottom otter trawl.

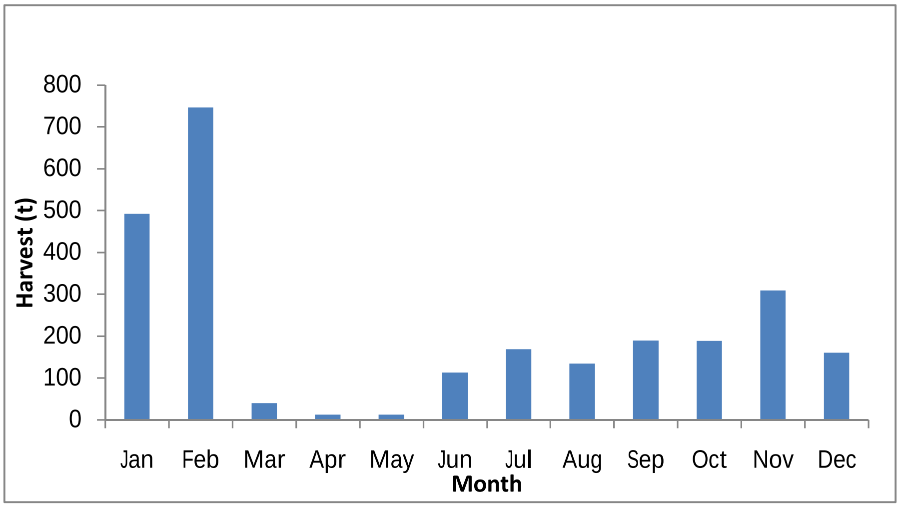

Figure 4.31. Study Area Atlantic Cod Harvest by Month, 2006-2008 Average.

4.5.4.3.3. Whelk

Whelk is becoming an increasingly important harvest species within the Study Area. From 2006-2008, annual whelk catches increased from roughly 9.5% to 26.2% of the overall catch. In fact, whelk surpassed redfish as the species with the highest catch in 2008 for the Study Area. Largely confined to areas on St. Pierre Bank outside of the Project Area, whelk harvest locations are depicted in Figure 4.32 for 2008. Figure 4.33 shows that whelk is predominately harvested between May and October. Whelk was solely harvested using pots.

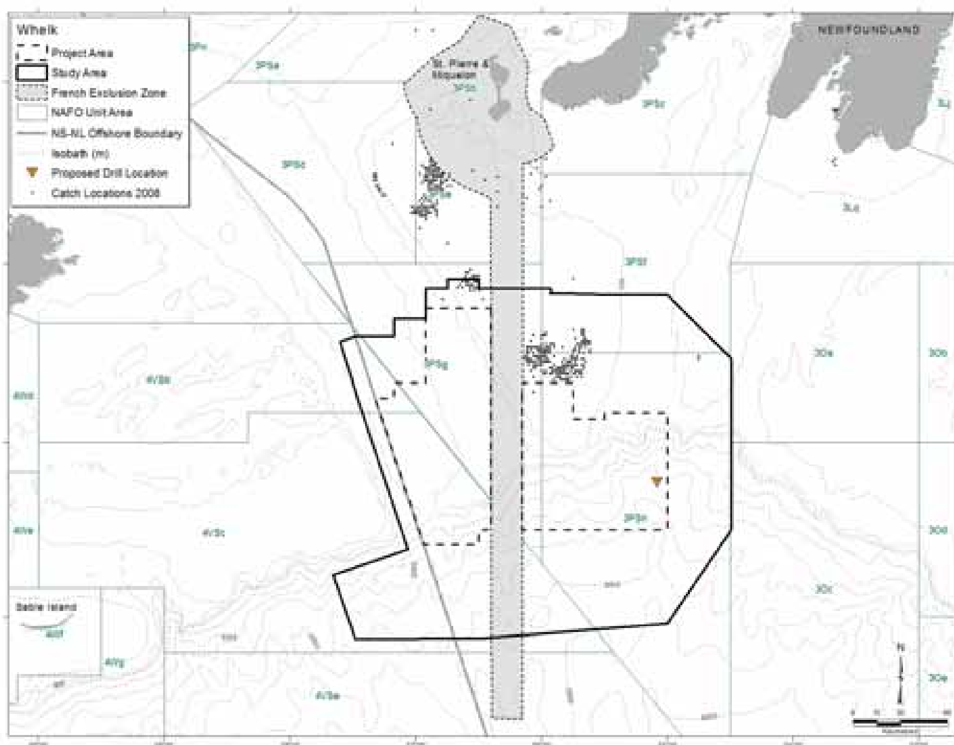

Figure 4.32. Whelk Harvesting Locations 2008.

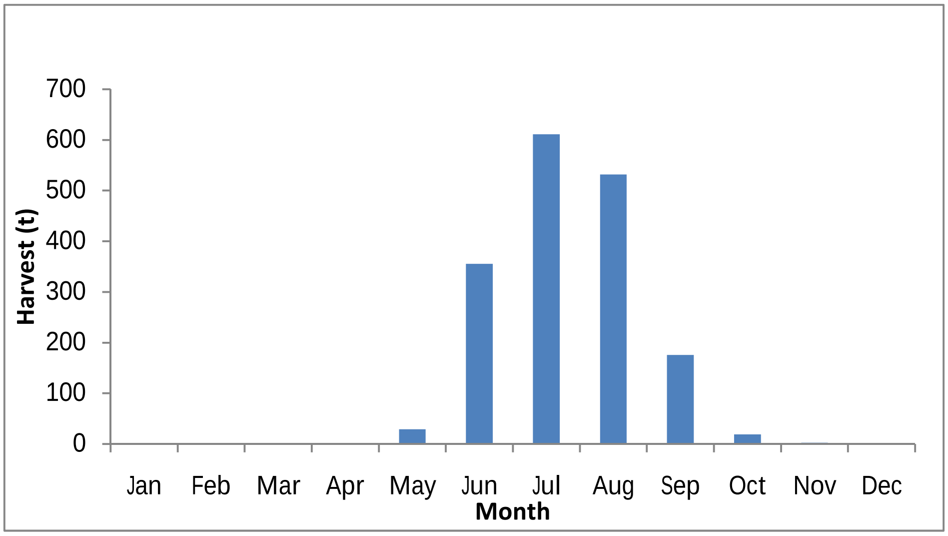

Figure 4.33. Study Area Whelk Harvest by Month, 2006-2008 Average.

4.5.4.3.4. White Hake

During the 2006-2008 period, white hake made up approximately 5% of the Study Area harvest. Figure 4.34 displays the recorded white hake harvesting locations in 2008. Figure 4.35 shows the timing of the harvest for the past three years. On the Scotian Shelf and adjacent waters, white hake is caught as a by-catch in the longline, gillnet and otter trawl fisheries targeting other species such as halibut, redfish, cod, pollock, and other groundfish (Bundy and Simon 2005). In Newfoundland waters, landings occur both as bycatch and from a directed fishery. On the Grand Banks, white hake is not regulated by quotas, but its relatively low market value, and closures because of high by-catch of other species, limit the directed effort inside the 200 mile EEZ. Beyond the EEZ, there are no constraints and the fishery appears to be increasing there (DFO 2003b). In the Study Area, the white hake harvest was predominately taken with fixed gear, such as gillnet (59%) and longline (38%), in the Study Area from 2006-2008. A small extent was harvested with bottom stern otter trawl (~3%).

4.5.4.3.5. Snow Crab

Snow crab accounted for approximately 9.5% of the overall harvest in the Study Area during 2006-2008. Figure 4.36 shows the georeferenced snow crab harvesting areas within the Study Area during 2008. Very little harvesting occurred in the Project Area.

Table 4.8 shows the 2009 snow crab quotas for the Study Area and adjacent licenses (3Ps), and also indicates when the harvest closed in 2009.

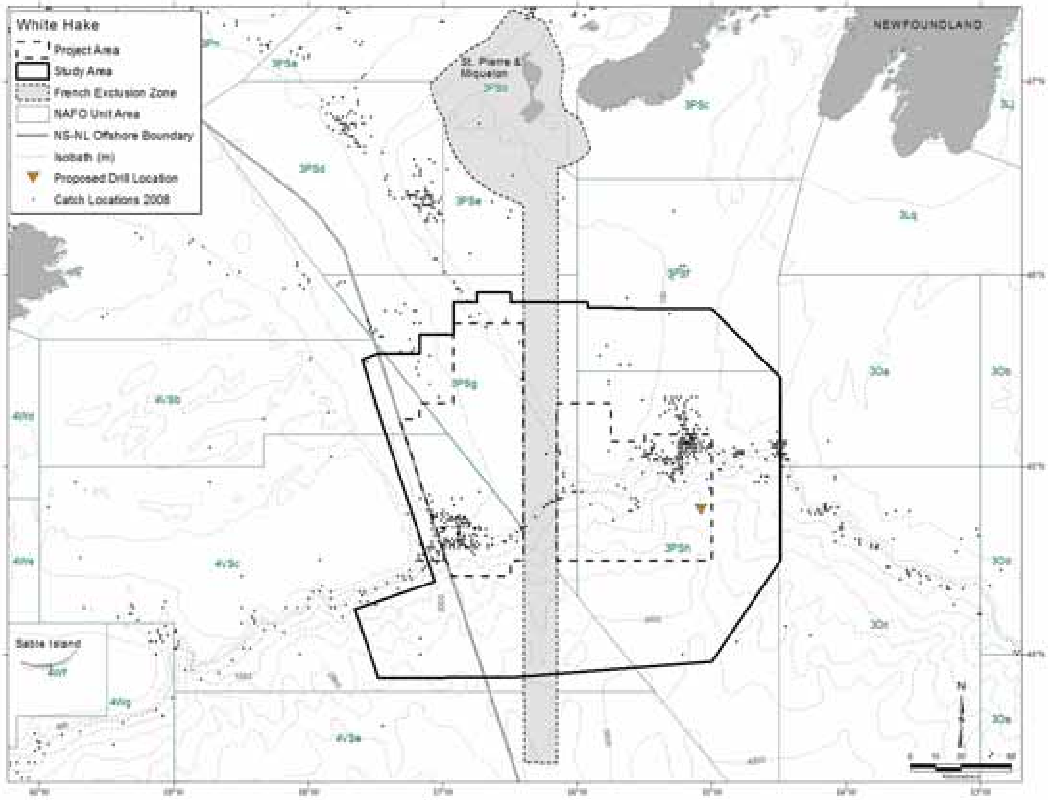

Figure 4.34. White Hake Harvesting Locations, 2008.

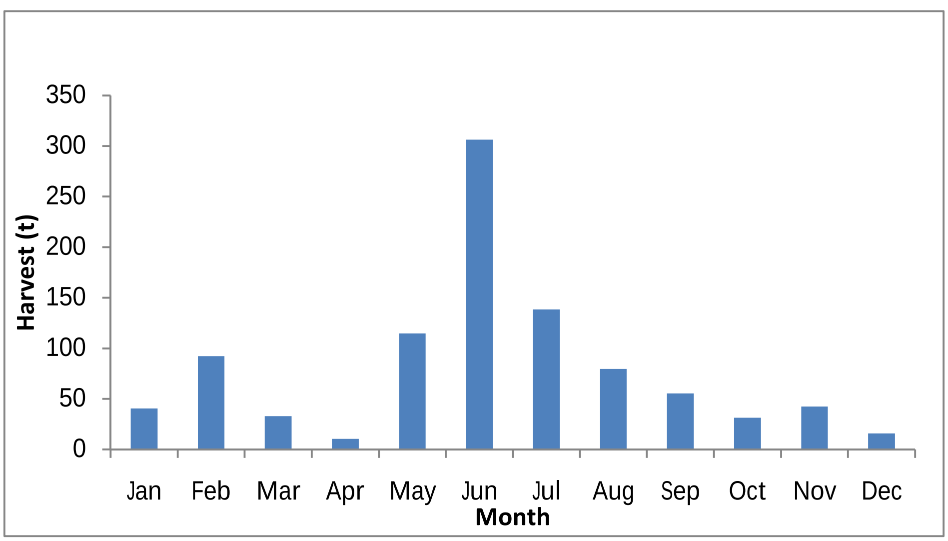

Figure 4.35. Study Area White Hake Harvest by Month, 2006-2008 Average.

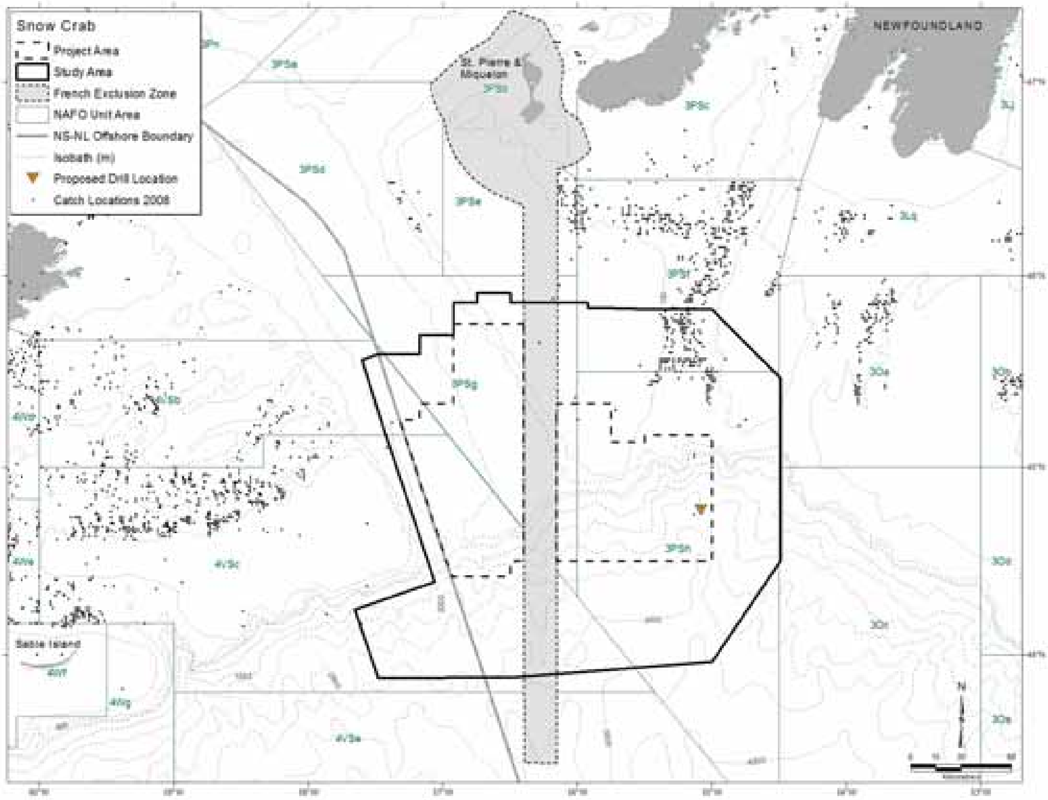

Figure 4.36. Snow Crab Harvesting Locations 2008.

Table 4.8. 2009 3Ps Snow Crab Quotas.

License Category / Quota Definition	Quota	Taken (t)	% Taken	Date Closed
Supplementary				
CFA 10 Between 46'30"N to 45'35"N (10BCD)	2,900	2,940	101	June 20, 2009
CFA 10 Exploratory South of 45'35"N (10X)	520	478	92	June 20, 2009
CFA 11 South of 46'30" N (11S)	210	63	30	June 20, 2009
Total	3,630	3,482	96	
Inshore				
CFA 10 North of 46'30"N (10A)	652	476	73	June 25, 2009
CFA 10 North of 46'30"N Outside 12 miles (10A)	848	1,212	143	June 25, 2009
CFA 11 East of Western Head < 35' (11E)	0	218	0	June 15, 2009
CFA 11 South of 46'30"N > 35' (11S)	50	57	113	June 30, 2009
CFA 11 S. of 46'30N/W.of 56'30W >35' Exp 11SX	100	78	78	June 20, 2009
CFA 11 West of Western Head Hare Bay (11W)	0	37	0	May 31, 2009
Total	1,650	2,078	126	

Source: DFO Quota Reports accessed 8 July 2009 (http://nfl02.nfl.dfo-mpo.gc.ca/publications/reports_rapports/cod_ 2009_clf2.htm).

As Figure 4.37 indicates, the snow crab fishery in the Study Area has occurred predominantly in the April to June period for the last three years. The snow crab fishery uses fixed gear crab pots.

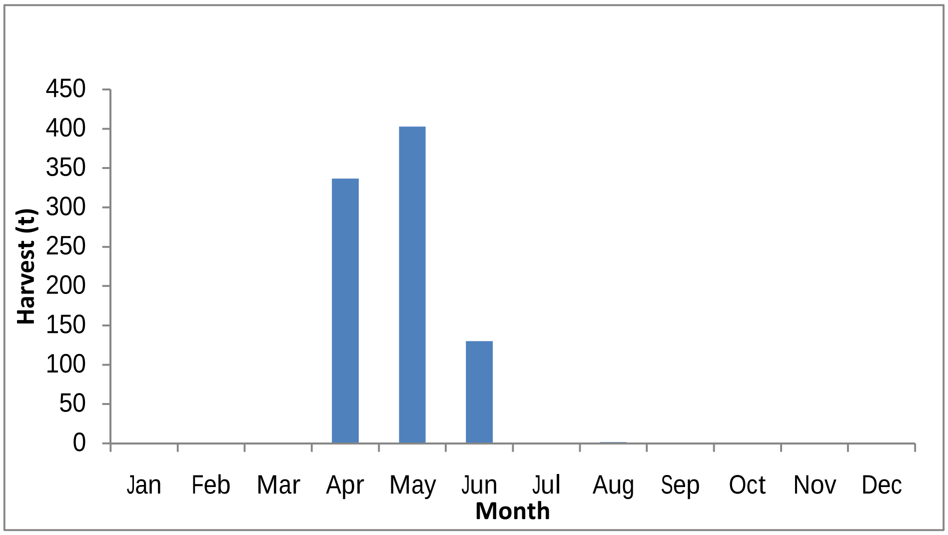

Figure 4.37. Study Area Snow Crab Harvest by Month, 2006-2008 Average.

4.5.4.3.6. Pollock

A significant directed fishery for pollock occurs on the Scotian Shelf using primarily otter trawl and gillnets, but also handlines and longline. Pollock are also caught in the small-mesh redfish fishery in Nova Scotian waters (DFO 2009c). The pollock fishery in 3Ps has generally been a bycatch fishery with large catches being taken in the otter trawl, gillnet and trap fisheries for cod (DFO 2005).

Pollock accounted for roughly 4% of the overall harvest in the Study Area from 2006-2008. The georeferenced pollock harvesting locations in 2008 are depicted in Figure 4.38. Figure 4.39 shows that the timing of the harvest has generally occurred from June through October for the past three years. In the Study Area, pollock were largely harvested with gillnet (93%). Relatively smaller catches were made using bottom stern otter trawl (5%), longline (1%), and pot (<1%).

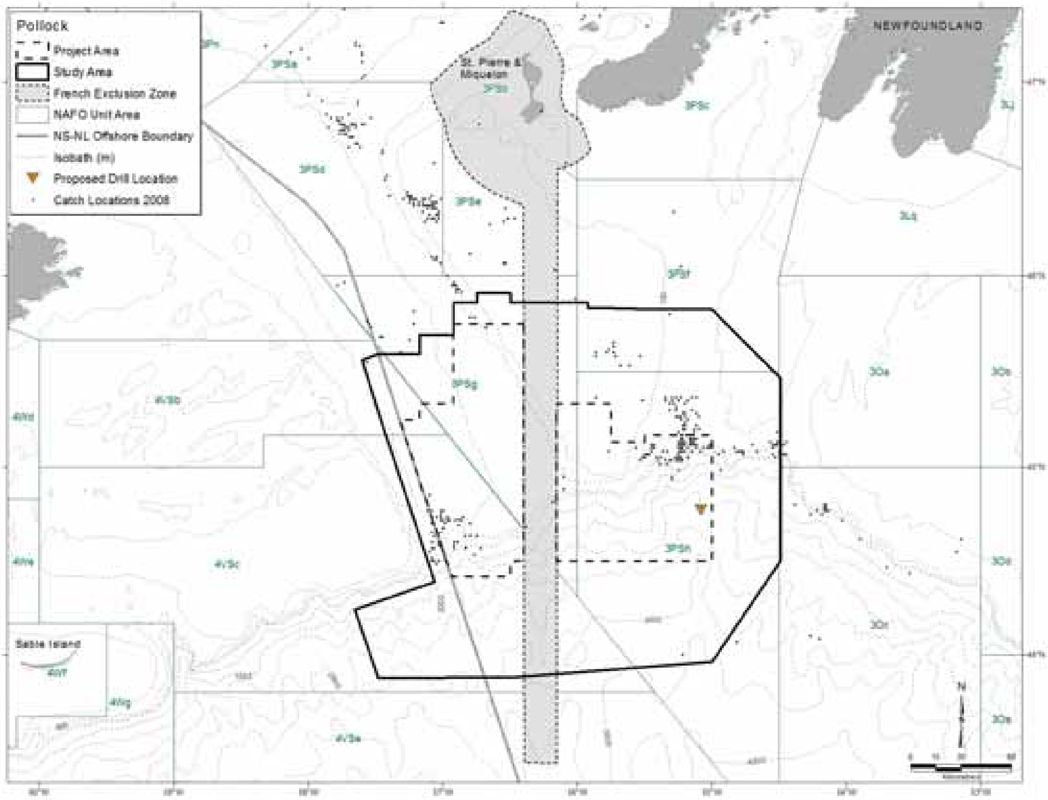

Figure 4.38. Pollock Harvesting Locations, 2008.

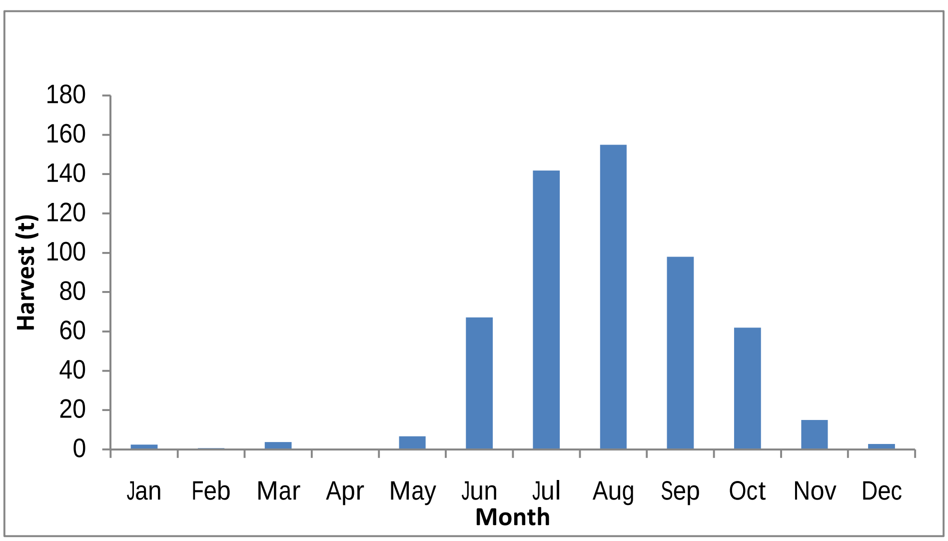

Figure 4.39. Study Area Pollock Harvest by Month, 2006-2008 Average.

4.5.4.3.7. Skates (spp.)

Thirteen species of skate are found in Atlantic Canadian waters, but of these the thorny skate (*R. radiata*) is the most common, comprising about 80% of the skate harvested in commercial offshore catches on the Grand Banks and the Northeastern Shelf from 1981–1994, and 90% of the skates caught in groundfish research surveys from 1951-1994 (Kulka and Mowbray 1999; Kulka et al. 1996). During 20062008, skates made up nearly 4% of the Study Area harvest.

Figure 4.40 indicates the recorded skate harvesting locations for 2008. As Figure 4.41 indicates, the great majority of the skate harvest has occurred between March and August over the past three years in the Study Area. Within the Study Area, the skate harvest has largely taken by bottom stern otter trawl gear (46% of the catch weight over the last three years combined), followed by gillnet (38%), and longline (15%).

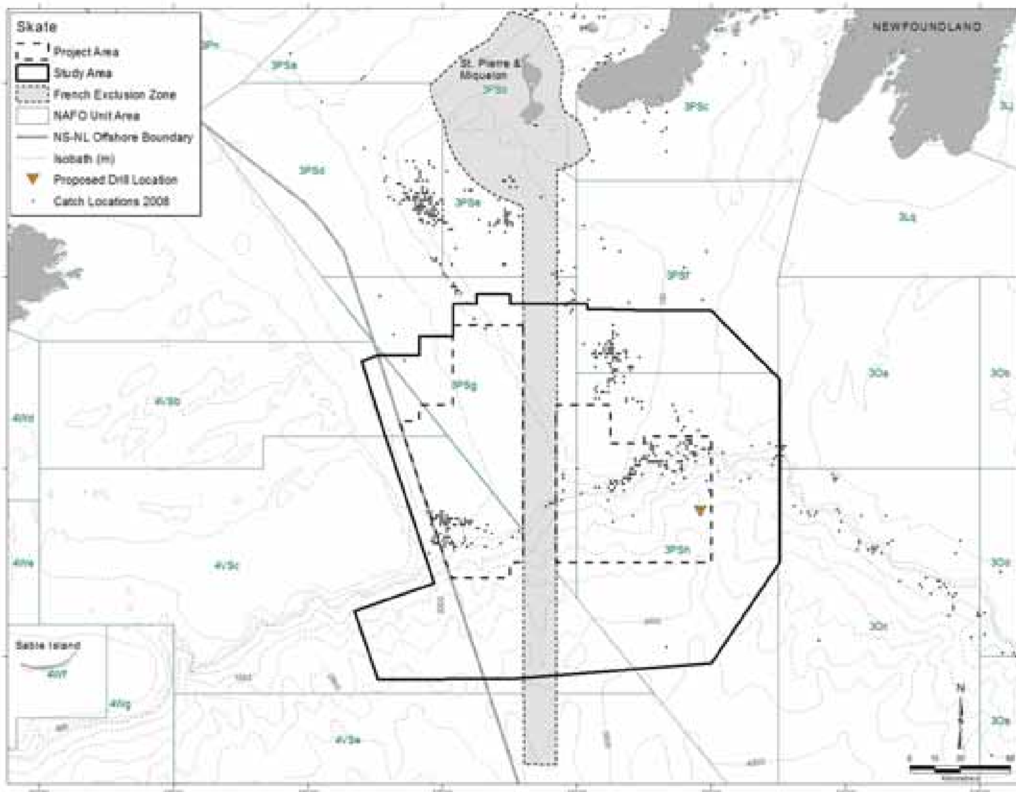

Figure 4.40. Skate (spp.) Harvesting Locations, 2008.

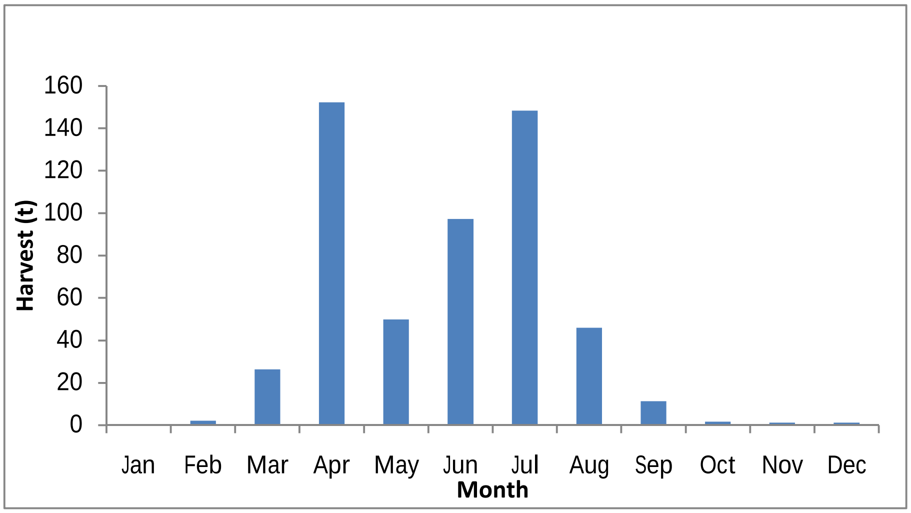

Figure 4.41. Study Area Skate (spp.) Harvest by Month, 2006-2008 Average.

4.5.4.3.8. Haddock

Roughly 2% of the overall harvest in the Study Area from 2006-2008 was for haddock. The haddock harvesting locations in 2008 are depicted in Figure 4.42. Figure 4.43 shows that the timing of the harvest for the past three years. Haddock harvesting occurs year-round with the lowest catches occurring from March through May. From 2006-2008, haddock were largely caught with gillnet (65%) and bottom stern otter trawl (26%). Lesser amounts were harvested using longline (9%) and pot (<1%).

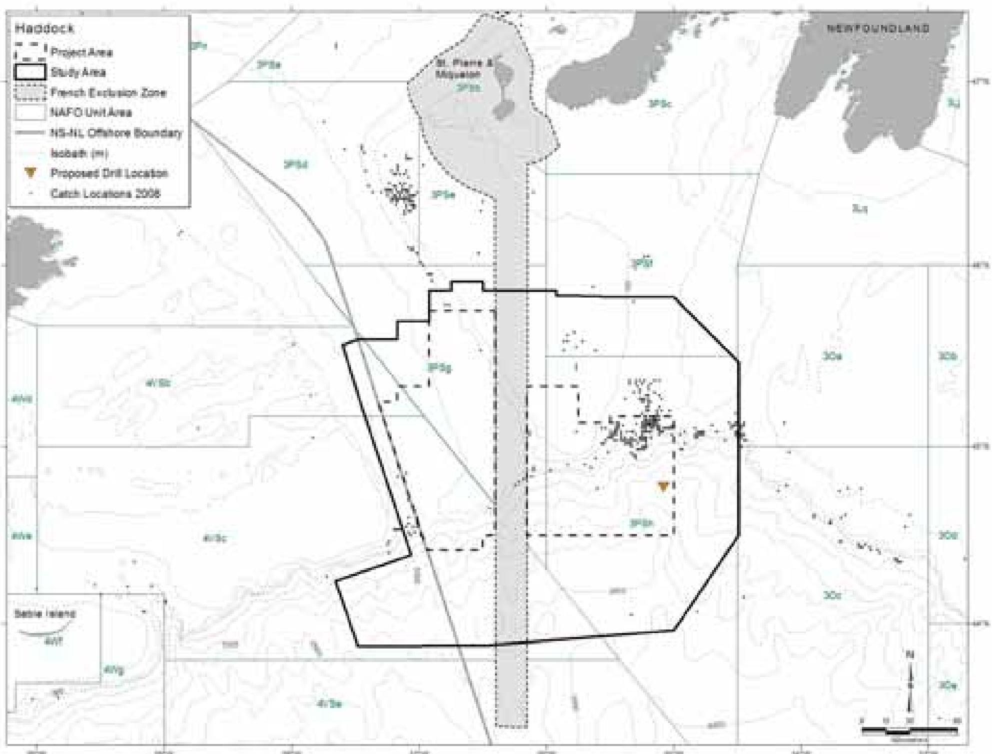

Figure 4.42. Haddock Harvesting Locations, 2008.

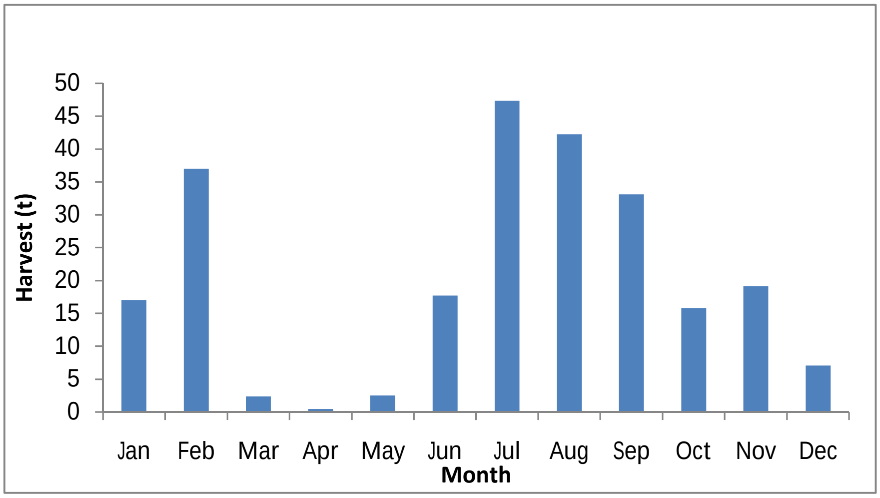

Figure 4.43. Study Area Haddock Harvest by Month, 2006-2008 Average.

4.5.4.3.9. Atlantic Halibut

The harvest of Atlantic halibut makes up a relatively small proportion of the overall Study Area catch (1.8% for 2006-2008). However, it is a high-value fishery. The Atlantic halibut harvesting locations in 2008 are depicted in Figure 4.44 while Figure 4.45 shows that the timing of the harvest for the past three years. From 2006-2008, Atlantic halibut were predominately harvested with longline (85%) within the Study Area. Gillnet (9%), bottom stern otter trawl (7%) and pot (<1%) accounted for the remainder of the catch during that time period.

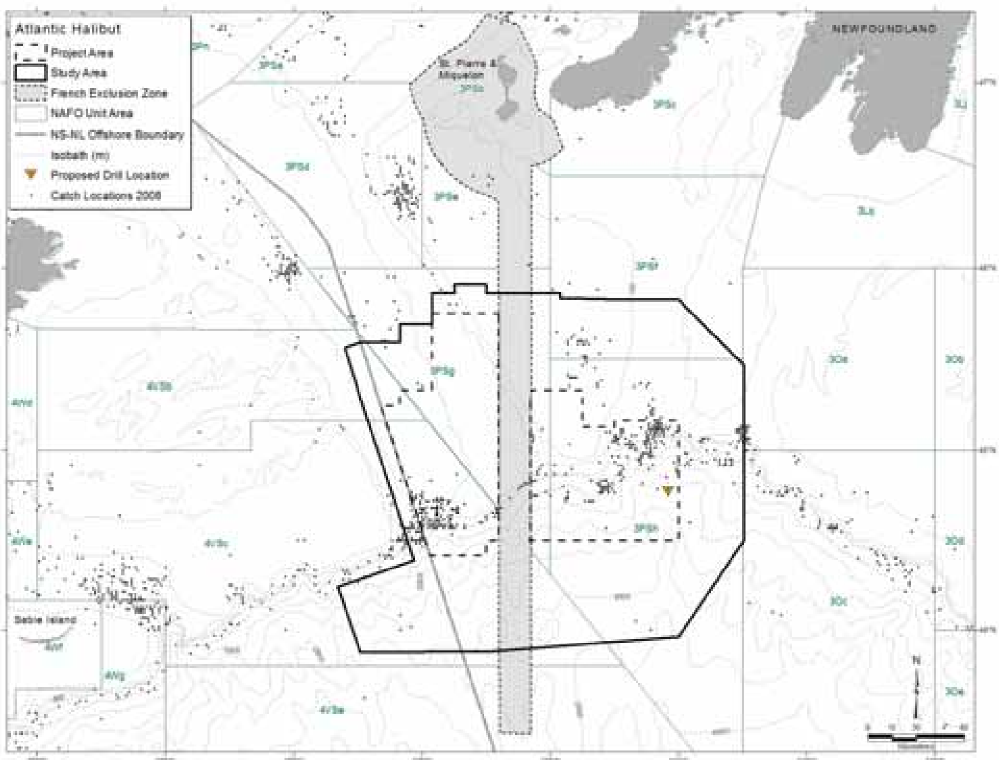

Figure 4.44. Atlantic Halibut Harvesting Locations, 2008.

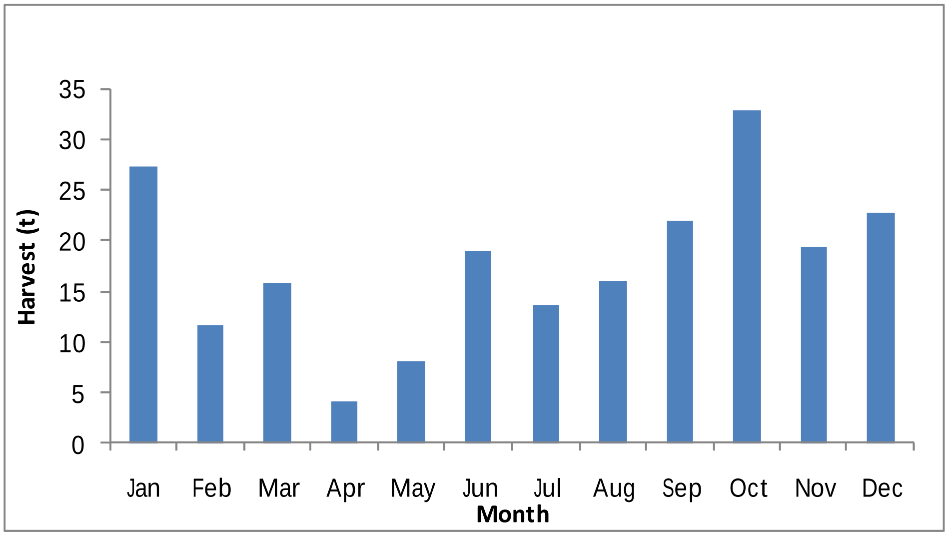

Figure 4.45. Study Area Halibut Harvest by Month, 2006-2008 Average.

4.5.4.3.10. Hagfish

The Atlantic hagfish fishery is an emerging fishery in the waters of Nova Scotia and Newfoundland. There has been a directed fishery for hagfish off Nova Scotia since the late 1980s and at present there are seven fishers authorized to harvest hagfish in the Scotia-Fundy portion of Nova Scotia. Of these fishers, two were granted permanent commercial access in 1997, four remain at the exploratory stage, and one received experimental access in 2005. Interest in the hagfish fishery in the Newfoundland and Labrador Region began with exploratory fishing in NAFO Subdivision 3Pn, which has occurred off and on since 1996. In 2005, a five year exploratory fishery was established on St. Pierre Bank in a study area that encompasses six 10 minute x 10 minute blocks and a single 10 minute x 4 minute block. Annual provisional fishery allocations of 181,440 kg were granted for the study area to monitor the influence of the fishery on the resource. The annual allocation is harvested by a single enterprise from September to December (DFO 2009d).

The Study Area harvest of hagfish accounted for approximately 1.8% of the overall catch from 2006-2008. Figure 4.46 shows the harvest locations for 2008 while Figure 4.47 shows that the harvest has largely occurred from August to November during the last three years. Within the Study Area, hagfish were solely harvested with hagfish barrels (a 227 L barrel trap with 14.3 mm escape holes).

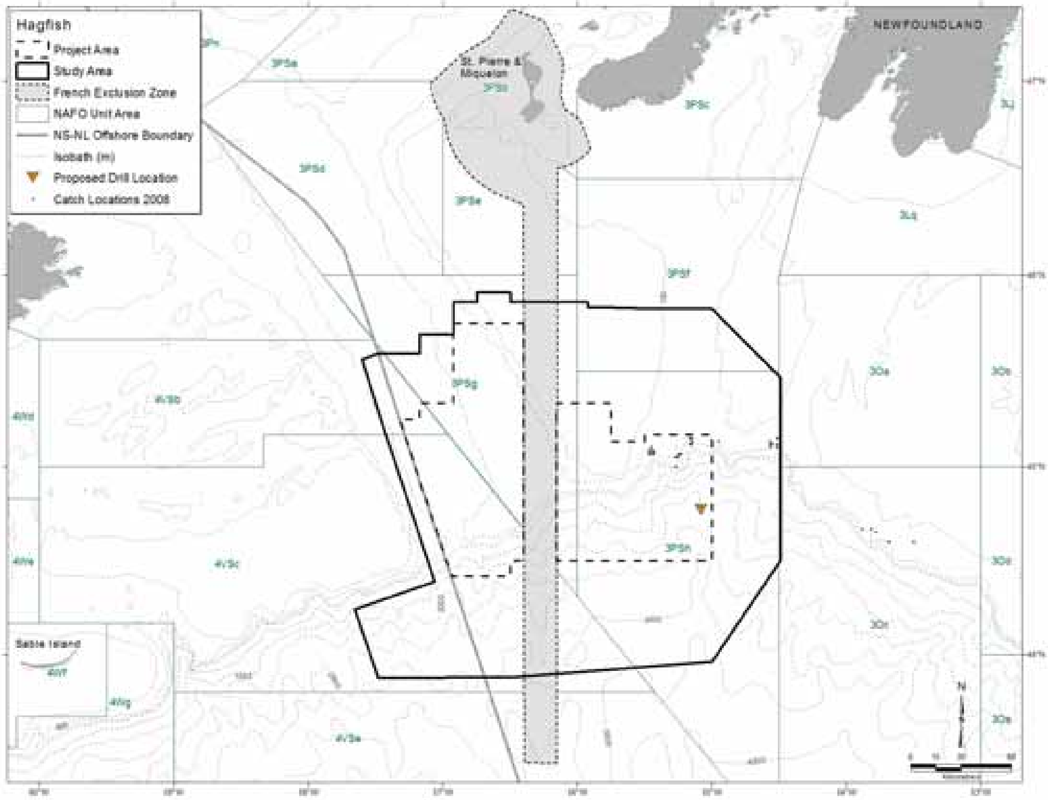

Figure 4.46. Hagfish Harvesting Locations 2008.

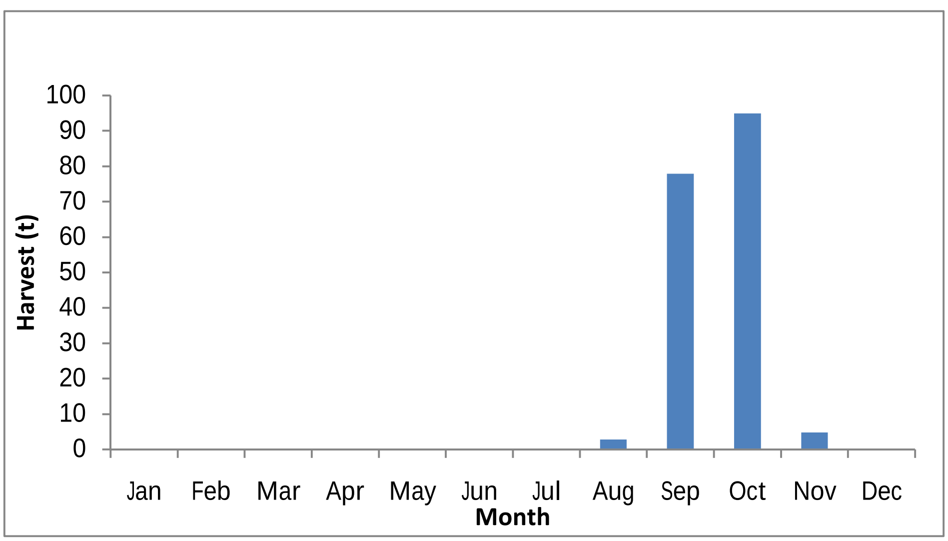

Figure 4.47. Study Area Hagfish Harvest by Month, 2006-2008 Average.

4.5.4.3.11. Stimpson's Surf Clams

Stimpson's surf clam accounted for roughly 1.3% of the overall harvest in the Study Area from 2006-2008 with the majority of this harvest (438t) taken in 2008. As shown in Figure 4.48, the majority of the georeferenced surf clam harvest occurs in Unit Area 4Vsc and to the west of the west of the Study Area.

Figure 4.49 shows that surf clam harvesting in the Study Area is sporadic. The surf clam was solely harvested with dredge within the Study Area from 2006-2008.

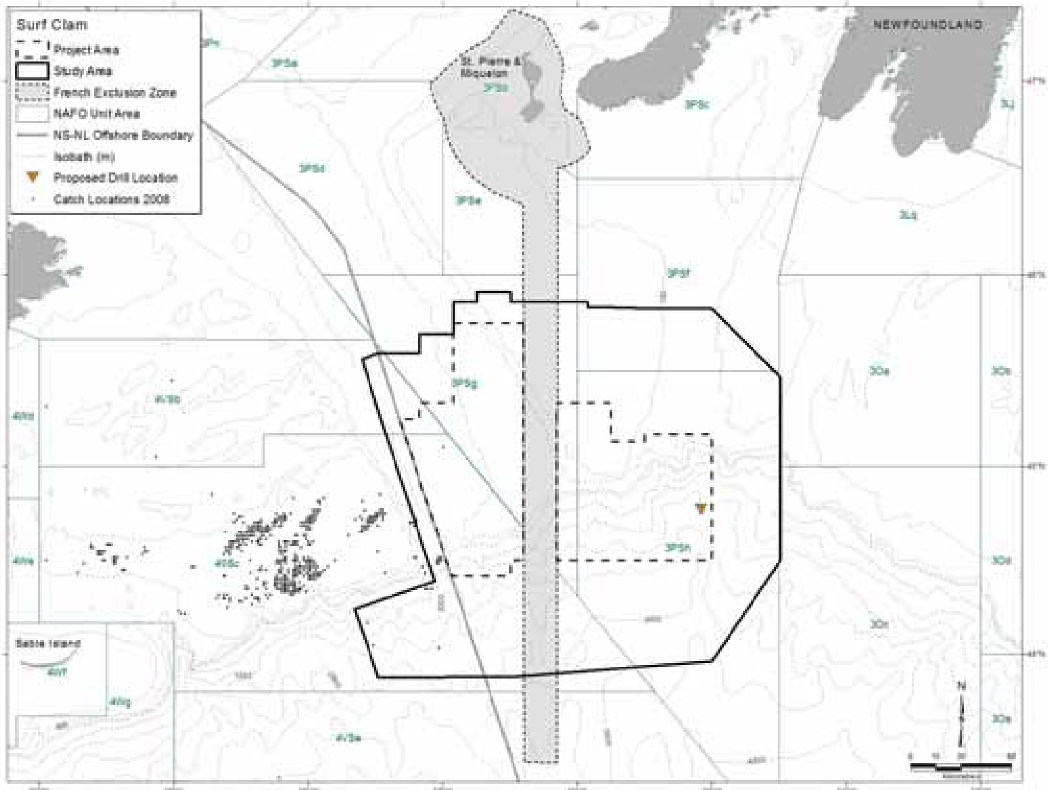

Figure 4.48. Stimpson's Surf Clam Harvesting Locations 2008.

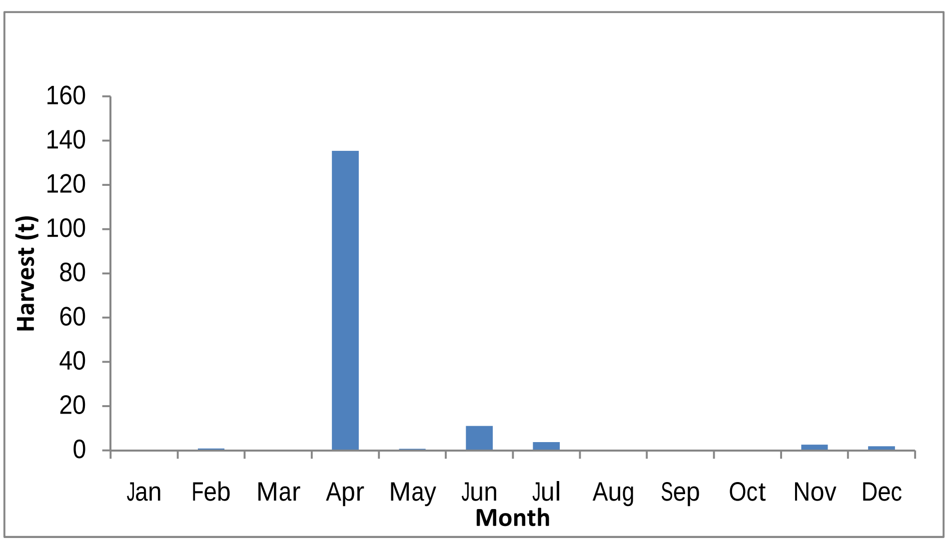

Figure 4.49. Study Area Stimpson's Surf Clam Harvest by Month, 2006-2008 Average.

4.5.4.3.12. Large Pelagic Species

Large pelagic species harvested within the Study Area made up less than 1% of the overall catch during 2006-2008. These included swordfish, sharks, and tuna. Although the total quantities have been very low relative to other species, these are high-value species and the gear used to harvest them is unique, and may be 80 km long, floating near the surface. These species are harvested predominately by Nova Scotia and, to a lesser extent, Newfoundland vessels. As Figure 4.50 illustrates, in and near the Study Area these species tend to be harvested along the edges of the shelf, in the thermocline near the 200-m contour. Figure 4.51 indicates when the Study Area harvest occurred during 2006-2008, i.e., primarily in September and October in these years.

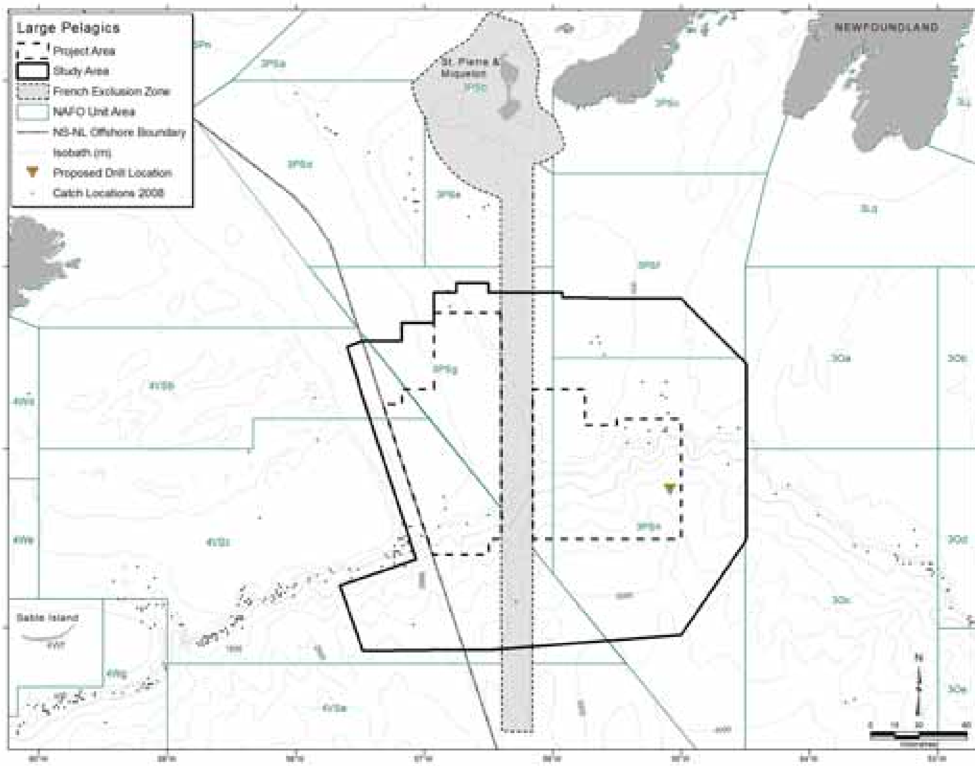

Figure 4.50. Large Pelagics Harvesting Locations, 2008.

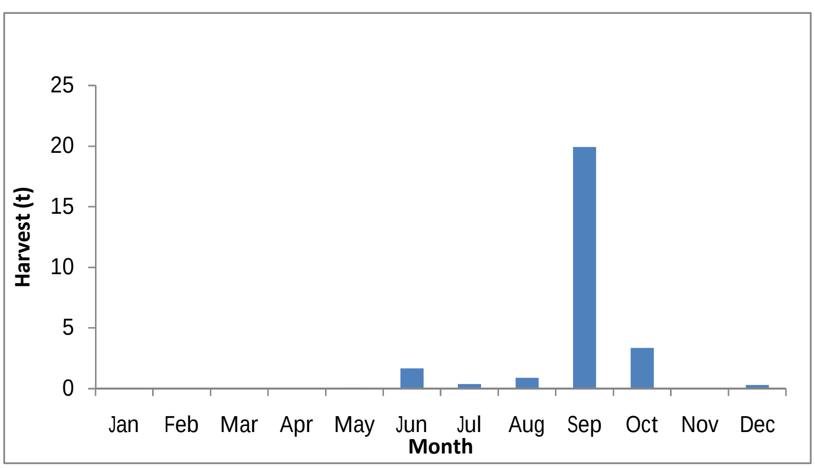

Figure 4.51. Large Pelagics Harvest by Month, 2006-2008 Average.

4.5.4.4 Fishing Gear

Fisheries within the Study Area are conducted using both fixed (mainly gillnets, longlines and pots) and mobile gear (mainly stern otter trawls). In general, fixed gear poses greater potential for conflicts with industry vessels especially if they are towing equipment (e.g., a compressed air sound array and streamer towed behind a vessel, multi-beam sonar, side scan sonar, bottom sampling and/or ROV video equipment, etc.). This is because fixed gear is often hard to detect when there is no fishing vessel near by, and gear may be set out over long distances. Because mobile gears are towed behind a vessel they pose less risk of conflict because the activity can be more easily observed and located on the water.

Table 4.9 indicates the quantities harvested by each type in 2006-2008.

Table 4.9. Study Area Harvest by Principal Gear Type, 2006-2008 Average.

Gear Type	Tonnes	% of Total
Mobile Gear		
Bottom Stern Otter Trawl	4,131.9	37.4%
Dredge	184.3	1.7%
Danish Seine	7.6	<0.1%
Troll Lines	3.5	<0.1%
Fixed Gear		
Pots	2,596.6	23.5%
Gill Nets	2,546.6	23.0%
Longlines	1,395.2	12.6%
Hagfish Barrels	180.5	1.6%
Trap Nets	16.4	0.1%
Total	7,982.10	100.0%

The following maps (Figures 4.52 to 4.57) show the location of fixed gear and mobile gear fishing in 2006, 2007 and 2008.

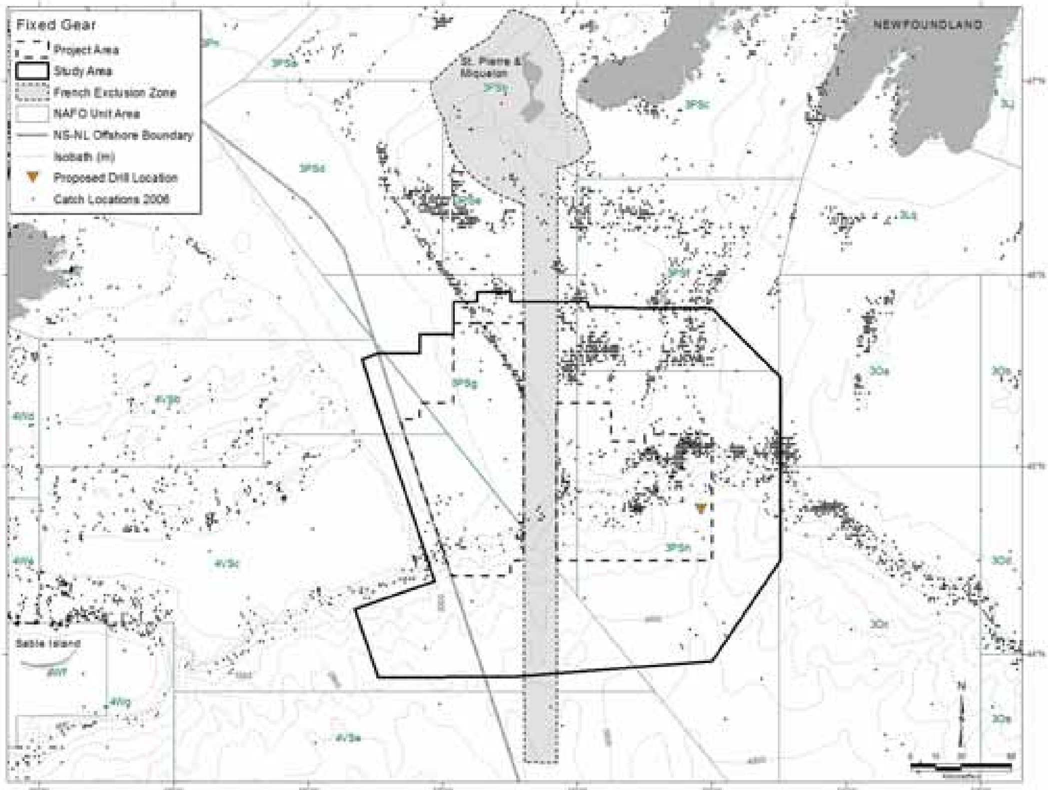

Figure 4.52. Fixed Gear Harvesting Locations, 2006.

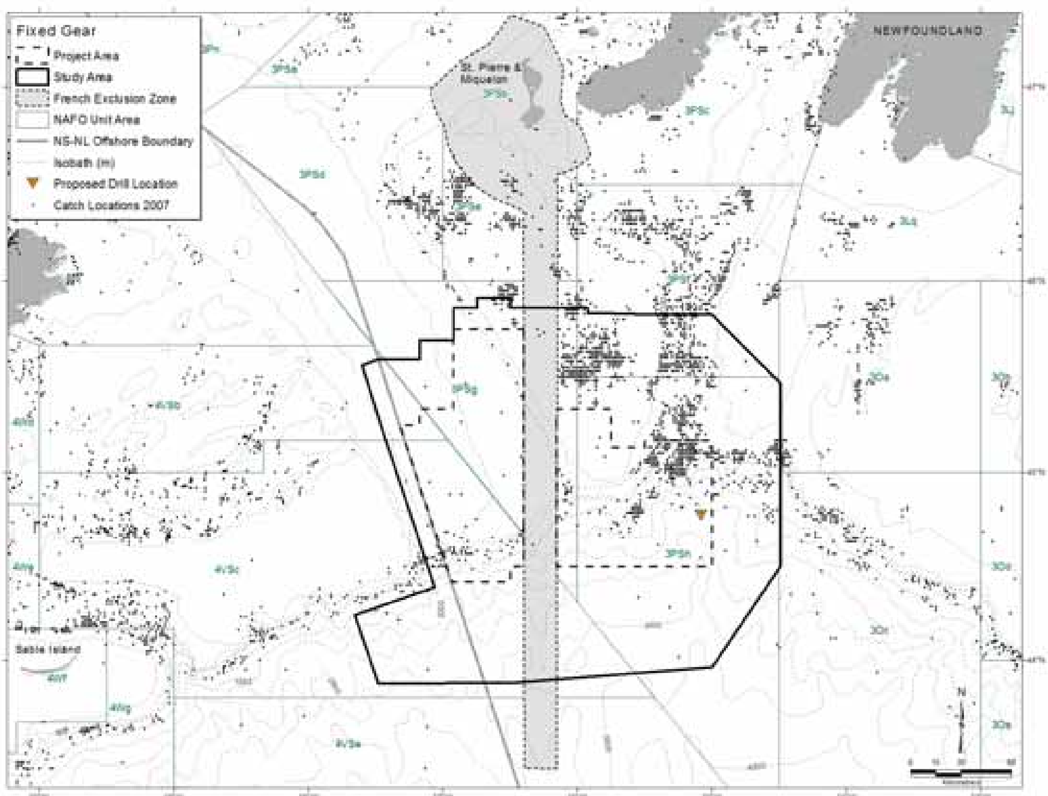

Figure 4.53. Fixed Gear Harvesting Locations, 2007.

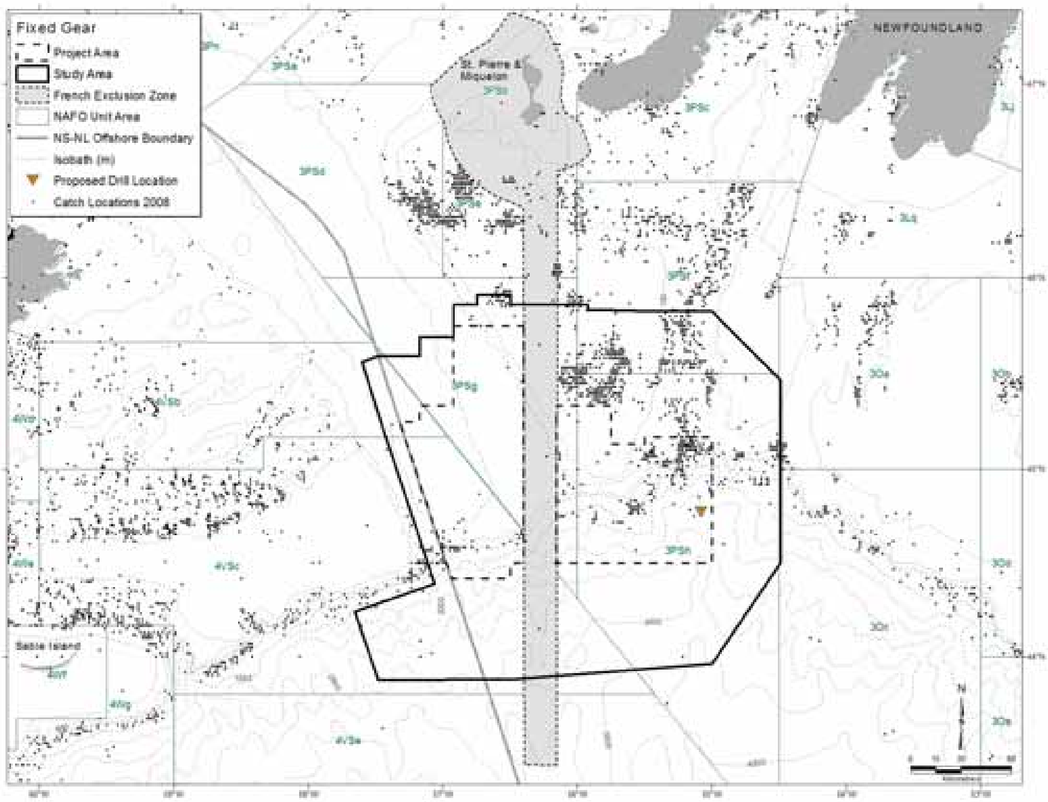

Figure 4.54. Fixed Gear Harvesting Locations, 2008.

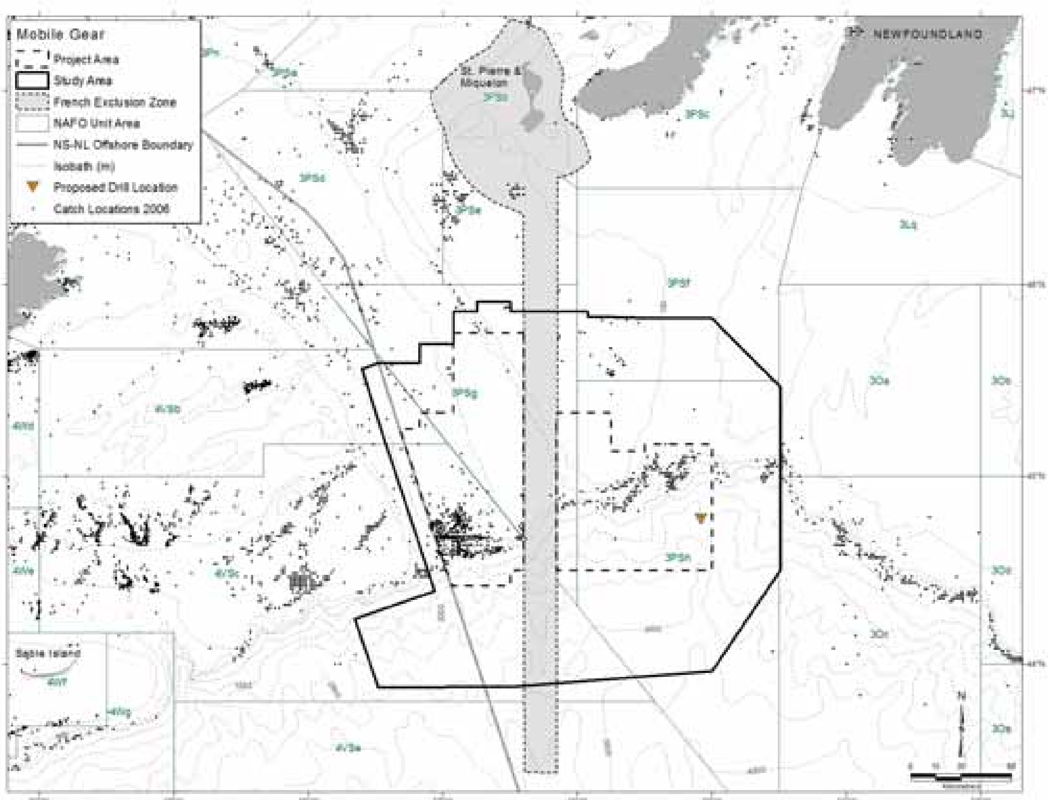

Figure 4.55. Mobile Gear Harvesting Locations, 2006.

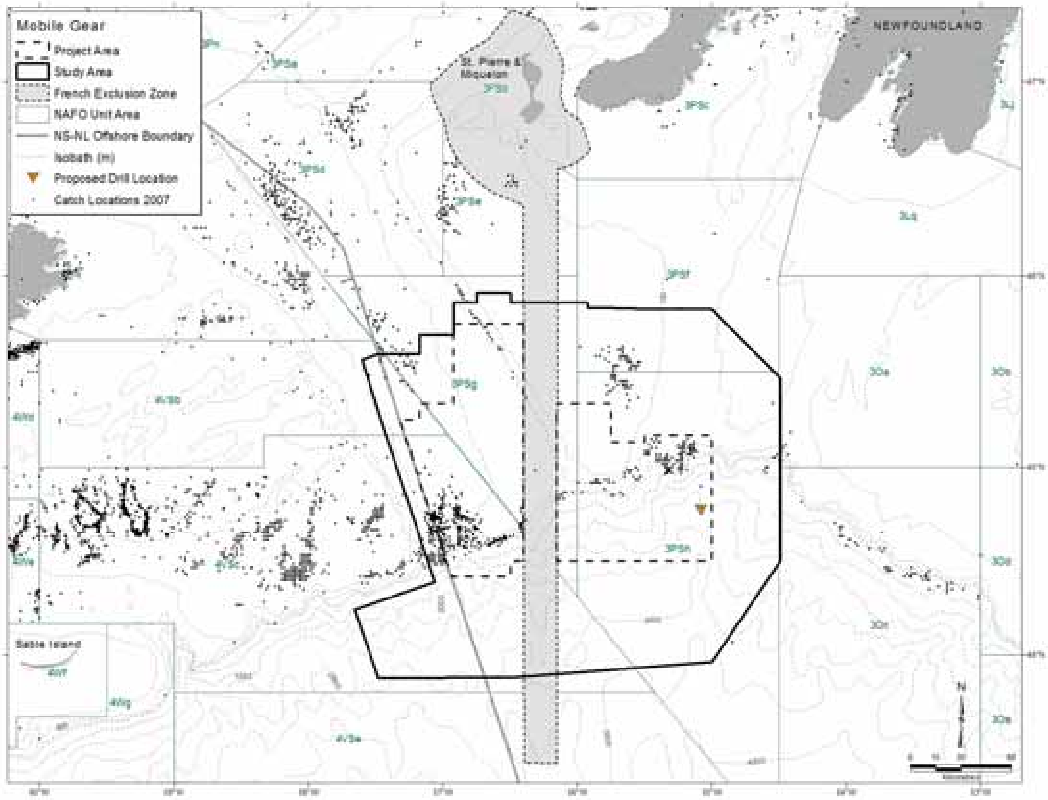

Figure 4.56. Mobile Gear Harvesting Locations, 2007.

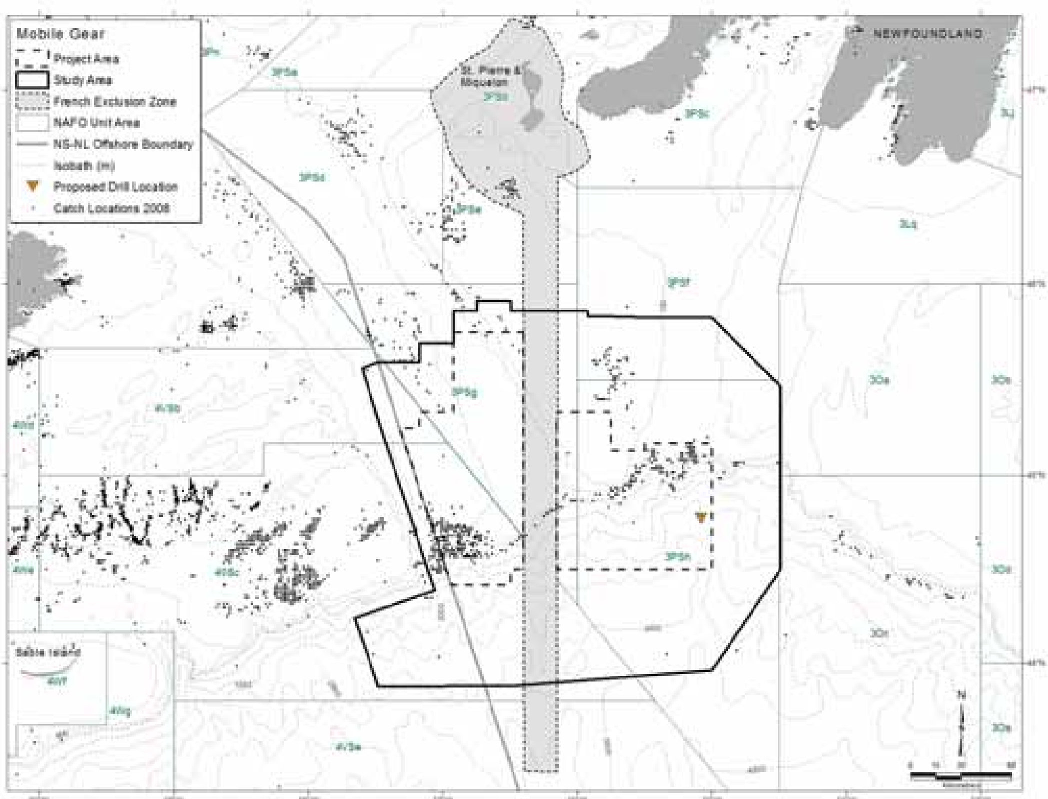

Figure 4.57. Mobile Gear Harvesting Locations, 2008.

4.5.4.5 Fisheries Summary

In general, fishing patterns are similar to the years analyzed in the original EA and addendum. The proposed deepwater drill site and immediate area see little if any fishing activity. As a result, the effects predictions and conclusions of the EA concerning the fisheries VEC remain valid.

4.6 DFO Research Vessel Survey Data

DFO and the fishing industry conduct fisheries research surveys throughout most of Atlantic Canada's offshore each year. Most recur annually; some might run for a few years, and a few are unique or one-time. The purpose of most of these surveys is to contribute information and field data to understanding the status and health of various commercial fish and invertebrate stocks, and – in some surveys – the other non-commercial species, as well. Most are conducted by collecting (catching) specimens using various types of nets or other harvesting gear.

The following table (Table 4.10) indicates the anticipated approximate timing of DFO research vessel (RV) surveys that could overlap parts of the Study Area or areas nearby. (It should be noted that some surveys cover very large areas outside the Study Area – e.g., the 4VWX survey, which includes all Scotian Shelf NAFO Divisions.). These schedules may vary from year to year, but tend to occur about the same time. In any given year, the relevant DFO planners and scientists will be contacted in order to avoid any potential conflicts. The following table indicates timing in recent years.

Table 4.10. DFO Research Surveys, Scotian Shelf, Southern Laurentian Channel and Eastern Grand Banks.

Survey	NAFO Division location	Approx. Timing
4VsW RV survey	4VsW	March
Summer RV survey	4VWX	July
Multispecies survey	3Ps	April - May

More detailed information regarding current and proposed industry surveys for the Study Area will be provided after consultations are completed. Brief summaries of industry surveys that have occurred in recent years are provided in the following paragraphs.

In the recent years, the Groundfish Enterprise Allocation Council (GEAC) has been involved in conducting fisheries research, such as annual redfish and multispecies surveys, in the general area of the Project. The Unit 2 redfish survey generally takes about 12 days to complete, and there are many survey locations (stations) within the proposed Study Area. The vessel proceeds to a particular station, tows its gear for about two hours and then proceeds on to the next station. In previous years, the 3Ps GEAC multi-species grid survey have involved approximately 100 sets (tows) as well as tagging of several fish species (e.g., Atlantic cod, American plaice, witch flounder, and yellowtail flounder). Research stations are located throughout the entire 3Ps zone, but most of the stations are located within the Study Area.

The 3Ps GEAC multi-species survey usually takes place during late November and early December and generally takes about 12 days to complete.

The 4VsW Sentinel Fisheries Program is another annual survey. It is a partnership between DFO and the Fishermen's and Scientists Research Society (FSRS). The 4VsW Sentinel Program involves a random survey, as well as a commercial index fishery. The random survey takes place between 1 September and 3 October and involves data collection at approximately 200 stations from the shore of Nova Scotia out to the edge of the Scotian Shelf; the commercial index component takes place during the regular season for groundfish species, usually between 1 June to 31 March (of the following year) but in previous consultations the FSRS has noted that the bulk of these survey activities generally occur in August and September. Both survey components utilize bottom (baited) longline gear.

The Scotian Shelf Atlantic Halibut Survey is also conducted annually by fishers and DFO. Fishers of the Nova Scotia fixed gear 45-65' fleet sector undertake these surveys on halibut grounds on the Scotian Shelf. During the regular halibut fishery, each participant fishes just one string of gear (longlines) at a prescribed location. Survey locations are at the exact same co-ordinates each year, and are sampled at the same time each year. DFO scientists have precise co-ordinates of all survey sites. The survey starts when the halibut season opens, and is generally completed within 2-3 weeks between late May and late June, according to fishers. The survey halibut are kept separate from the catch made under the fisher's quota, and both catches are recorded in the vessel's logbook as well as by DFO personnel onshore. The exact co-ordinates of all the sites can be obtained from the relevant DFO manager.

4.6.1 DFO Research Vessel Survey Data

The DFO survey data for 2006, 2007, and 2008 were analyzed for species and catch numbers and weights. The main species are summarized below by depth. It should be noted that virtually all of the catches are on the slope and shelf, but this is likely at least partly due to the fact that the research vessels do not typically sample deeper than slope waters.

4.6.1.1 Average Water Depth ≤100 m

Survey catches on areas of the 3P Shelf where average depths were less than 100 m were dominated by yellowtail flounder, sea cucumber, American plaice, offshore sandlance, and Atlantic cod in terms of catch weight. Numerically, sandlance, mailed sculpin, American plaice, sea cucumber, and capelin were dominant species.

4.6.1.2 Average Water Depth 101 to 200 m

Survey catches in areas of the 3Ps Shelf where average depths ranged between 101 m and 200 m were dominated by Atlantic cod, thorny skate, American plaice, capelin, and deepwater redfish in terms of catch weight and number. Capelin, deepwater redfish, and American plaice were also numerically dominant at this depth range.

4.6.1.3 Average Water Depth 201 to 300 m

Survey catches in areas of the 3Ps Slope where average depths ranged between >200 m and 300 m were dominated by deepwater redfish, Atlantic cod, thorny skate, witch flounder, and white hake in terms of catch weight. Deepwater redfish, capelin, silver hake, haddock, and witch flounder were numerically dominant.

4.6.1.4 Average Water Depth 301 to 400 m

Survey catches in areas of the 3Ps Slope and the Laurentian Channel where average depths ranged between >300 m and 400 m were dominated (by weight) by deepwater redfish, thorny skate, Atlantic cod, witch flounder, and longfin hake in terms of fauna catch weight. Plant material and stone were also high in terms of overall catch weight. The survey catch numbers in these areas was dominated by deepwater redfish, capelin, longfin hake, witch flounder, and marlin spike.

4.6.1.5 Average Water Depth 401 to 500 m

Survey catches in areas of the 3Ps Slope and Laurentian Channel where average depths ranged between >400 m and 500 m were dominated by deepwater redfish, black dogfish, Greenland halibut, unspecified invertebrates, longfin hake, and thorny skate. The survey catch numbers in these areas was dominated by deepwater redfish, longfin hake, black dogfish, marlin spike, and witch flounder.

4.6.1.6 Average Water Depth >500 m

Survey catches in areas of the 3Ps Slope where average depths exceeded 500 m were dominated by longfin hake, deepwater redfish, Greenland halibut, longnose eel, and witch flounder in terms of catch weight. The survey catch numbers in areas with average depths exceeding 500 m was dominated by longnose eel, lanternfish, longfin hake, witch flounder, and roundnose grenadier.

5.0 Summary of Potential Effects

Potential effects of ConocoPhillips drilling program on benthos/invertebrates, fish, invertebrate and fish habitat, sea turtles, seabirds, marine mammals, and Species at Risk were assessed in sections 5.4-5.9 and 6.6 of Buchanan et al. (2006). Additional issues arising during follow-up consultations were addressed in Buchanan et al. (2007). To the best of our knowledge, no new information has become available that would change the effects assessments made in the original drilling program EA and 2007 addendum. Mitigations of the 2009 program's effects on the environment will be followed as summarized in Section 7.3 of Buchanan et al. (2006) and several of the comment responses in Buchanan et al. (2007).

In summary, the effects predictions determined in the 2006 EA of Buchanan et al. (2006) and as clarified in the 2007 addendum (Buchanan et al. 2007) remain valid.

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Appendix 1. Updated Climatology Report for the Laurentian Sub-basin

Climatology of the Laurentian Sub-basin

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1.0 Climatology

1.1 Data Sources

Wind and wave climate statistics for the area were extracted from the MSC50 North Atlantic wind and wave climatology data set compiled by Oceanweather Inc under contract to Environment Canada. The MSC50 data set consists of continuous wind and wave hindcast data in 1-hour time steps from January 1954 to December 2005, on a 0.1° latitude by 0.1° longitude grid. Winds from the MSC50 data set are 1-hour averages of the effective neutral wind at a height of 10 m (Harris, 2007). In this study, Grid Point 7966 located at 45.0°N; 56.0°W was deemed to be most representative of conditions in the Laurentian Sub-Basin (Figure 1.1).

Wind speed and direction statistics for the area were also compiled using data from the International Comprehensive Ocean-Atmosphere Data Set (ICOADS). A subset of global marine surface observations from ships, drilling rigs, and buoys covering the period from January 1950 to May 2007 was used in this report. Wind speeds from the ICOADS data set are 10-minute averages. The ICOADS data subset covered an area bounded to the north by 46.5°N, to the south by 43.5°N, to the east by 54.0°W and to the west by 58.0°W. The ICOADS data set has certain inherent limitations in that the observations are not spatially or temporally consistent. In addition, even though the data used in this report were subjected to standard quality control procedures, the data set is somewhat prone to observation and coding errors, resulting in some erroneous observations within the data set. The errors were minimized by using the standard filtering system using source exclusion flags, composite QC flags and an outlier trimming level of 3.5 standard deviations. The ICOADS data set is also suspected to contain a fair-weather bias, due to the fact that ships tend to avoid severe weather or simply do not transmit weather observations during storm situations.

In addition to the MSC50 data set, wave height statistics were also calculated for data from the Meteorological Service of Canada Banqureau Bank buoy located at 44°16'0"N: 57°5'1"W (Figure 1.1). This data set has gaps and contains 89823 out of 179990 possible hourly records from December 02, 1988 – June 14, 2009.

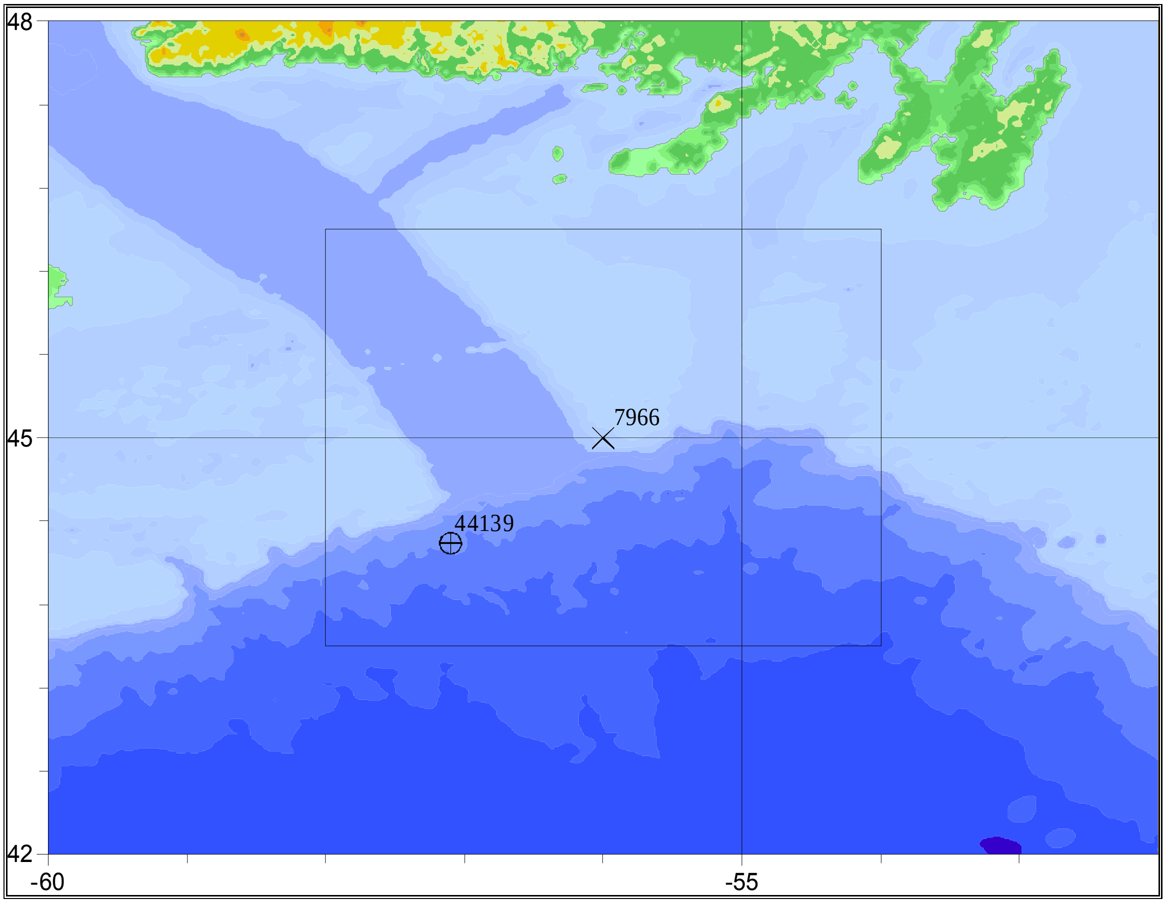

Figure 1.1 Locations of the Climate Data Sources

1.2 Wind Climatology

The Laurentian Sub-Basin experiences predominately westerly winds throughout the year. West to northwest winds which are prevalent during the winter months begin to shift counter-clockwise during March and April resulting in a predominant southwest wind by the summer months. As autumn approaches, the tropical-to-polar temperature gradient strengthens and the winds shift slightly, becoming predominately westerly again by late fall and into winter.

Low pressure systems crossing the area are more intense during the winter months. As a result, mean wind speeds tend to peak during this season. Mean wind speeds at grid point 7966 in the MSC50 data set as well as the ICOADS data set peak during the month of January (Table 1.1). Grid Point 7966 had January mean wind speeds of 11.1 m/s, while the ICOADS dataset recorded mean wind speed of 11.2 m/s during the same month. While wind speeds from both of these dataset are similar, the winds from the ICOADS data set are not directly comparable to the MSC50 data set because the winds in the ICOADS data set were either estimated or measured by anemometers at various heights above sea level. The wind speed is dependent on height since the wind speed increases at increasing heights above sea level. Also, winds speeds from each of the data sources have different averaging periods. The MSC50 winds are 1-hour averages while the ICOADS winds are 10-minute average winds. The adjustment factor to convert from 1-hour mean values to 10-minute mean values is usually taken as 1.06 (U.S. Geological Survey, 1979).

Table 1.1 Mean Wind Speed (m/s) Statistics

Month	Grid point 7966	ICOADS
January	11.1	11.2
February	10.8	10.8
March	10.1	10.0
April	8.6	8.6
May	6.9	7.2
June	6.3	6.6
July	5.8	6.3
August	6.3	6.5
September	7.5	7.5
October	8.8	8.9
November	9.9	9.9
December	10.9	10.9

A wind rose of the annual wind speed and a histogram of the wind speed frequency from grid points 7966 are presented in Figure 1.2 and Figure 1.3. Monthly wind roses along with histograms of the frequency distributions of wind speeds for Grid Point 7966 can be found in Appendix 1. There is a marked increase in the occurrence of winds from the west to northwest in the winter months as opposed to the summer months, which is consistent with the wind climatology of the area.

The percentage exceedance of wind speeds at grid point 7966 is presented in Figure 1.4. Plots for individual months are presented in Appendix 2.

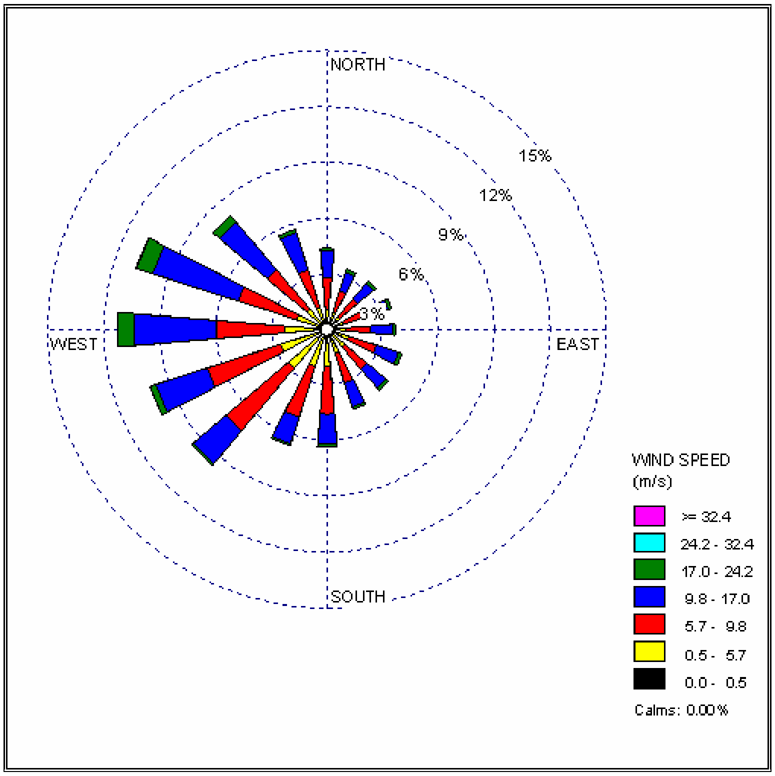

Figure 1.2 Annual Wind Rose for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W 1954 – 2005

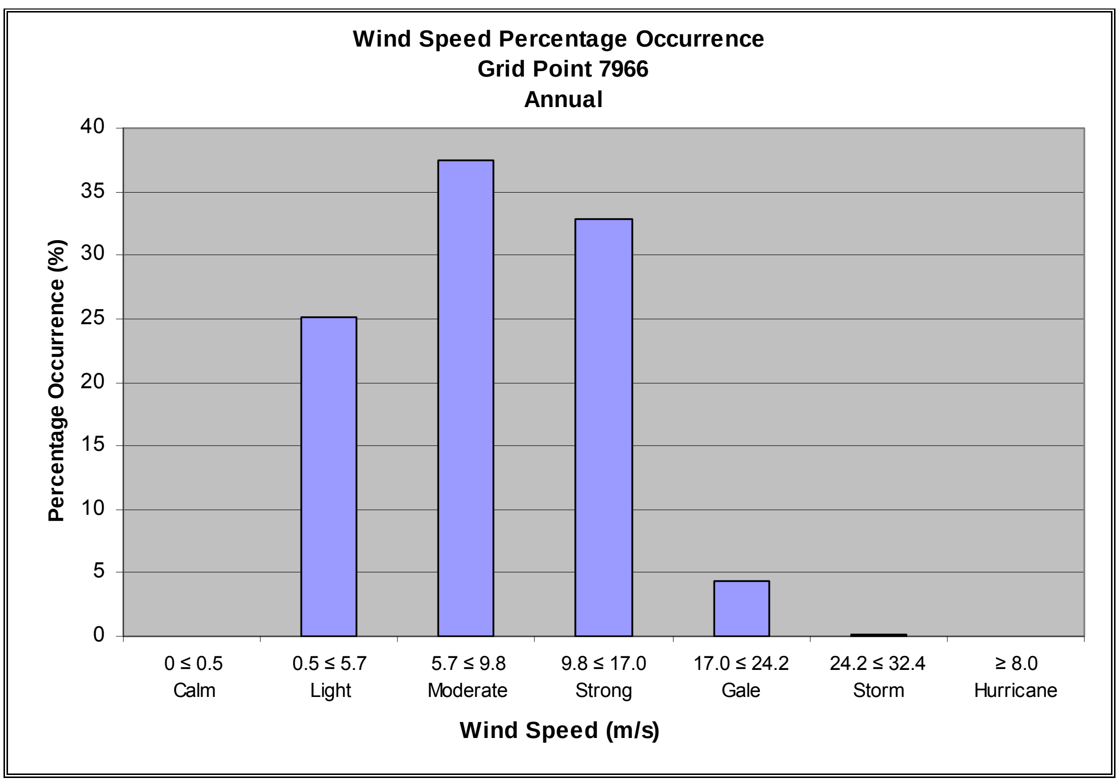

Figure 1.3 Annual Percentage Frequency of Wind Speeds for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W 1954 – 2005

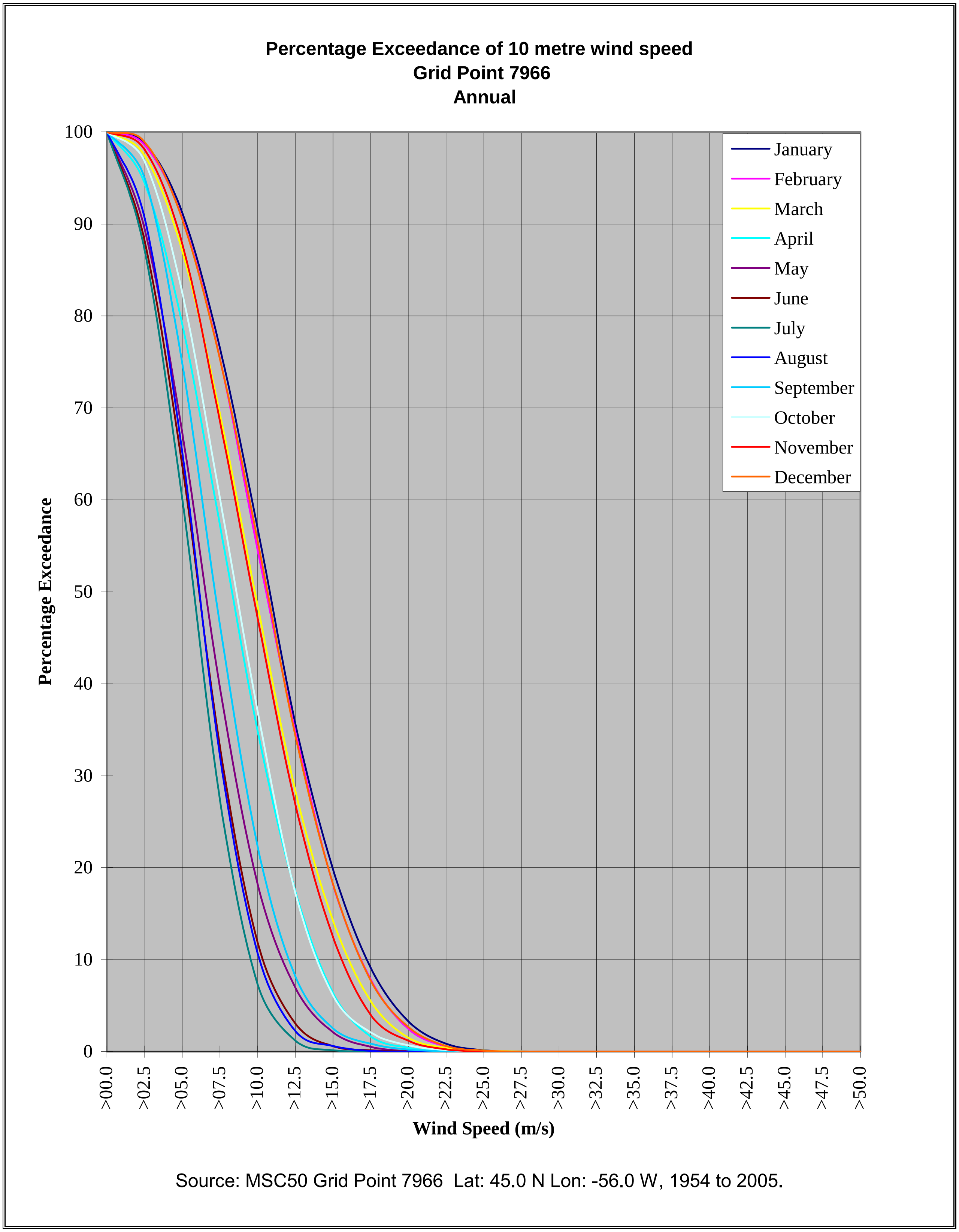

Figure 1.4 Percentage Exceedance of 10 metre wind speed for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W

Intense mid-latitude low pressure systems occur frequently from early autumn to late spring. In addition, remnants of tropical systems have passed near Newfoundland between spring and late fall. Therefore, while mean wind speeds tend to peak during the winter months, maximum wind speeds may occur at anytime during the year. A table of monthly maximum wind speeds for each of the data sets is presented in Table 1.2.

Rapidly deepening storm systems known as weather bombs frequently move across the Laurentian Sub-Basin. These storm systems typically develop in the warm waters of Cape Hatteras and move northeast across Newfoundland and the Grand Banks. On January 10, 1982, hurricane force winds of 33.4 m/s were recorded by a ship passing through the region. This was the highest wind recorded in the ICOADS dataset for this region. These winds were the result of a low pressure system which rapidly deepened over the warm waters of the Gulf Stream on January 9th, 1982, then moved across the study area and into Newfoundland.

While mid-latitude low pressure systems account for the majority of the peak wind events offshore southern Newfoundland, storms of tropical origin can also on occasion pass over the region. On September 5th, 1978, Category 3 Hurricane Ella crossed the region with maximum sustained wind speeds of 54.0 m/s and a central pressure of 960mb. During this event, wind speeds in the MSC50 data set peaked at 50.0 m/s from the northeast. Wind speeds of 15.4 m/s were recorded by a ship located at 44.60°N; 58.00°W as this system passed.

Table 1.2 Maximum Wind Speeds (m/s) Statistics

Month	Grid Point 7966	ICOADS
January	29.3	33.4
February	28.6	30.9
March	29.3	33.0
April	23.6	28.3
May	23.6	24.2
June	22.0	21.6
July	21.2	21.6
August	20.5	22.0
September	33.1	24.7
October	29.9	28.3
November	27.3	30.9
December	28.1	31.9

1.3 Wave Climatology

The main parameters for describing wave conditions are the significant wave height, the maximum wave height, the peak spectral period, and the characteristic period. The significant wave height is defined as the average height of the 1/3 highest waves, and its value roughly approximates the characteristic height observed visually. The maximum height is the greatest vertical distance between a wave crest and adjacent trough. The spectral peak period is the period of the waves with the largest energy levels, and the characteristic period is the period of the 1/3 highest waves. The characteristic period is the wave period reported in ship observations, and the spectral period is reported in the MSC50 data set.

A sea state may be composed of the wind wave alone, swell alone, or the wind wave in combination with one or more swell groups. A swell is a wave system not produced by the local wind blowing at the time of observation and may have been generated within the local weather system, or from within distant weather systems. The former situation typically arises when a front, trough, or ridge crosses the point of concern, resulting in a marked shift in wind direction. Swells generated in this manner are usually of low period. Swells generated by distant weather systems may propagate in the direction of the winds that originally formed to the vicinity of the observation area. These swells may travel for thousands of miles before dying away. As the swell advances, its crest becomes rounded and its surface smooth. As a result of the latter process, swell energy may propagate through a point from more than one direction at a particular time.

The wave climate of the Laurentian Sub-Basin is dominated by extra-tropical storms, primarily during October through March. However severe storms may, on occasion, occur outside these months. Storms of tropical origin may occur during the early summer and early winter, but most often from late August through October. Hurricanes are usually reduced to tropical storm strength or evolve into post-tropical storms by the time they reach the area. However, they are still capable of producing storm force winds and high waves.

Mean monthly ice statistics were used when calculating the wave heights in the MSC50 data. As a result, if the mean monthly ice coverage for a particular grid point is greater than 50% for a particular month, the whole month (from the 1st to the 31st) gets “iced out”; meaning that no forecast wave data has been generated for that month. This sometimes results in gaps in the wave data.

The annual wave rose from the MSC50 data is presented in Figure 1.5. The wave rose shows that the majority of wave energy comes from the southwest, and accounts for 13.8% of the wave energy at grid point 7966. Waves were “iced out” for 2.35% of the time over the 50-year record; this value may be somewhat high since monthly ice files were used when generating the waves.

During autumn and winter, the dominate direction of the combined significant wave height is from the west to northwest. This corresponds with a higher frequency of occurrence of the wind wave during these months, suggesting that during the late fall and winter, the wind wave is the main contributor to the combined significant wave height. During the months of March and April, the wind wave remains predominately westerly, while the swell begins to back to southerly, resulting in the vector mean direction of the combined significant wave heights backing to southwesterly. A mean southwesterly direction for the combined significant wave heights during the summer months is a result of a mainly southwesterly wind wave and a southwesterly swell. As winter approaches during the months of September and October, the wind wave will veer to the westerly and become the more dominant component of the combined significant wave height. This will result in the frequency of occurrence of the combined significant wave heights veering to westerly once again.

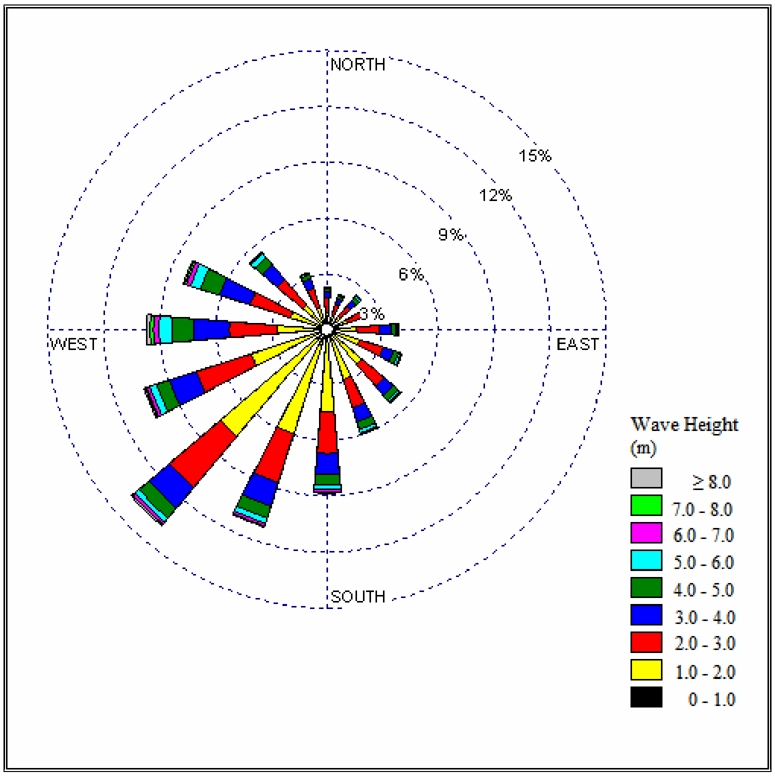

Figure 1.5 Annual Wave Rose for MSC50 Grid Point 7966 located near 45.0°N, 56.0°W

The annual percentage frequency of significant wave heights is presented in Figure 1.6. This histogram shows that the majority of significant wave heights are between 1.0 and 3.0 m in the Laurentian Sub-Basin. There is a gradual decrease in frequency of wave heights above 3.0 m and only 0.6% of wave heights exceed 8.0 m. Monthly wave roses along with histograms of the frequency distributions of wave heights for Grid Point 7966 can be found in Appendix 3.

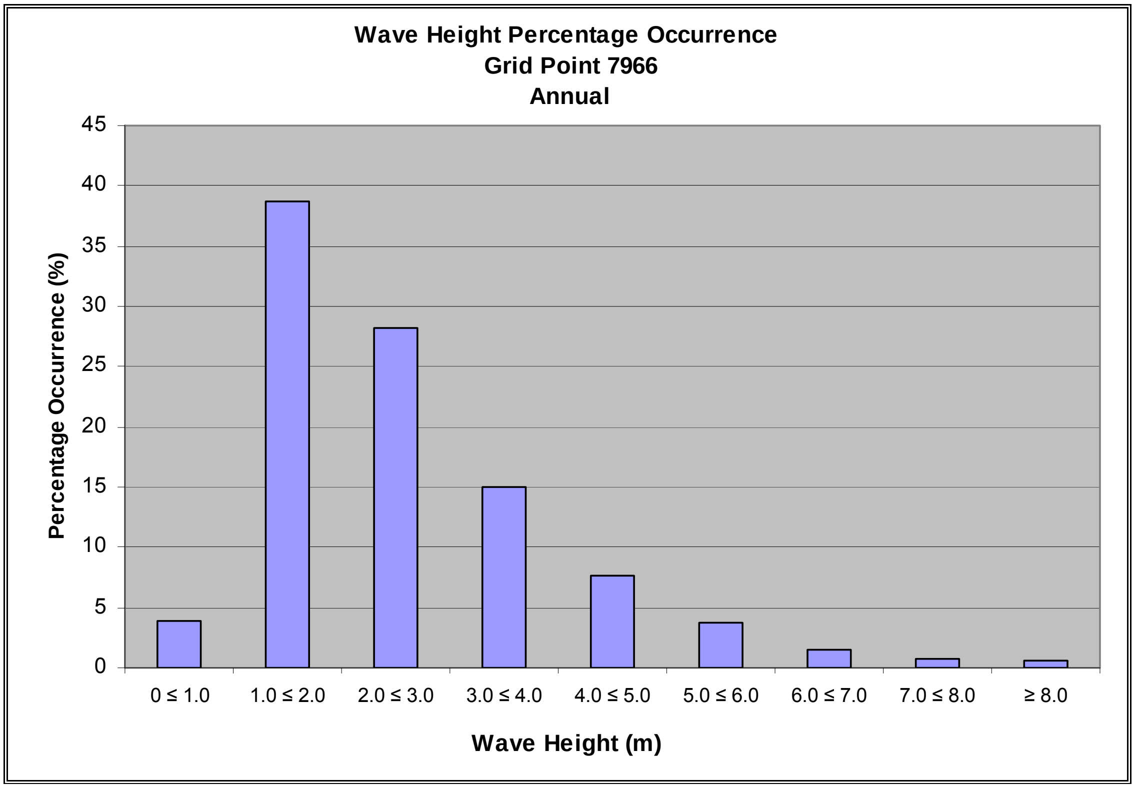

Figure 1.6 Annual Percentage Frequency of Wave Height for MSC50 Grid Point 7966 located near 45.0°N, 56.0°W. 1954 – 2005

Significant wave heights in the Laurentian Sub-Basin peak during the winter months. The MSC50 data set has a mean monthly significant wave height of 3.5 m in December at grid point 7966 while Buoy 44139 peaked in February with a mean monthly significant wave height of 3.9 m. The lowest significant wave heights occur in the summer with July month having the lowest mean monthly significant wave height in both data sets.

Table 1.3 Mean Significant Wave Height Statistics (m) for the MSC50 data set

	Grid Point 7966	**MSC Buoy 44139**
January	3.4	3.2
February	3.0	3.9
March	2.8	2.9
April	2.5	2.2
May	1.9	1.8
June	1.7	1.5
July	1.6	1.4
August	1.7	1.6
September	2.1	1.9
October	2.5	2.4
November	3.0	2.6
December	3.5	3.0

Significant wave heights of 10.0 m or more occurred in each month between October and March, with the highest waves of 12.2 m occurring during the month of January (Table 1.4) at Grid point 7966 and 12.8 m during the month of December at MSC Buoy 44139. While maximum significant wave heights tend to peak during the winter months, a tropical system could pass through the area and produce high wave heights in any month. The maximum significant wave height of 12.1 m at grid point 7966 and 10.9 m at Buoy 44139 in the month of October occurred on October 29, 1991 and was the result of the merging of a Nor'easter and the remnants of a tropical storm. This system later became known as “The Halloween Storm” or “The Perfect Storm”.

Table 1.4 Maximum Significant Wave Height Statistics (m) for the MSC50 data set

	Grid Point 7966	**MSC Buoy 44139**
January	12.2	10.1
February	11.2	10.1
March	11.5	11.9
April	8.6	07.6
May	9.6	06.6
June	6.2	09.8
July	6.8	04.4
August	7.5	08.4
September	9.0	09.0
October	12.1	10.9
November	10.5	09.5
December	11.5	12.8

Figure 1.7 shows percentage exceedance curves of significant wave heights for grid point 7966. Percentage exceedance plots for the months of January through April show that the curves do not reach 100% because of the presence of ice in the Laurentian Sub-Basin during these months. Monthly plots of percentage exceedance of significant wave heights are presented in Appendix 4.

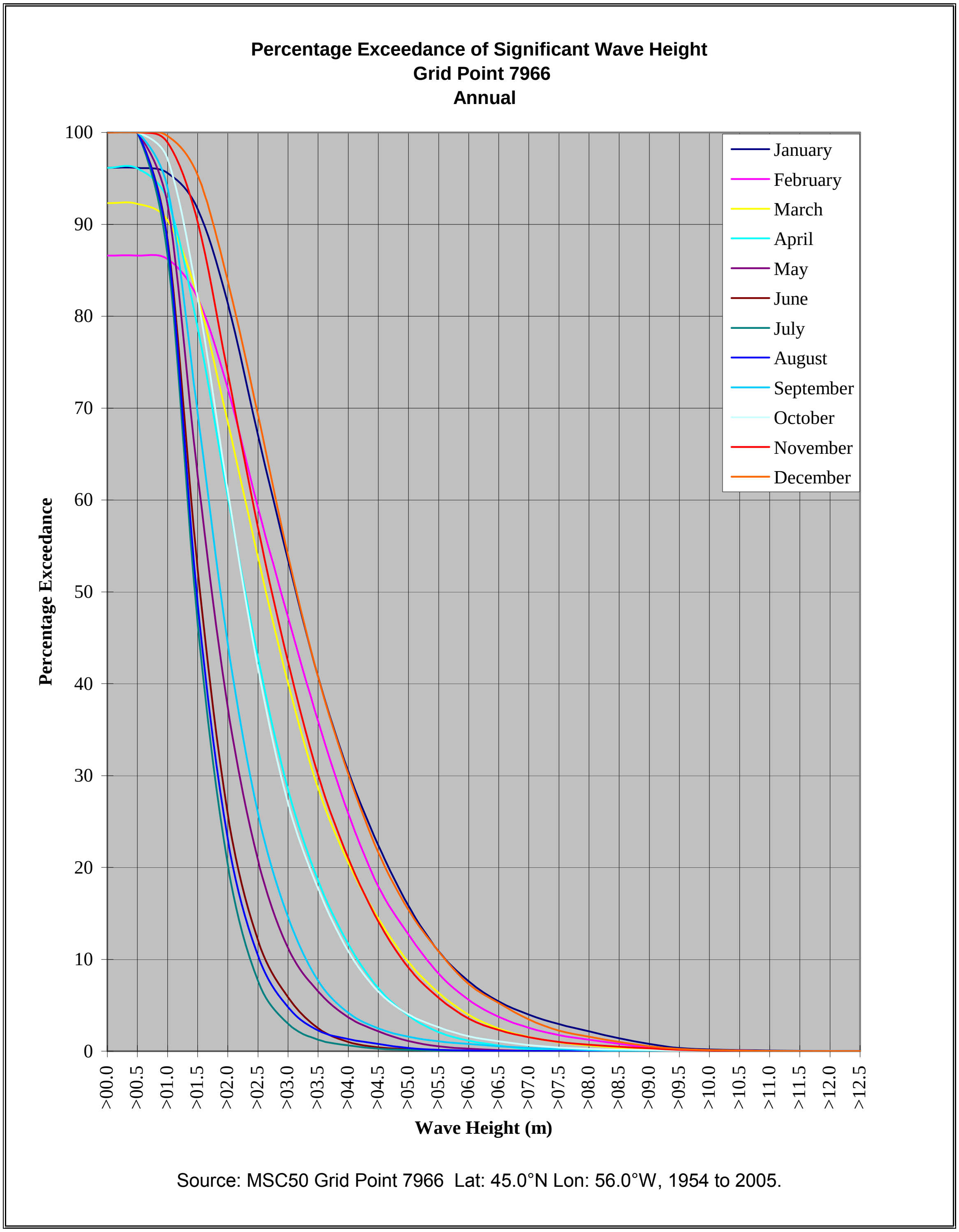

Figure 1.7 Percentage Exceedance of Significant Wave Height for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W

The spectral peak period of waves vary with season with the most common period varying from 7 seconds from June to October to 9 seconds from November to March. Annually, the most common peak spectral period is 7 seconds, occurring 22.3% of the time. Periods above 12 seconds occur more frequently during the winter months; though they have been reported in every month. The percentage occurrence of spectral peak period for each month is shown in Table 1.5 and Figure 1.8.

Table 1.5 Percentage Occurrence of Peak Spectral Period of the Total Spectrum for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W

	Peak Spectral Period (seconds)															
Month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
January	0.0	0.0	0.0	0.3	1.8	5.2	15.2	13.2	**20.1**	17.7	12.5	8.0	4.6	1.2	0.1	0.0
February	0.0	0.0	0.0	0.3	2.1	6.6	16.3	13.9	**19.5**	16.9	11.6	7.2	4.1	1.4	0.1	0.1
March	0.0	0.0	0.0	0.7	3.9	8.5	16.1	14.5	**18.0**	16.0	11.0	5.7	3.9	1.5	0.1	0.0
April	0.0	0.0	0.0	0.8	4.1	9.7	17.4	**20.0**	19.3	16.7	7.0	2.9	1.7	0.3	0.0	0.0
May	0.0	0.0	0.0	1.0	6.4	12.3	22.6	**27.3**	14.3	9.9	4.1	1.3	0.5	0.2	0.0	0.1
June	0.0	0.0	0.0	1.0	7.0	16.3	**29.3**	26.2	11.3	6.2	1.2	0.3	1.0	0.3	0.1	0.0
July	0.0	0.0	0.0	0.8	6.6	18.2	**31.8**	25.5	10.1	5.1	0.6	0.4	0.5	0.2	0.2	0.2
August	0.0	0.0	0.0	1.0	8.3	20.0	**34.1**	19.3	7.6	5.4	1.2	0.9	1.4	0.5	0.2	0.1
September	0.0	0.0	0.0	0.7	6.0	14.7	**25.5**	20.6	12.3	8.0	3.7	3.5	3.6	1.0	0.3	0.3
October	0.0	0.0	0.0	0.6	4.8	10.9	**24.5**	21.3	16.8	10.6	5.3	2.6	2.0	0.6	0.0	0.0
November	0.0	0.0	0.0	0.4	2.7	8.1	18.6	17.4	**20.7**	18.2	7.4	4.3	1.9	0.4	0.0	0.0
December	0.0	0.0	0.0	0.3	1.7	5.2	15.8	14.9	**20.6**	19.0	10.6	7.3	3.7	0.8	0.0	0.1
Winter	0.0	0.0	0.0	0.3	1.8	5.7	15.8	14.0	**20.1**	17.9	11.6	7.5	4.1	1.1	0.1	0.1
Spring	0.0	0.0	0.0	0.8	4.8	10.2	18.7	**20.6**	17.2	14.2	7.4	3.3	2.0	0.7	0.0	0.0
Summer	0.0	0.0	0.0	0.9	7.3	18.2	**31.7**	23.6	9.7	5.5	1.0	0.6	0.9	0.3	0.1	0.1
Autumn	0.0	0.0	0.0	0.6	4.5	11.2	**22.9**	19.7	16.6	12.3	5.5	3.5	2.5	0.6	0.1	0.1
Annual	0.0	0.0	0.0	0.6	4.6	11.3	**22.3**	19.5	15.9	12.5	6.4	3.7	2.4	0.7	0.1	0.1

Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

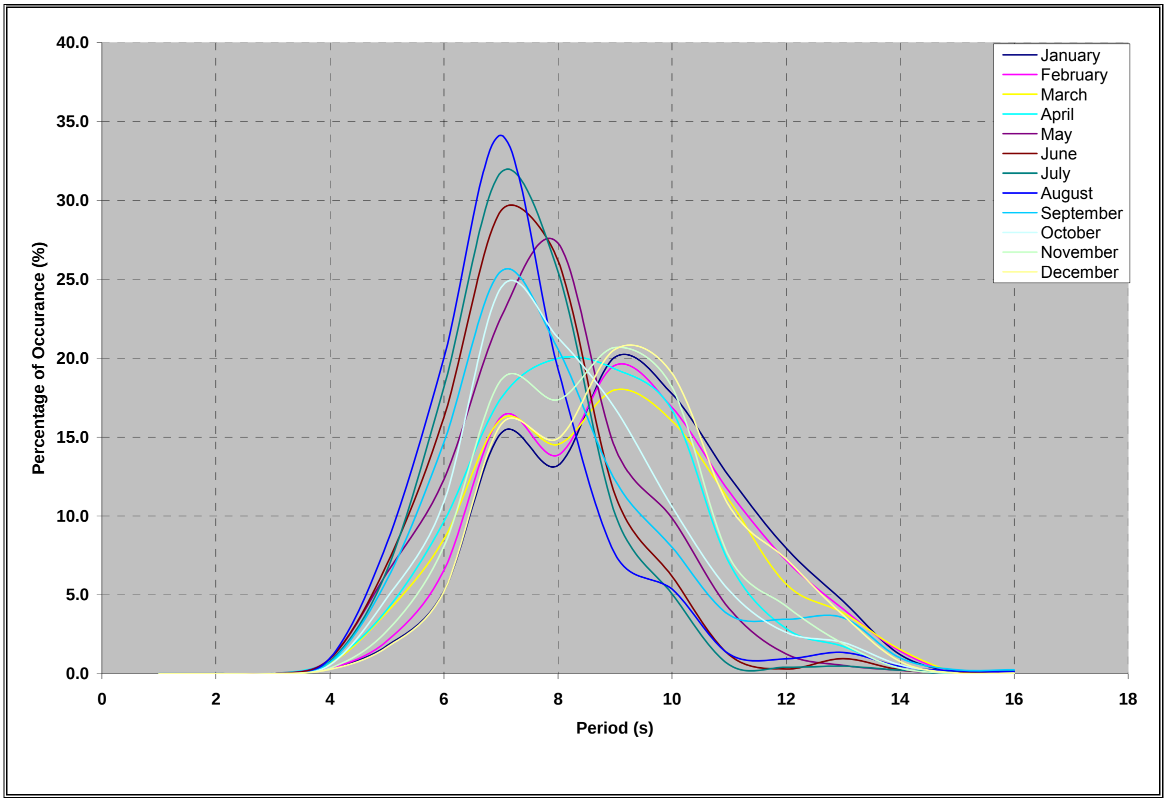

Figure 1.8 Percentage of Occurrence of Peak Wave Period for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W

A scatter diagram of the significant wave height versus spectral peak period is presented in Table 1.6. From this table it can be seen that the most common wave is 2 m with a peak spectral period of 7 seconds, and the second most common wave being 1 m and a peak spectral period of 7 seconds. Note that wave heights in these tables have been rounded to the nearest whole number. Therefore, the 1 m wave bin would include all waves from 0.51 m to 1.49 m.

Table 1.6 Percent Frequency of Occurrence of Significant Combined Wave Height and Peak Spectral Period for MSC50 Grid Point 7966 located near 45.0°N; 56.0°W

		Wave Height (m)													Total
		<1	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	
Period (s)	**0**	2.33													2.33
	1	0.00													0.00
	2	0.00													0.00
	3	0.00	0.00												0.00
	4	0.00	0.53	0.11											0.64
	5	0.00	3.13	1.38	0.04	0.00									4.55
	6	0.00	4.56	6.21	0.37	0.00									11.15
	7	0.00	6.70	10.49	4.59	0.14	0.00								21.92
	8	0.01	5.33	5.93	5.74	2.08	0.08	0.00	0.00						19.17
	9	0.00	1.47	4.64	4.00	4.09	1.14	0.05	0.00						15.40
	10	0.00	1.27	3.17	2.39	2.00	2.28	0.85	0.08	0.00	0.00				12.05

	11	0.00	0.33	1.27	1.37	0.81	0.78	0.89	0.54	0.10	0.01				6.08
	12	0.00	0.28	0.64	0.61	0.66	0.43	0.24	0.23	0.26	0.16	0.01			3.52
	13		0.34	0.60	0.30	0.32	0.27	0.17	0.09	0.06	0.09	0.05	0.01		2.30
	14		0.14	0.13	0.09	0.07	0.08	0.06	0.04	0.02	0.01	0.01	0.01	0.00	0.67
	15		0.02	0.02	0.02	0.01	0.01	0.01	0.00	0.00	0.00		0.00	0.00	0.09
	16		0.03	0.02	0.02	0.01		0.00		0.00					0.07
	17		0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00					0.03
	18		0.00	0.00											0.00
		2.36	24.15	34.62	19.54	10.19	5.08	2.27	0.99	0.45	0.27	0.07	0.02	0.01	100.00

1.4 Tropical Systems

The hurricane season in the North Atlantic basin normally extends from June through November, although tropical storm systems occasionally occur outside this period. While the strongest winds typically occur during the winter months and are associated with mid-latitude low pressure systems, storm force winds may occur at any time of the year as a result of tropical systems. Once formed, a tropical storm or hurricane will maintain its energy as long as a sufficient supply of warm, moist air is available. Tropical storms and hurricanes obtain their energy from the latent heat of vapourization that is released during the condensation process. These systems typically move east to west over the warm water of the tropics. However, some of these systems turn northward and make their way towards Newfoundland and the Grand Banks. Since the capacity of the air to hold water vapour is dependent on temperature, the hurricanes begin to lose their tropical characteristics as they move northward over the colder ocean waters. By the time these weakening cyclones reach Newfoundland, they are usually embedded into a mid-latitude low and their tropical characteristics are usually lost.

There has been a significant increase in the number of Hurricanes that have developed within the Atlantic Basin within the last 15 years. Figure 1.9 shows the 5-year average (Note: 2005-2008 is only a 4-year average) of tropical storms which have developed within the Atlantic Basin since 1960. This increase in activity has been attributed to naturally occurring cycles in tropical climate patterns near the equator called the tropical multi-decadal signal and typically lasts 20 to 30 years (Bell, 2006). As a result of the increase in tropical activity in the Atlantic Basin, there has also been an increase in tropical storms or their remnants entering the Canadian Hurricane Centre Response zone, and consequently, a slight increase in the number of tropical storms entering the study area. It should be noted that the unusually high number of tropical storms in 2005 may be skewing the results for the 2005 – 2008 season. The average number of storms for the 3-year period of 2006 – 2008 is only 14.7 opposed to 18.5 storms for the 4-year period of 2005 – 2008.

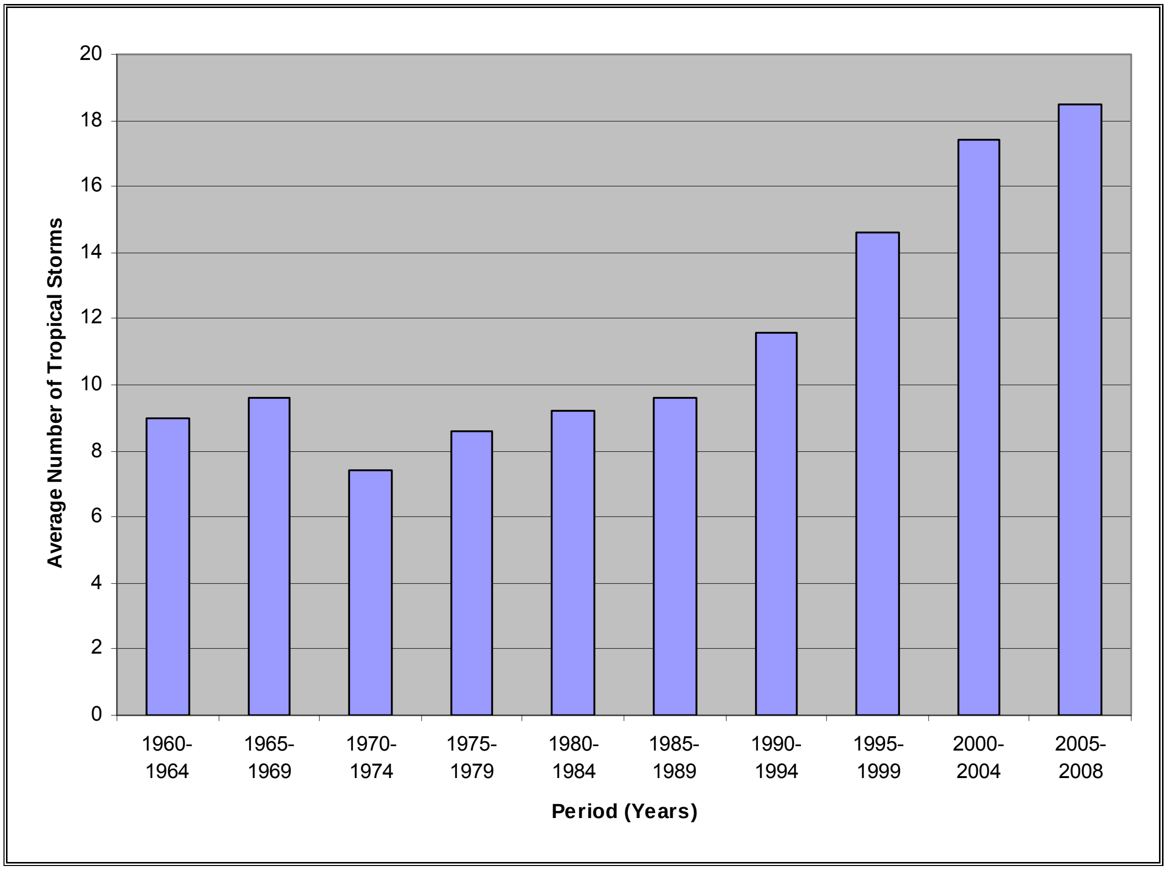

Figure 1.9 5-Year Average of the number of Tropical Storms which formed in the Atlantic Basin since 1960.

Since 1950, 64 tropical systems have passed within 278 km of 45.0°N; 56.0°W. The names are given in Table 1.7 and the tracks over the Laurentian Sub-Basin are shown in Figure 1.10. It must be noted tgat the values in the table are the maximum 1-minute mean winds speeds occurring within the tropical system at the 10-m reference level as it passed within 278 km of the location.

On occasion, these systems still maintain their tropical characteristics when they reach Newfoundland. On two occasions, a Category 3 Hurricane crossed the region. The first was hurricane Ella which passed by on September 5, 1978 with maximum wind speeds near 54 knots and a central pressure of 960 mb. The second was Hurricane Debby which passed by on September 18, 1982 with maximum sustained wind speeds near 51 knots and a central pressure of 960 mb.

Table 1.7 Tropical Systems Passing within 278 km of 45.00ºN, 56.00ºW (1950 to 2007)

Year	Month	Day	Hour	Name	Lat	Long	Wind (m/s)	Pressure (mb)	Category
1950	9	14	0000Z	Dog	42.90	-55.90	25.72	N/A	Post-Tropical
1950	10	5	0600Z	George	44.60	-56.70	33.44	N/A	Post-Tropical

1952	9	8	0000Z	Baker	42.50	-57.40	36.01	N/A	Category 1
1954	9	3	0000Z	Dolly	44.30	-56.40	33.44	N/A	Post-Tropical
1955	8	21	0000Z	Diane	43.30	-57.00	18.01	N/A	Post-Tropical
1955	9	21	1800Z	Ione	46.70	-57.40	23.15	N/A	Post-Tropical
1956	8	19	0000Z	Betsy	42.80	-55.00	25.72	N/A	Post-Tropical
1957	9	27	0000Z	Frieda	44.00	-54.50	23.15	N/A	Post-Tropical
1959	6	21	0600Z	Not Named	46.30	-57.00	23.15	N/A	Post-Tropical
1960	8	21	0000Z	Cleo	44.20	-60.50	18.01	N/A	Tropical Storm
1961	10	22	0000Z	Gerda	44.00	-56.50	15.43	N/A	Post-Tropical
1962	9	2	1200Z	Alma	42.20	-61.00	7.72	N/A	Post-Tropical
1962	10	9	0000Z	Daisy	45.50	-57.70	25.72	N/A	Post-Tropical
1962	10	22	0600Z	Ella	42.90	-56.30	30.87	N/A	Post-Tropical
1964	9	15	1200Z	Dora	46.00	-59.00	28.29	N/A	Post-Tropical
1964	9	24	1800Z	Gladys	44.70	-60.30	30.87	990	Post-Tropical
1966	7	3	1200Z	Becky	44.70	-56.80	23.15	N/A	Post-Tropical
1969	8	12	1800Z	Blanch	46.00	-54.90	30.87	N/A	Post-Tropical
1969	9	25	1800Z	Not Named	43.40	-57.90	33.44	N/A	Category 1
1970	10	17	1800Z	Not Named	42.50	-57.50	36.01	980	Category 1
1971	7	7	1200Z	Arlene	44.70	-56.30	23.15	N/A	Tropical Storm
1973	10	28	0000Z	Gilda	45.40	-55.20	28.29	N/A	Post-Tropical
1975	10	3	0600Z	Gladys	43.70	-57.00	43.73	960	Category 2
1978	9	5	0000Z	Ella	45.00	-55.00	54.02	960	Category 3
1980	9	8	0600Z	Georges	42.90	-55.10	36.01	993	Category 1
1982	6	20	1200Z	Sub-Tropical 1	44.50	-60.00	30.87	984	Sub-Tropical
1982	9	18	1800Z	Debby	43.50	-56.10	51.44	960	Category 3
1984	9	1	1800Z	Cesar	44.00	-54.90	20.58	998	Tropical Storm
1984	9	16	0000Z	Diane	43.50	-61.90	30.87	994	Tropical Storm
1984	10	18	0600Z	Josephine	44.00	-55.10	25.72	994	Tropical Storm
1985	7	19	0600Z	Ana	46.00	-57.60	28.29	996	Post-Tropical
1989	8	8	1200Z	Dean	46.50	-56.50	28.29	991	Tropical Storm
1990	10	15	0600Z	Lili	46.60	-56.40	20.58	994	Post-Tropical
1991	10	28	1800Z	Not Named	44.00	-59.00	15.43	1006	Post-Tropical
1993	9	10	0000Z	Floyd	43.80	-53.90	33.44	990	Category 1
1994	8	23	1200Z	Chris	42.20	-55.50	23.15	1003	Tropical Storm
1995	8	22	0600Z	Felix	44.50	-55.80	25.72	986	Tropical Storm
1995	9	11	0000Z	Luis	43.90	-57.70	41.16	965	Category 1
1996	9	4	1200Z	Eduoard	43.40	-55.50	25.72	994	Post-Tropical
1996	9	15	1800Z	Hortense	46.00	-55.00	20.58	996	Post-Tropical
1997	7	27	0600Z	Danny	42.80	-56.00	20.58	1004	Post-Tropical
1998	8	30	0600Z	Bonnie	44.30	-57.00	23.15	1000	Tropical Storm
1998	9	3	1200Z	Danielle	43.40	-54.80	36.01	965	Category 1
1998	9	5	1800Z	Earl	45.00	-56.00	25.72	986	Post-Tropical
1999	9	23	0600Z	Gert	44.60	-54.50	30.87	968	Tropical Storm
1999	10	19	0600Z	Irene	44.90	-51.50	41.16	968	Post-Tropical
2000	9	17	1200Z	Florence	42.50	-55.00	25.72	1000	Tropical Storm
2000	9	25	1200Z	Helene	44.00	-55.50	28.29	988	Tropical Storm
2000	10	8	1200Z	Leslie	46.00	-57.00	20.58	1003	Post-Tropical

2000	10	19	1800Z	Michael	44.00	-58.50	43.73	965	Category 2
2001	8	28	0600Z	Dean	43.50	-56.00	28.29	996	Tropical Storm
2001	9	14	1800Z	Erin	44.70	-55.20	33.44	984	Category 1
2001	9	19	1200Z	Gabrielle	43.50	-54.00	30.87	978	Post-Tropical
2002	7	16	1800Z	Arthur	42.50	-54.50	25.72	997	Tropical Storm
2004	8	5	1800Z	Alex	42.70	-55.00	46.30	970	Category 2
2004	9	1	1800Z	Gaston	45.00	-55.00	23.15	998	Post-Tropical
2005	7	30	0600Z	Franklin	44.70	-54.60	23.15	1003	Post-Tropical
2005	9	18	1200Z	Ophelia	46.20	-59.90	23.15	1000	Post-Tropical
2005	10	26	1200Z	Wilma	45.00	-55.00	25.72	986	Post-Tropical
2006	6	16	0600Z	Alberto	46.00	-58.50	25.72	972	Post-Tropical
2006	7	18	1200Z	Not Named	45.50	-58.00	15.43	1007	Tropical Low
2006	9	13	1200Z	Florence	45.50	-55.60	36.01	967	Post-Tropical
2006	10	2	1800Z	Isaac	45.50	-53.70	28.29	995	Tropical Storm
2007	8	1	1200Z	Chantal	46.00	-54.50	28.29	990	Post-Tropical

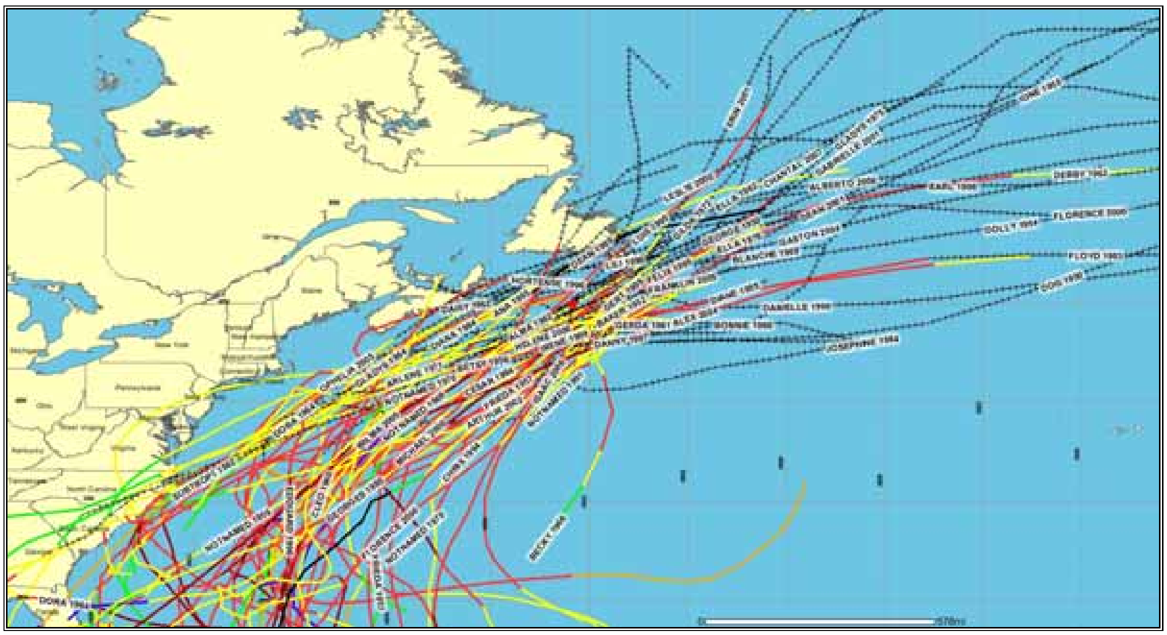

Figure 1.10 Storm Tracks of Tropical Systems Passing within 278 km of 45.00ºN, 56.00ºW, 1950 to 2007

2.0 Climate Variability

Climate is naturally variable and can change over a range of time scales from the very short term, to seasonally, and to longer time periods in response to small and large-scale changes of atmospheric circulation patterns. Short-term meteorological variations are largely a consequence of the passage of synoptic scale weather systems: low pressure systems, high pressure systems, troughs and ridges. The energetics of these features varies seasonally in accordance with the changes in the strength of the mean tropical - polar temperature gradient. Long-term changes occur in response to small and large-scale changes of atmospheric circulation patterns and in the past in the Northern Hemisphere were mainly the result of changes in the North Atlantic Oscillation (NAO). While the NAO still has an effect on climate patterns, there is a general consensus amongst the scientific community that Greenhouse Gas emissions have played a significant role in the climate during the last 50 years. However, the high degree of climate variation naturally experienced makes it difficult to identify, with any degree of certainty, trends that are a direct result of climate change (Environment Canada, 1997).

The dominate features of the mean sea level pressure pattern in the North Atlantic Ocean are the semi-permanent area of relatively low pressure in the vicinity of Iceland and the sub-tropical high pressure region near the Azores. The relative strengths of these two systems control the strength and direction of westerly winds and storm tracks in the North Atlantic and therefore play a significant role in the climate of the North Atlantic. The fluctuating pressure difference between these two features is known as the North Atlantic Oscillation (NAO).

A measure of the North Atlantic Oscillation is the NAO Index, which is the normalized difference in pressure between the Icelandic low and the Azores high. A large difference in pressure results in a positive NAO Index and can be the result of a stronger than normal subtropical high, a deeper than normal sub-polar low, or a combination of both. A time-series of the Winter (DJF) North Atlantic Oscillation Index is presented in Figure 2.1 and shows that during the period of 1950 – 2009 there is a general trend towards increasing NAO Index indicating that in recent years either the Icelandic low is deeper or the Azores high is stronger than on average. This trend is also present in the Summer (JJA) North Atlantic Oscillation index, albeit significantly weaker.

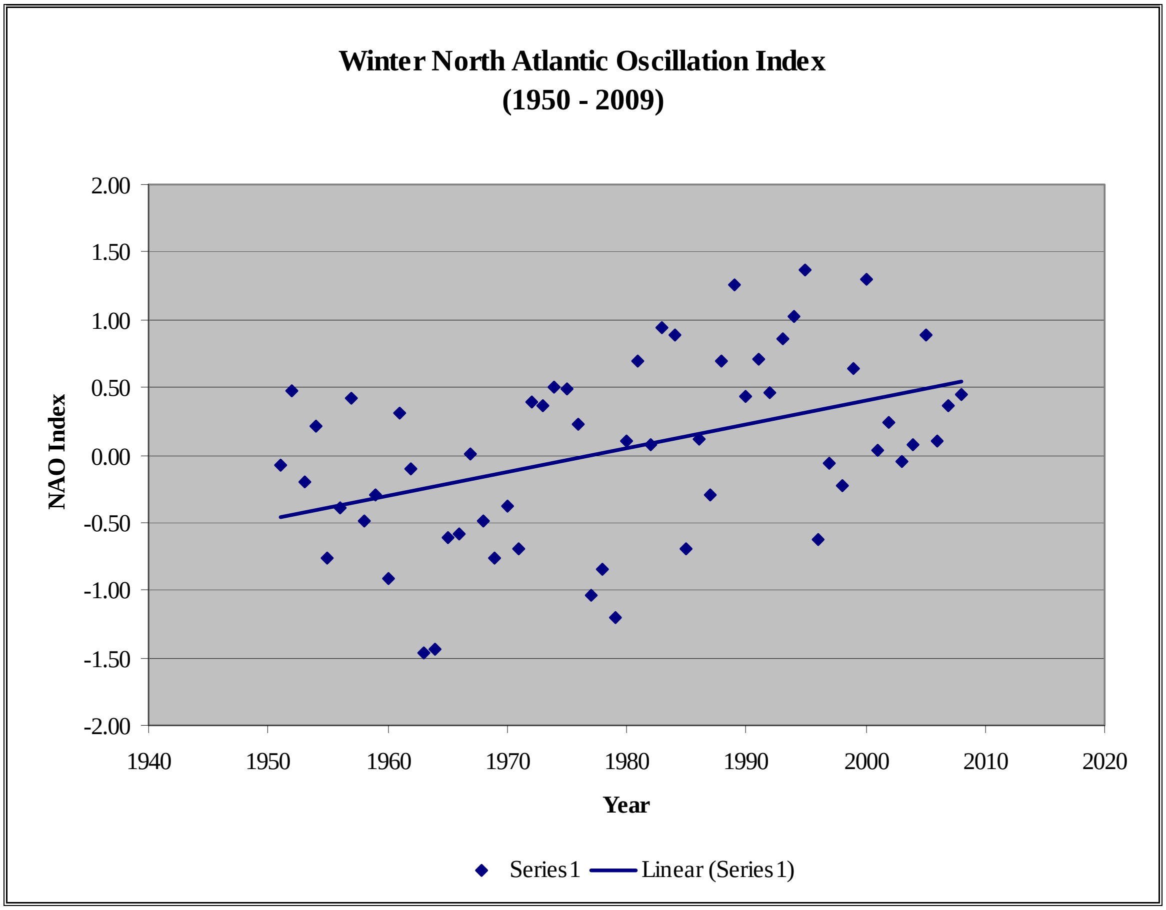

Figure 2.1 Winter North Atlantic Oscillation Index (1950 - 2009)

In general, over the Northwest Atlantic during the winter season, a positive NAO index brings with it an increase in frequency and strength of westerly winds in the upper atmosphere, which tends to steer storm systems in a more west to east direction. As a result, a positive NAO index results in an increase in storm systems coming off of the continent resulting in colder temperatures, increased precipitation, and relatively stronger winds. Due to the weaker trend in NAO index and other atmospheric patterns however, conclusions could not be drawn about correlations between summer NAO indices and temperature, precipitation and winds during the summer months.

During the summer months, the NAO index has a less direct effect on the climate of Eastern Canada; however, studies have shown that the NAO has an effect on the track of hurricanes in the North Atlantic. During seasons with a negative NAO index, hurricanes tend to favour a track that parallels lines of latitude often ending up in the Gulf of Mexico and the Caribbean (Elsner, 2003), while during seasons with a positive NAO index, hurricanes tend to curve northward (Elsner & Bosak, 2004) along the United States Eastern Seaboard.

3.0 Wind and Wave Extreme Value Analysis

An analysis of extreme wind and waves was performed using Grid Point 7966 of the MSC50 data set. This data set was determined to be the most representative of the available datasets, as it provides a continuous 52-year period of hourly data for the study area. The extreme values for wind and waves were calculated using the peak-over-threshold method, and after considering four different distributions, the Gumbel distribution was chosen to be the most representative as it provided the best fit to the data.

Since extreme values can vary depending on how well the data fits the distribution, a sensitivity analysis was carried out to determine the number storms to use. The number of storms determined to provide the best fit annually and monthly for each grid point is presented in Table 3.1.

Based on a recent Oceanweather study known as GUEST (Grid to Eulerian Wind Speed Transformation), a 15% increase should be applied in extreme speed estimates to convert the hindcast 1hr/10m winds to true 1hr/10m winds.

The wave and wind extreme value analysis results presented in this report are generally representative of the lease block area but are not necessarily suitable for site-specific metocean criteria at any given location within the lease block.

Table 3.1 Number of Storms Providing Best Fit for Extreme Value Analysis of Winds and Waves

		Annually	Monthly
Grid Point 7966	Wind	555	130
	Wave	271	62

3.1 Extreme Value Estimates for Winds from the Gumbel Distribution

The extreme value estimates for wind were calculated for the return periods of 1-year, 10-years, 25-years, 50-years and 100-years. The calculated annual and monthly values for 1-hour, 10-minutes and 1-minute are presented in Table 3.2 to Table 3.4. The analysis used hourly mean wind values for the reference height of 10-meters above sea level. These values were converted to 10-minute and 1-minute wind values using a constant ration of 1.06 and 1.22, respectively (U.S. Geological Survey 1979). The annual 100-year extreme 1-hour wind speed was determined to be 31.4 m/s for grid point 7966. Monthly, the highest extreme winds occur during January having 100-year extreme wind estimates of 29.5 m/s.

Table 3.2 1-hr Extreme Wind Speed Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	GridPoint #7966				
Period	**1**	**10**	**25**	**50**	**100**
January	22.3	26.0	27.4	28.4	29.5
February	21.7	25.6	27.1	28.1	29.2
March	20.9	25.1	26.6	27.8	28.9
April	18.2	21.7	23.0	23.9	24.9
May	15.9	19.9	21.4	22.4	23.5
June	14.3	18.0	19.4	20.4	21.4
July	13.0	16.3	17.6	18.5	19.4
August	13.8	17.9	19.4	20.5	21.6
September	16.9	22.7	24.8	26.4	28.0
October	18.7	23.9	25.8	27.3	28.7
November	20.0	24.2	25.6	26.8	27.9
December	21.9	25.6	26.9	27.9	28.9
Annual	24.5	28.0	29.4	30.4	31.4

Table 3.3 10-min Extreme Wind Speed Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	GridPoint #7966				
Month	**1**	**10**	**25**	**50**	**100**
January	23.4	27.1	28.3	29.3	30.2
February	23.2	28.4	30.0	31.3	32.6
March	21.2	25.9	27.5	28.7	29.8
April	19.1	23.5	24.9	26.0	27.1
May	16.2	20.3	21.7	22.7	23.7
June	14.9	18.7	19.9	20.9	21.8
July	13.7	18.1	19.5	20.6	21.6
August	14.5	21.8	24.3	26.1	27.9
September	17.7	23.3	25.2	26.6	27.9
October	18.9	24.7	26.6	28.0	29.4
November	20.7	25.8	27.5	28.8	30.0
December	22.7	27.8	29.4	30.7	31.9
Annual	26.2	29.8	31.2	32.3	33.4

Table 3.4 1-min Extreme Wind Speed Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	GridPoint #7966				
Month	**1**	**10**	**25**	**50**	**100**
January	27.2	31.8	33.4	34.7	35.9
February	26.5	31.3	33.0	34.3	35.6
March	25.5	30.6	32.5	33.9	35.3
April	22.2	26.5	28.0	29.2	30.4
May	19.4	24.3	26.0	27.4	28.7
June	17.4	22.0	23.7	24.9	26.2
July	15.8	19.9	21.4	22.6	23.7

August	16.8	21.8	23.6	25.0	26.3
September	20.6	27.7	30.3	32.2	34.1
October	22.8	29.2	31.5	33.2	35.0
November	24.4	29.5	31.3	32.6	34.0
December	26.8	31.2	32.8	34.1	35.3
Annual	29.9	34.2	35.8	37.1	38.3

3.2 Extreme Value Estimates for Waves from a Gumbel Distribution

The annual and monthly extreme value estimates for significant wave height for return periods of 1-year, 10-years, 25-years, 50-years and 100-years are given in Table 3.5. The annual 100-year extreme significant wave height was determined to be 13.0 m at grid point 7966. On a monthly basis, the highest 100-year extreme wave height occurs in January and was estimated to be 12.3 m. This corresponds with the maximum wave height of 12.2 m which occurs in the Osmosis data set on January 14, 2002.

Table 3.5 Extreme Significant Wave Height Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	Grid Point #7966				
Month	**1**	**10**	**25**	**50**	**100**
January	8.2	10.5	11.2	11.8	12.3
February	7.4	10.1	10.9	11.5	12.1
March	6.8	9.4	10.2	10.8	11.4
April	5.5	7.5	8.2	8.6	9.1
May	4.3	6.7	7.5	8.0	8.6
June	3.6	5.3	5.9	6.3	6.7
July	3.1	5.2	5.8	6.3	6.8
August	3.5	5.9	6.6	7.2	7.7
September	4.6	7.9	8.9	9.6	10.4
October	5.7	8.7	9.7	10.4	11.1
November	6.7	9.6	10.5	11.1	11.8
December	8.0	10.2	10.9	11.4	12.0
Annual	9.5	11.3	12.0	12.5	13.0

The maximum individual wave heights were calculated within Oceanweather's OSMOSIS software by evaluating the Borgman integral (Borgman 1973), which was derived from a Raleigh distribution function. The variant of this equation used in the software has the following form (Forristall, 1978):

$$\Pr\{H > h\} = \exp\left[-1.08311\left(\frac{h^2}{8M_0}\right)^{1.063}\right]; \quad T = \frac{M_0}{M_1}$$

where h is the significant wave height, T is the wave period, and M_0 and M_1 are the first and second spectral moments of the total spectrum. The associated peak periods are calculated by plotting the peak periods of the chosen storm peak values versus the corresponding significant wave heights. This plot is fitted to a power function ($y = ax^b$), and the resulting equation is used to calculate the peak periods associated with the extreme values of significant wave height. The maximum individual wave heights and extreme associated peak periods are presented in Table 3.6 and Table 3.7. Maximum individual wave heights and the extreme associated peak periods peak during the month of January.

Table 3.6 Extreme Maximum Wave Height Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	Grid Point #7966				
Month	**1**	**10**	**25**	**50**	**100**
January	15.1	19.5	20.8	21.8	22.8
February	13.6	18.7	20.2	21.3	22.4
March	12.7	17.9	19.5	20.7	21.9
April	10.3	13.9	15.0	15.9	16.7
May	8.3	12.6	13.9	14.9	15.9
June	6.8	10.0	11.0	11.7	12.5
July	6.0	9.4	10.5	11.3	12.1
August	6.7	10.8	12.0	12.9	13.9
September	8.6	14.4	16.1	17.5	18.8
October	10.5	16.8	18.8	20.2	21.7
November	12.4	17.6	19.2	20.4	21.6
December	14.7	18.9	20.2	21.1	22.1
Annual	17.5	20.9	22.2	23.2	24.2

Table 3.7 Extreme Associated Peak Period Estimates for Return Periods of 1, 10, 25, 50 and 100 Years

	Grid Point #7966				
Month	**1**	**10**	**25**	**50**	**100**
January	12.1	13.6	14.0	14.3	14.6
February	11.4	13.2	13.7	14.1	14.5
March	11.2	12.6	13.0	13.3	13.5
April	10.3	11.8	12.2	12.5	12.8
May	9.5	11.2	11.7	12.0	12.3
June	8.7	10.2	10.6	10.9	11.1
July	8.5	10.9	11.6	12.1	12.5
August	8.9	11.5	12.2	12.7	13.2
September	9.5	12.1	12.8	13.3	13.7
October	11.5	14.0	14.6	15.1	15.5
November	11.2	12.8	13.2	13.5	13.8
December	11.8	13.0	13.4	13.6	13.9
Annual	12.8	13.7	14.0	14.2	14.4

3.3 Joint Probability of Extreme Wave Heights and Spectral Peak Periods

A contour plot depicting the joint wave height and period combinations values for return periods of 1-year, 10-years, 25-years, 50-years and 100-years is presented in Figure 3.1. The annual values for the significant wave height estimates and the associated spectral peak periods are given in Table 3.8. The extreme wave height for all return periods was higher using the Weibull Distribution when compared to the Gumbel Distribution.

Table 3.8 Annual Extreme Significant Wave Estimates and Spectral Peak Periods for Return Periods of 1, 10, 25, 50 and 100 Years

	Return Period (years)	Significant Wave Height (m)	Spectral Peak Period Median Value (s)
Grid point 7966	1	10.3	13.2
	10	12.3	14.5
	25	13.0	15.0
	50	13.6	15.4
	100	14.1	15.8

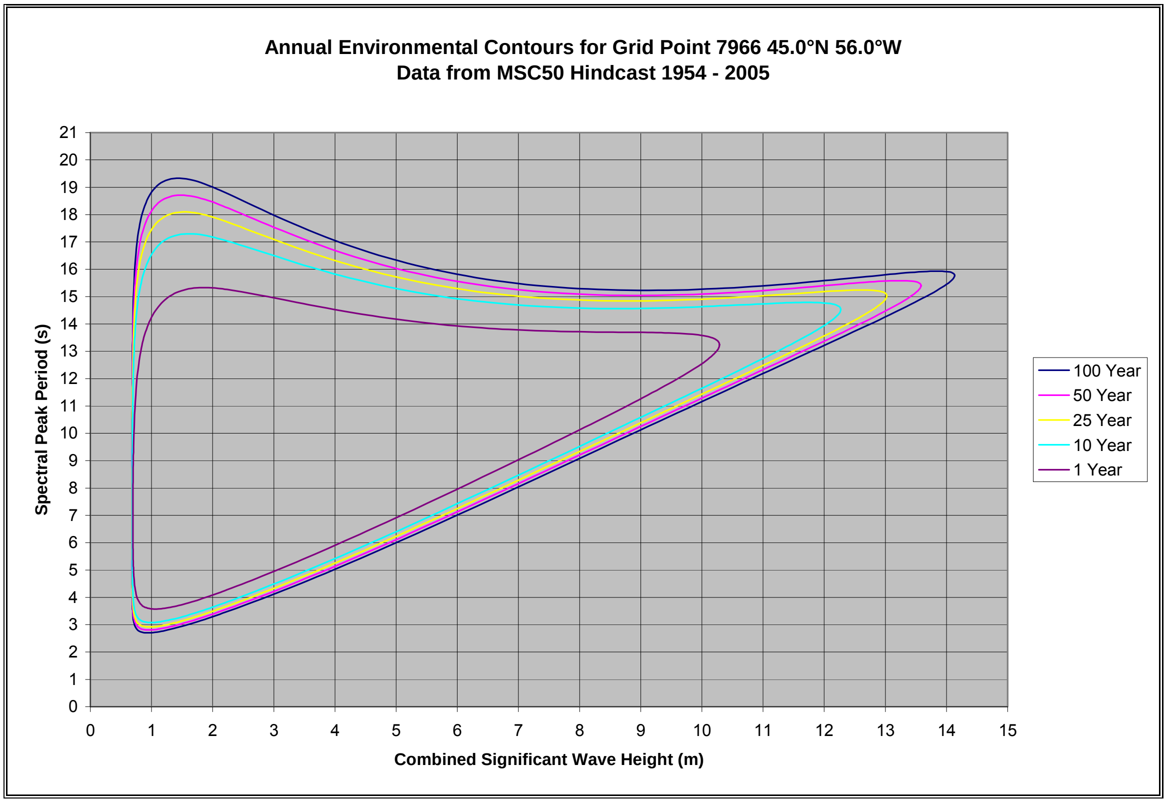

Figure 3.1 Environmental Contour Plot for Grid Point 7966 (45.0°N 56.0°W)

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Appendix 1a

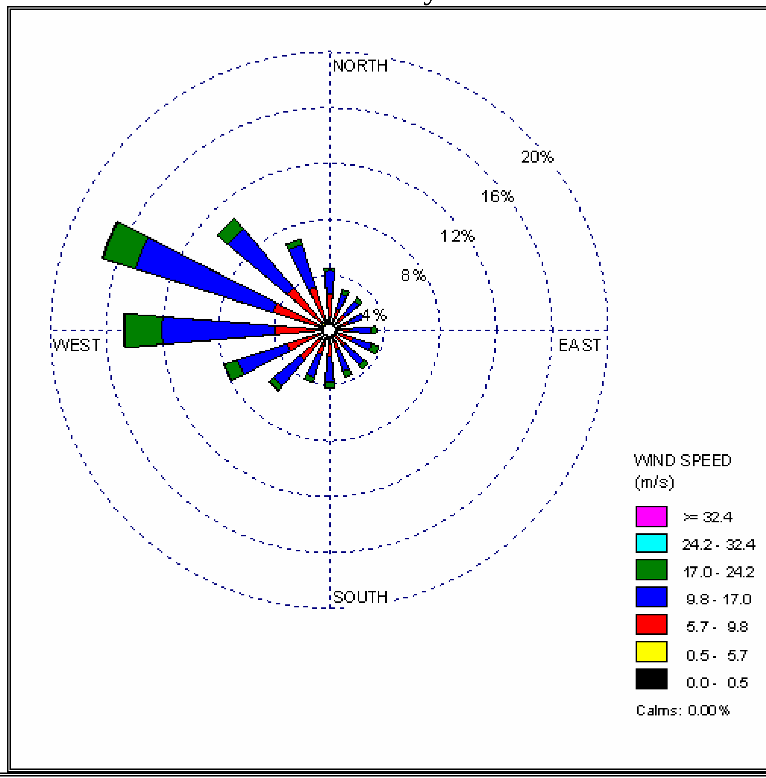
Wind Roses

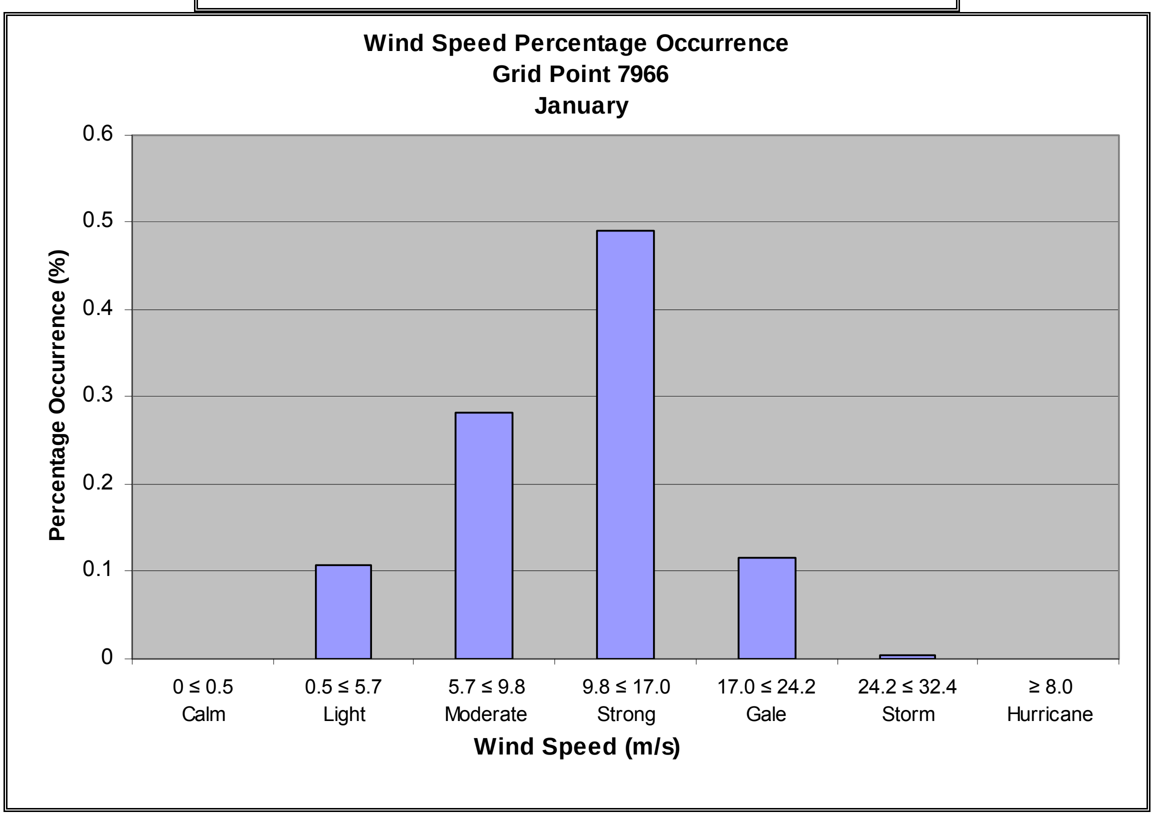
And

Wind Speed Frequency Distributions

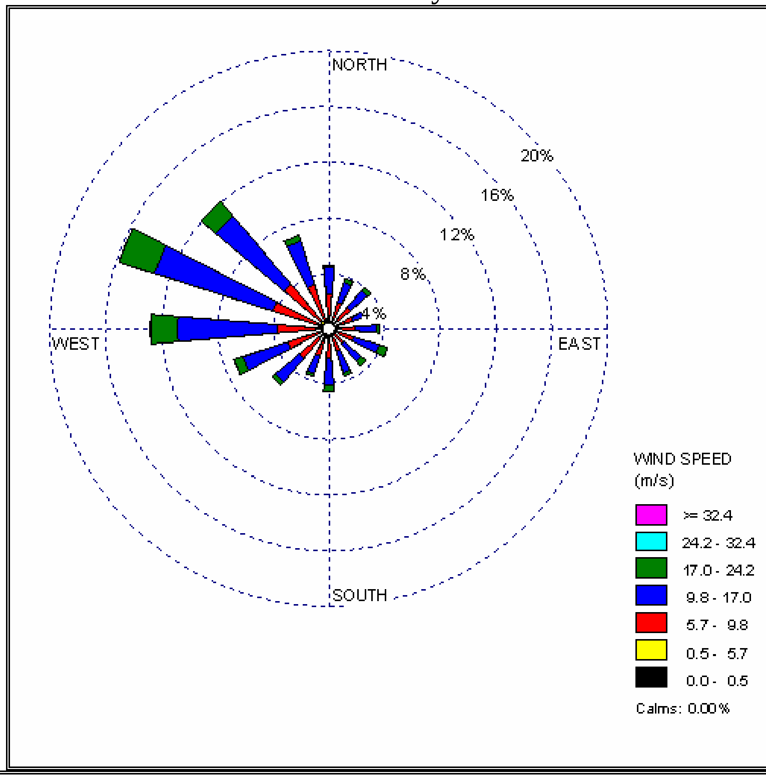
for MSC50 GridPoint 7966

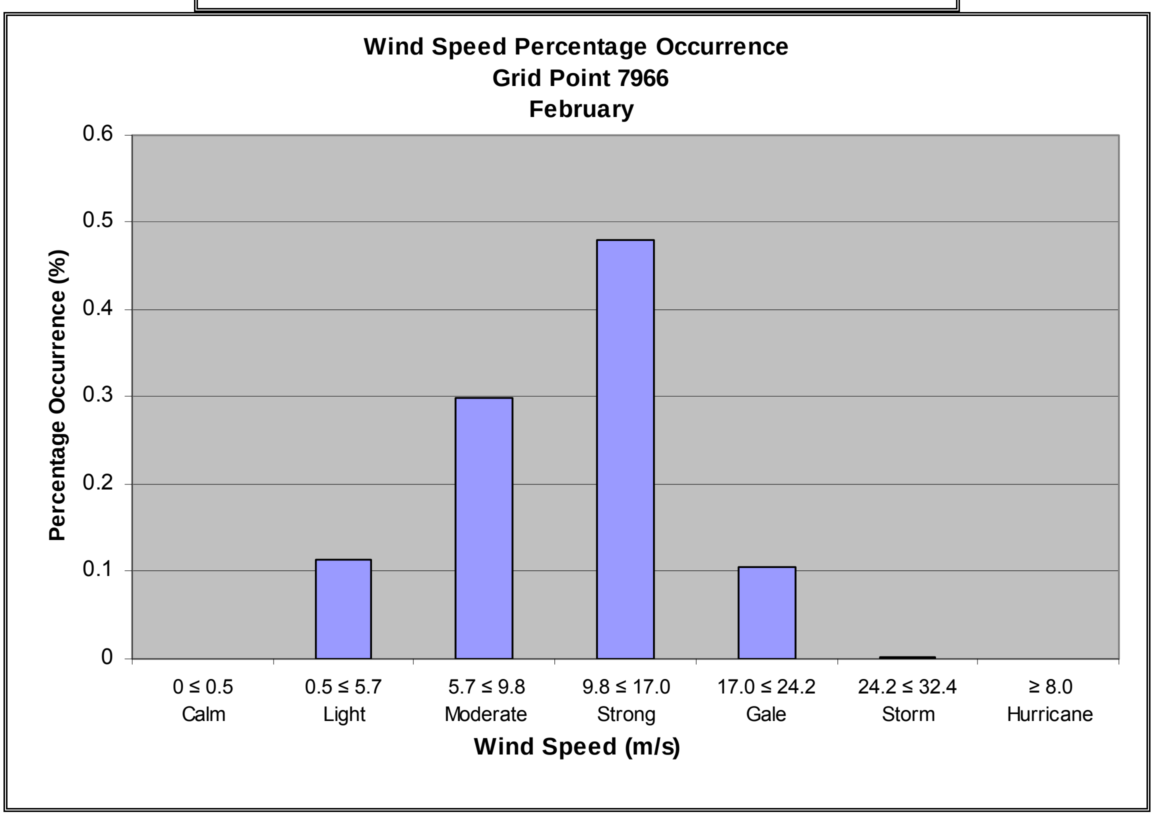
January


NORTH
SOUTH
EAST
WEST
4%
8%
12%
16%
20%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

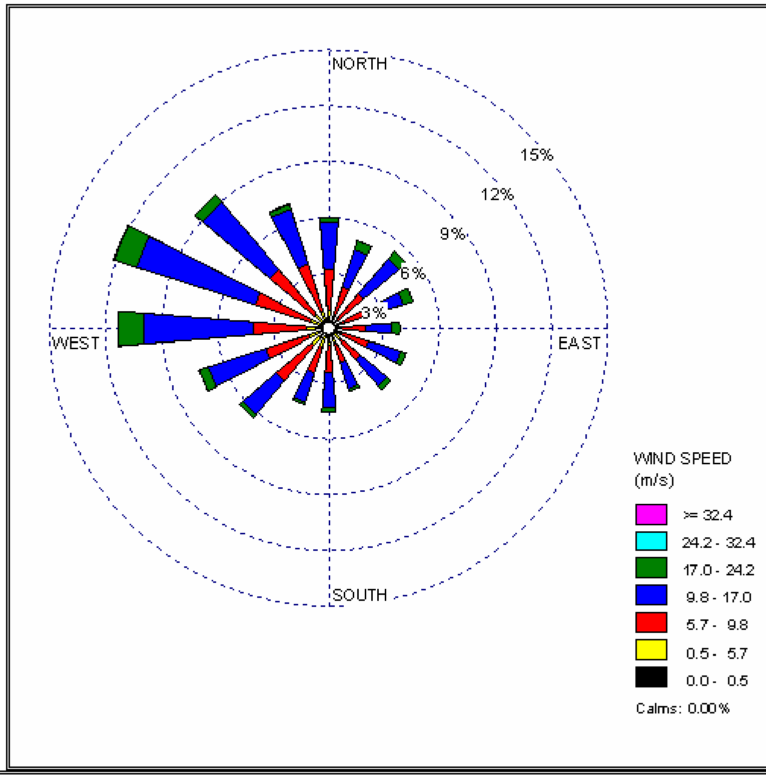

Wind Speed Percentage Occurrence
Grid Point 7966
January
Percentage Occurrence (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
0 ≤ 0.5 Calm
0.5 ≤ 5.7 Light
5.7 ≤ 9.8 Moderate
9.8 ≤ 17.0 Strong
17.0 ≤ 24.2 Gale
24.2 ≤ 32.4 Storm
≥ 8.0 Hurricane
Wind Speed (m/s)

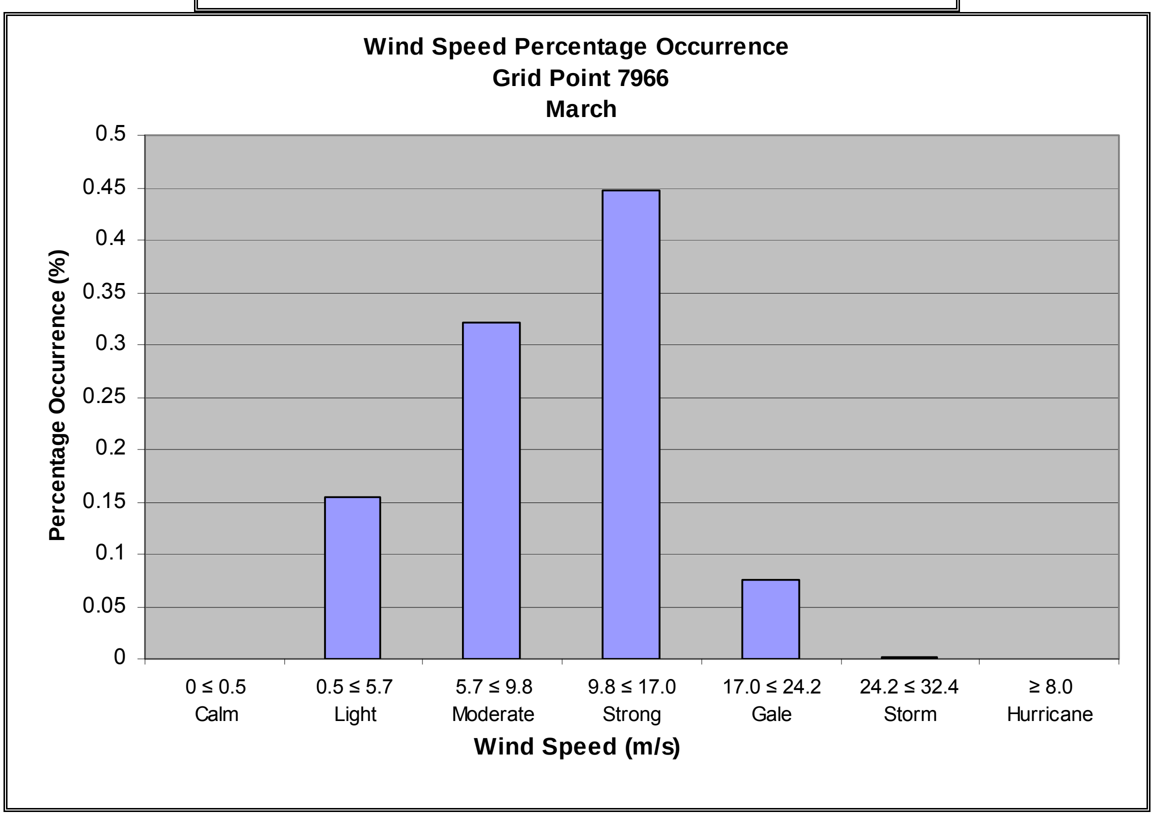
February


NORTH
SOUTH
WEST
EAST
4%
8%
12%
16%
20%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

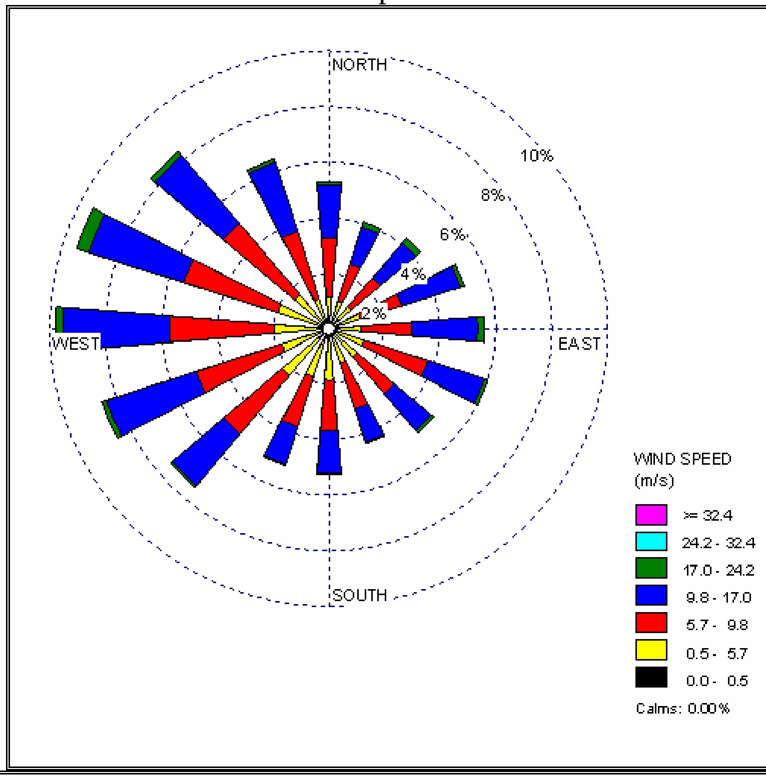

Wind Speed Percentage Occurrence
Grid Point 7966
February
Percentage Occurrence (%)
0
0.1
0.2
0.3
0.4
0.5
0.6
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

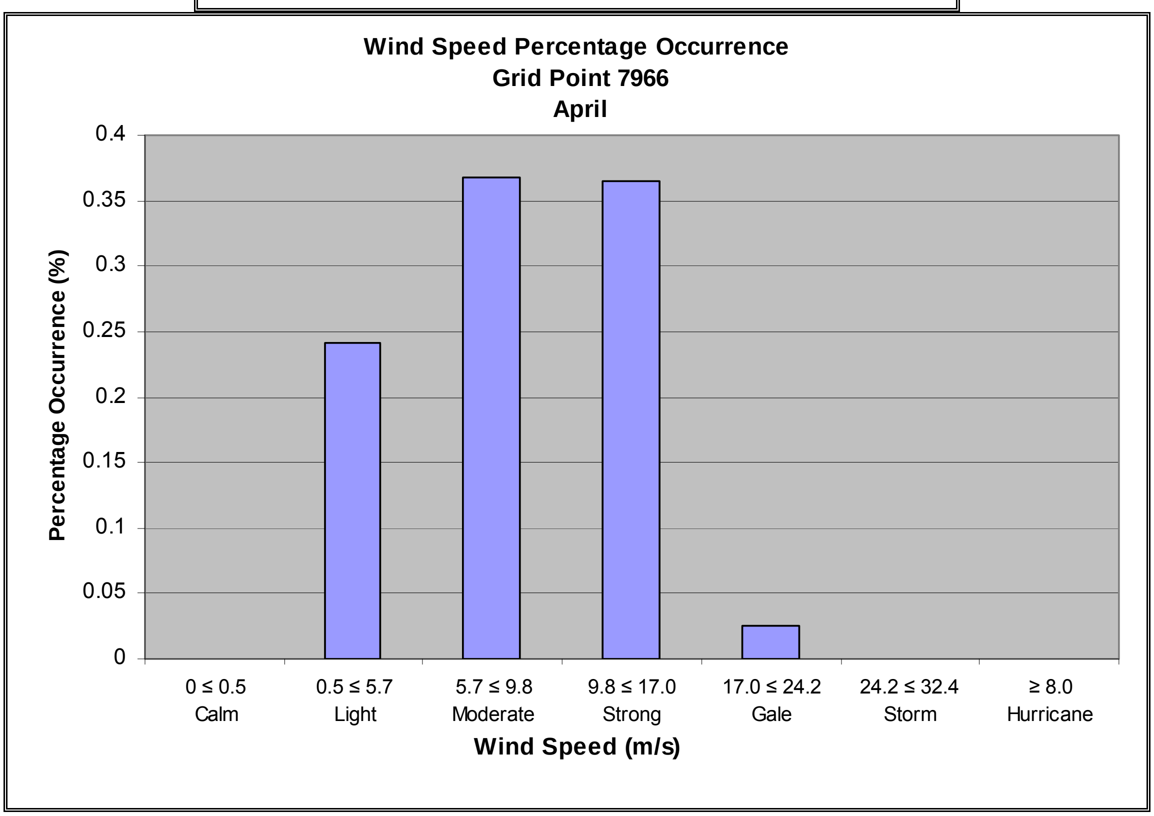
March


NORTH
SOUTH
WEST
EAST
15%
12%
9%
6%
3%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

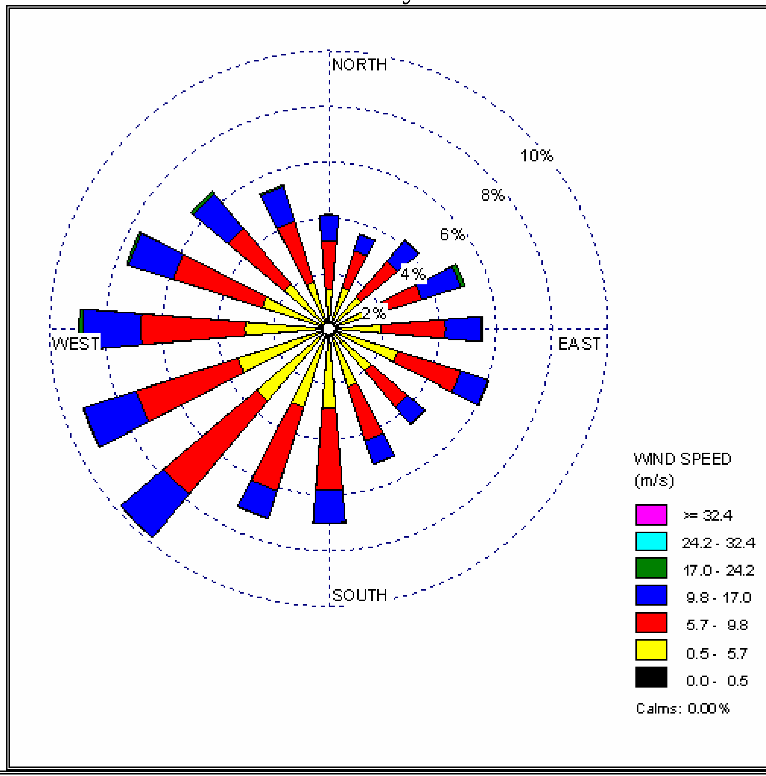

Wind Speed Percentage Occurrence
Grid Point 7966
March
Percentage Occurrence (%)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5 Calm
0.5 ≤ 5.7 Light
5.7 ≤ 9.8 Moderate
9.8 ≤ 17.0 Strong
17.0 ≤ 24.2 Gale
24.2 ≤ 32.4 Storm
≥ 8.0 Hurricane
Wind Speed (m/s)

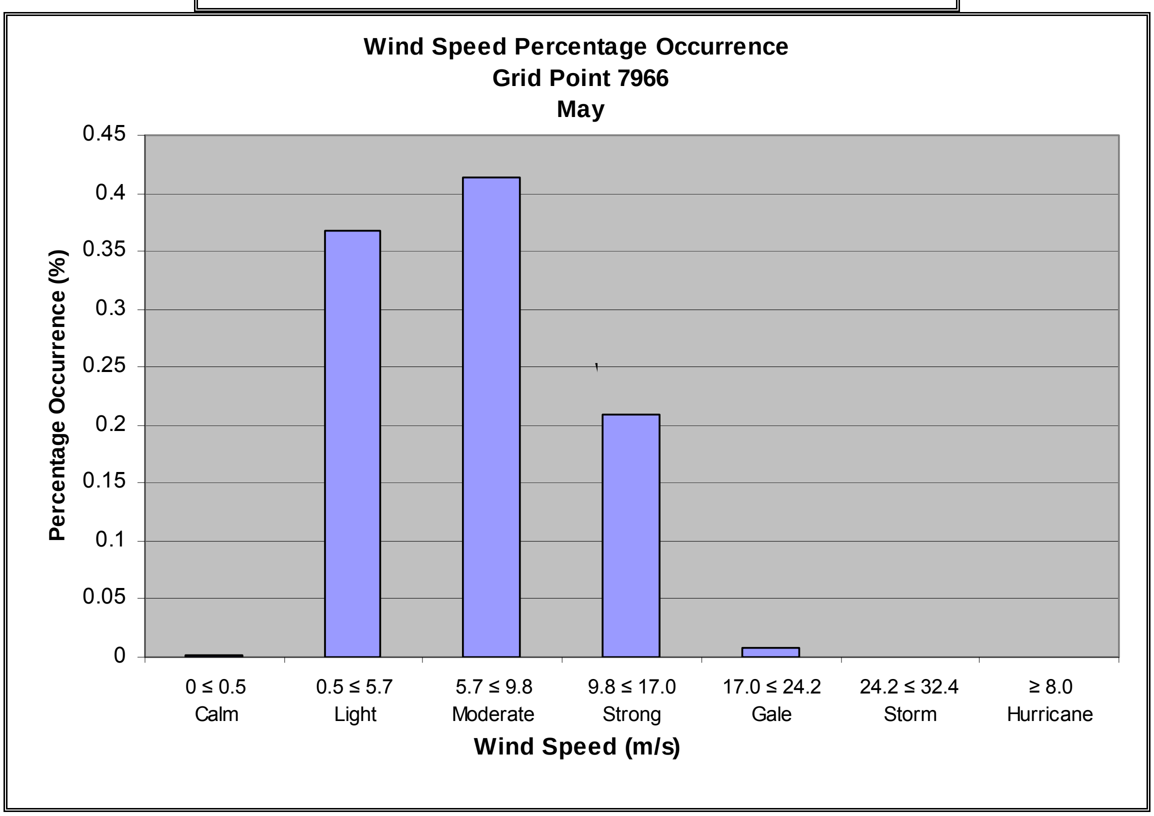
April


NORTH
SOUTH
EAST
WEST
2%
4%
6%
8%
10%
WIND SPEED (m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

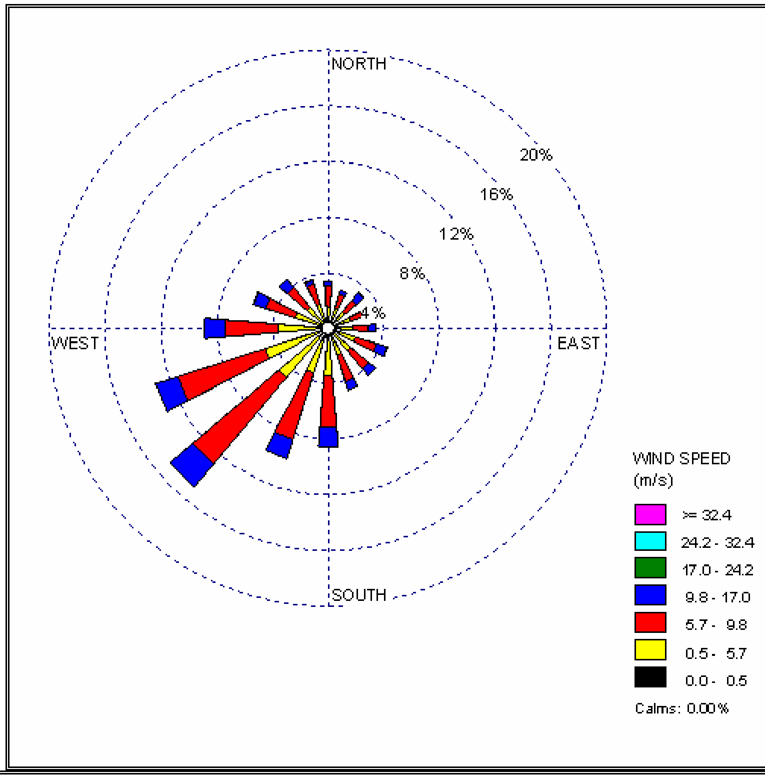

Wind Speed Percentage Occurrence
Grid Point 7966
April
Percentage Occurrence (%)
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5 Calm
0.5 ≤ 5.7 Light
5.7 ≤ 9.8 Moderate
9.8 ≤ 17.0 Strong
17.0 ≤ 24.2 Gale
24.2 ≤ 32.4 Storm
≥ 8.0 Hurricane
Wind Speed (m/s)

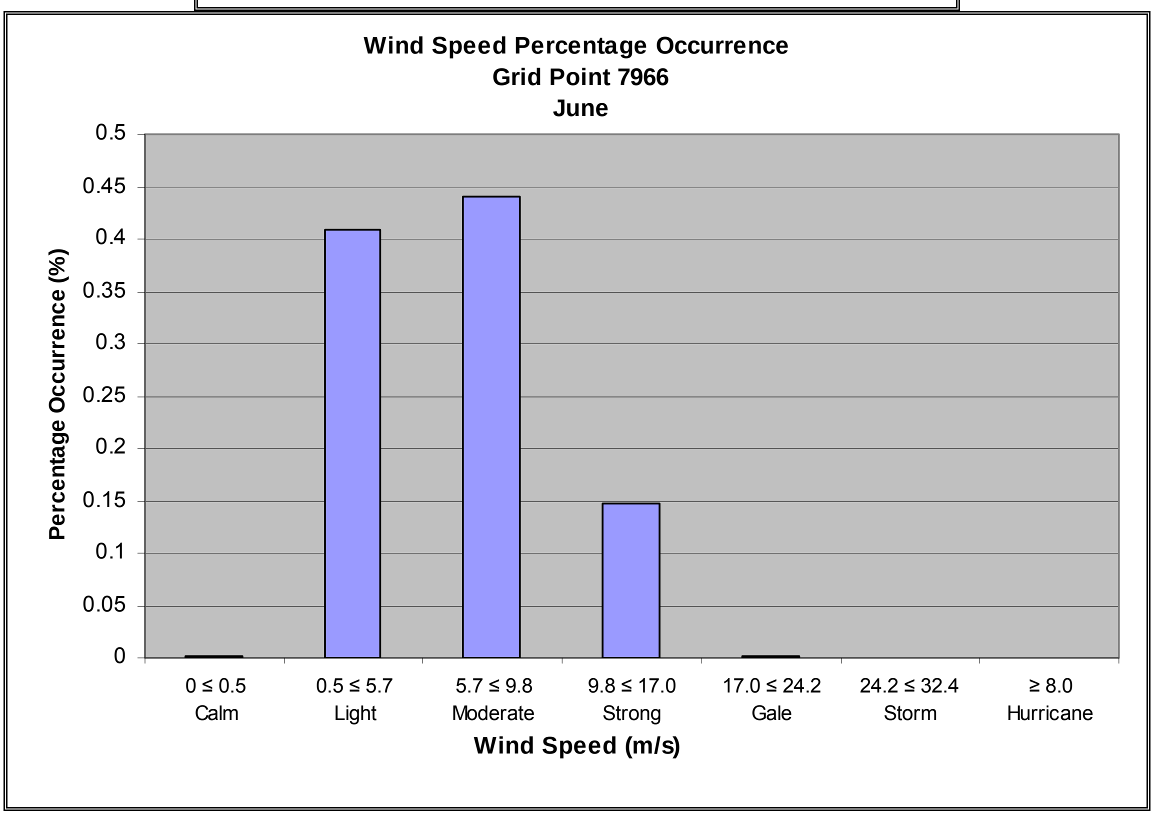
May


NORTH
SOUTH
WEST
EAST
10%
8%
6%
4%
2%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

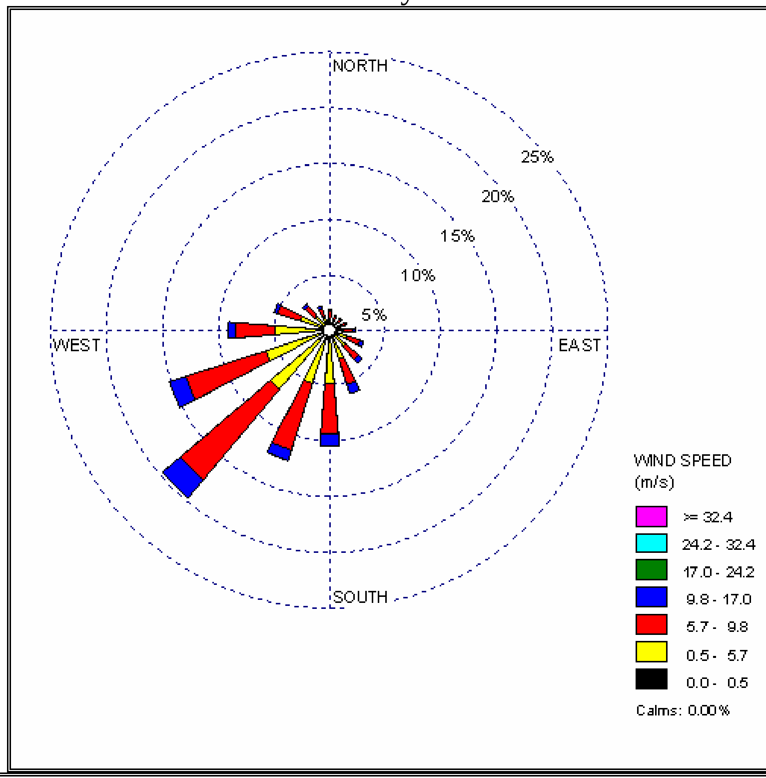

Wind Speed Percentage Occurrence
Grid Point 7966
May
Percentage Occurrence (%)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5 Calm
0.5 ≤ 5.7 Light
5.7 ≤ 9.8 Moderate
9.8 ≤ 17.0 Strong
17.0 ≤ 24.2 Gale
24.2 ≤ 32.4 Storm
≥ 8.0 Hurricane
Wind Speed (m/s)

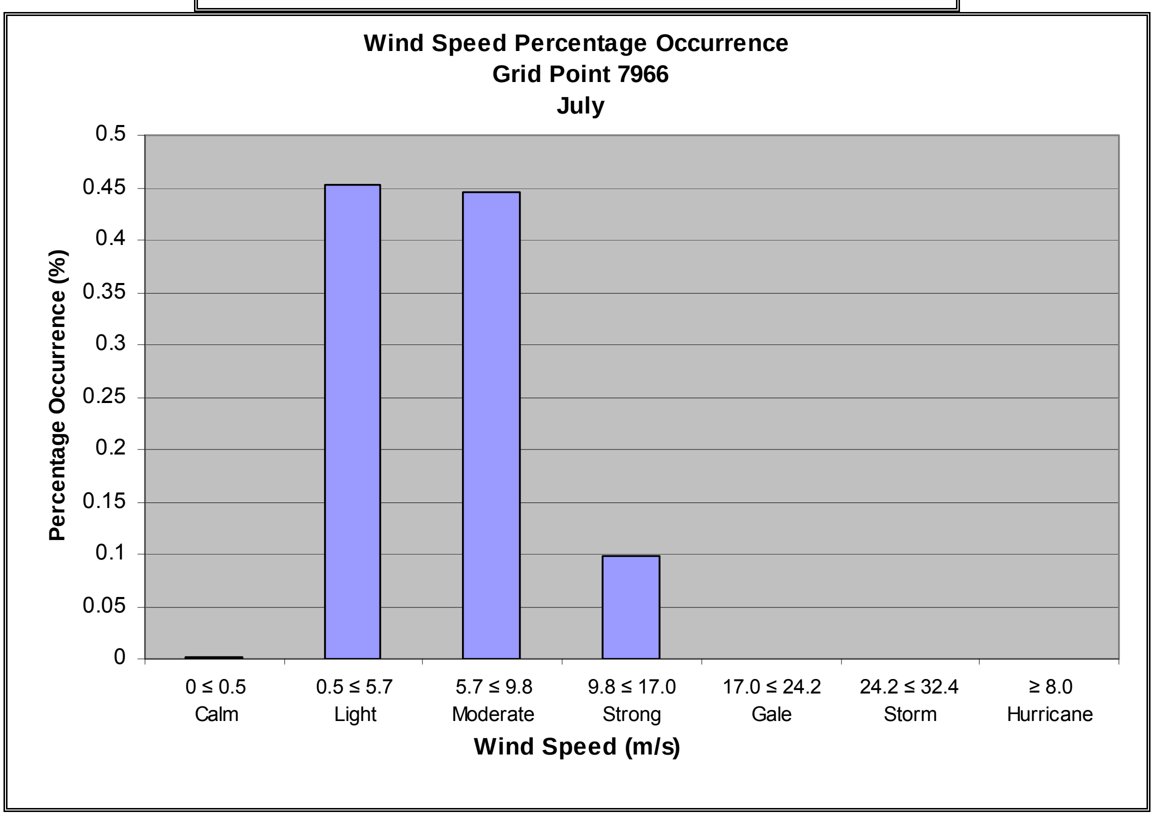
June


NORTH
SOUTH
WEST
EAST
20%
16%
12%
8%
4%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

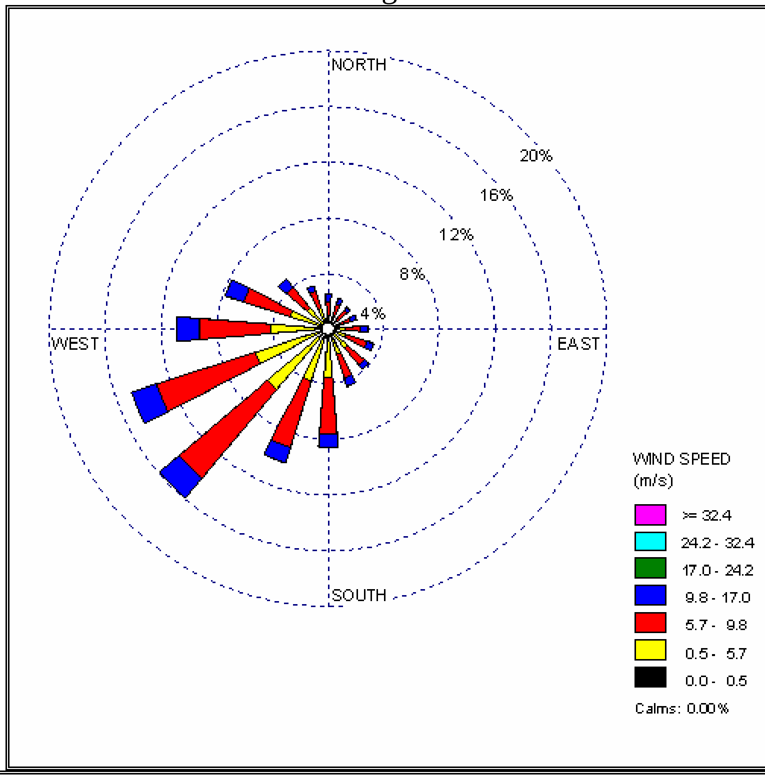

Wind Speed Percentage Occurrence
Grid Point 7966
June
Percentage Occurrence (%)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

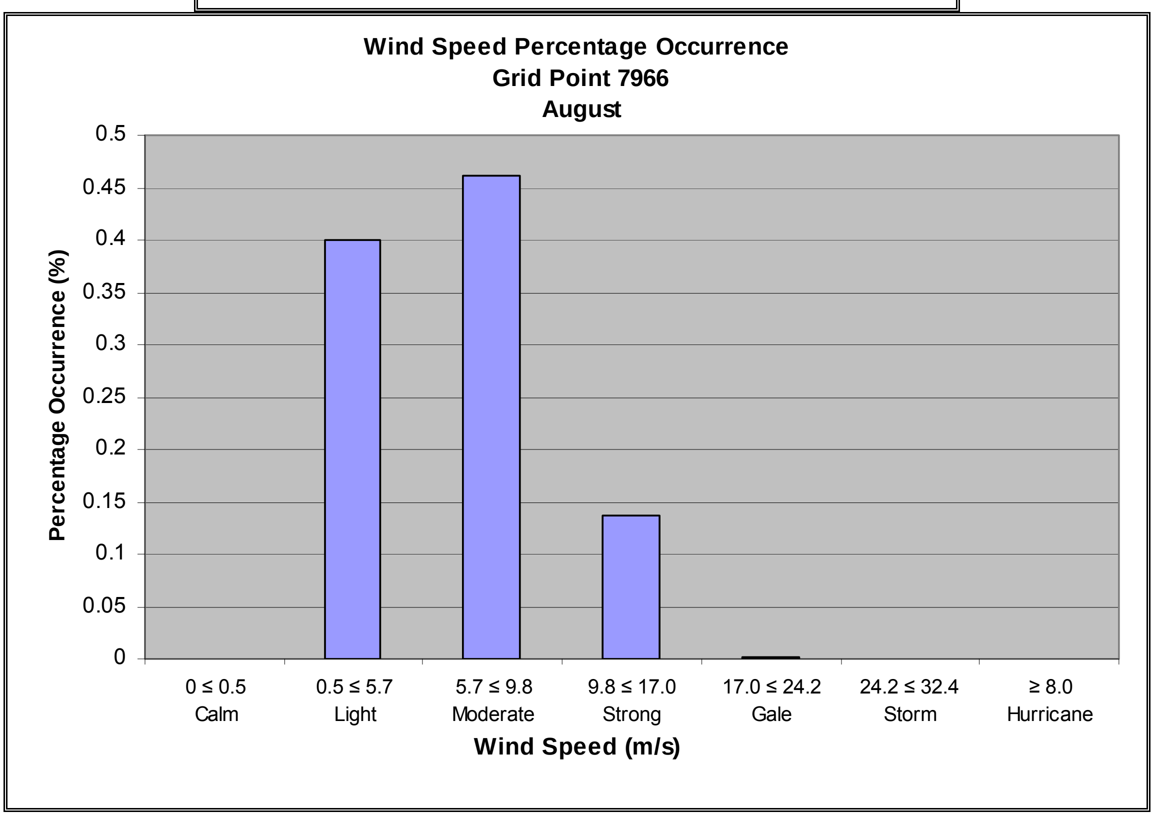
July


NORTH
SOUTH
WEST
EAST
5%
10%
15%
20%
25%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%


Wind Speed Percentage Occurrence
Grid Point 7966
July
Percentage Occurrence (%)
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

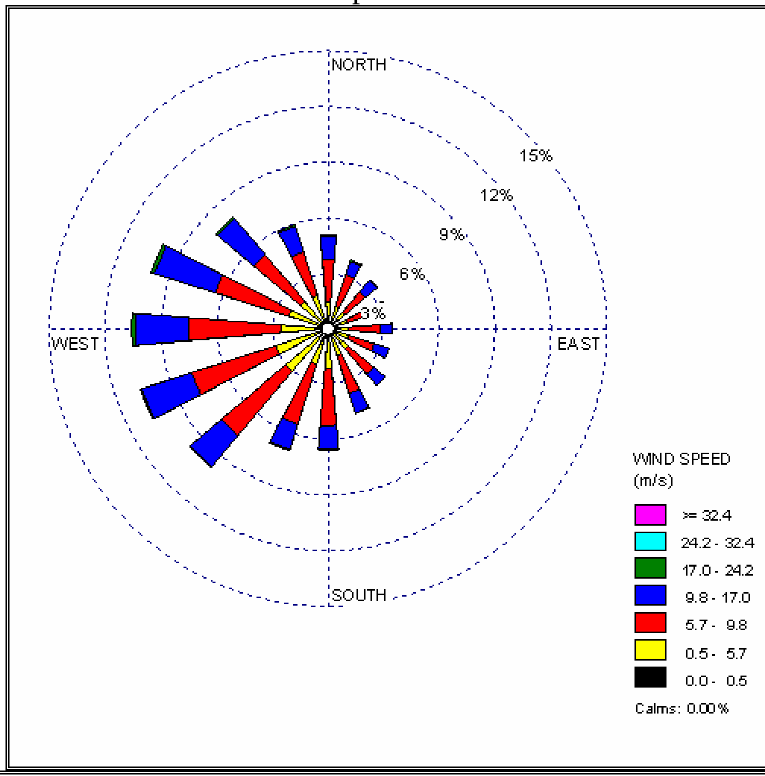
August

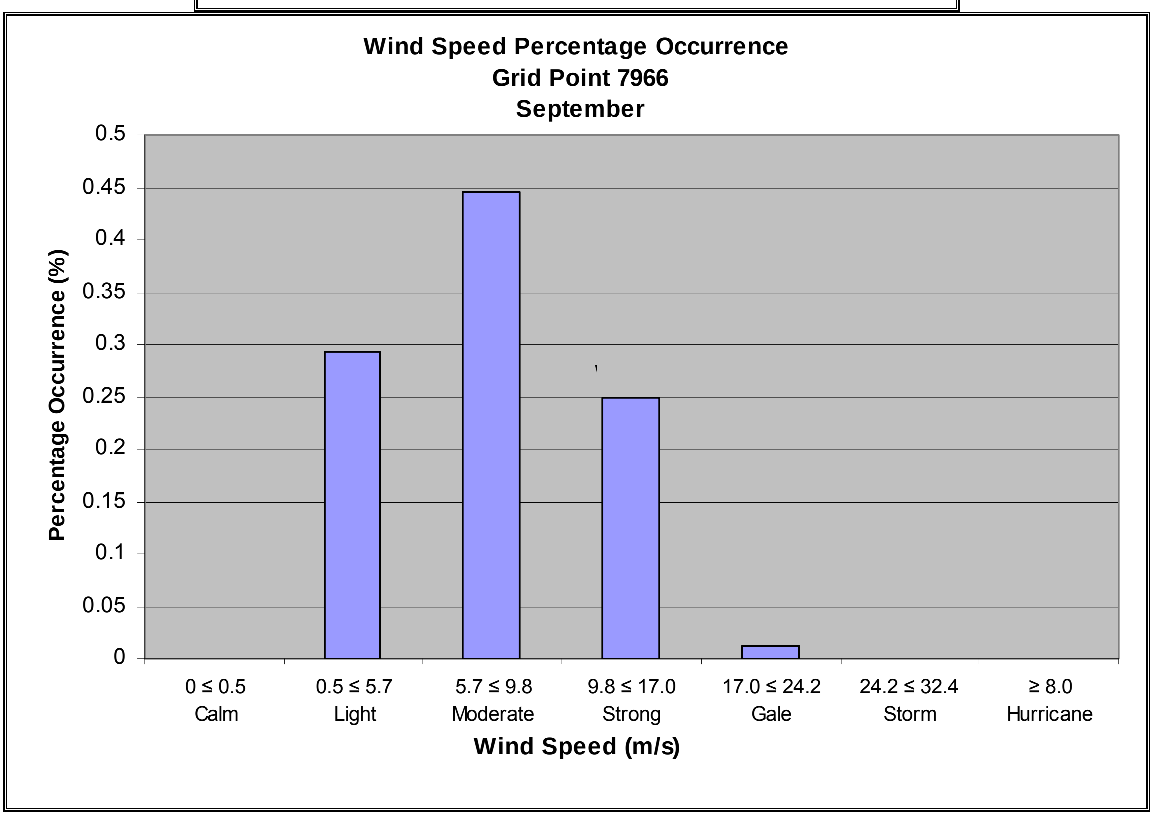




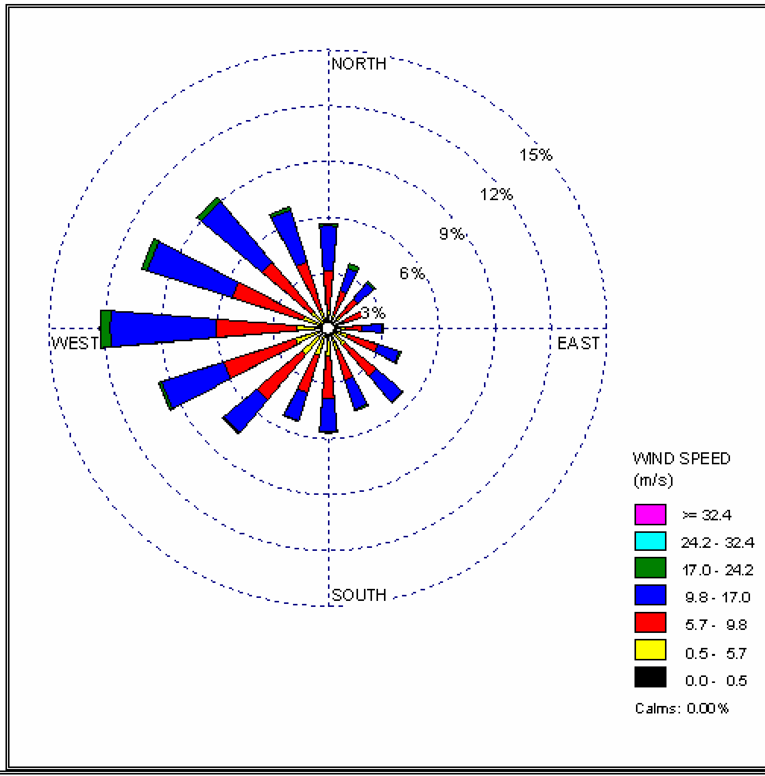
Oceans LTD.

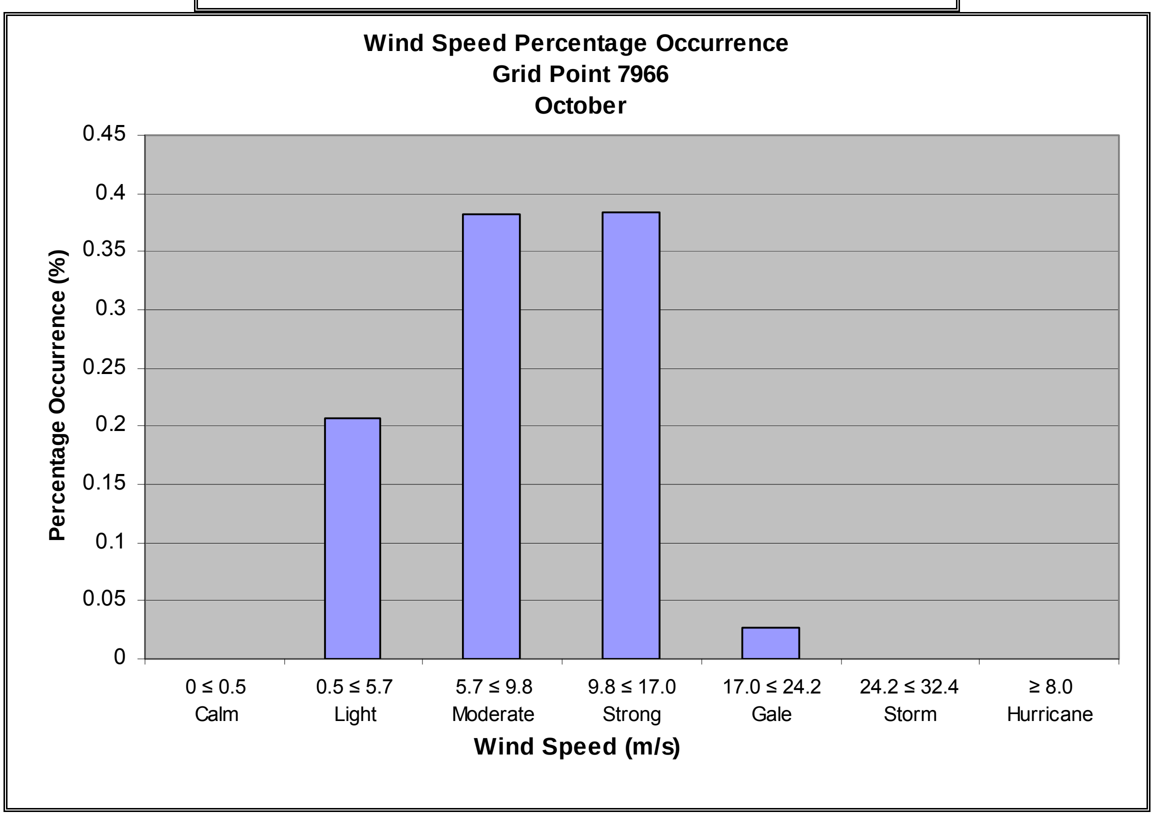
September


NORTH
15%
12%
9%
6%
3%
WEST
EAST
SOUTH
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

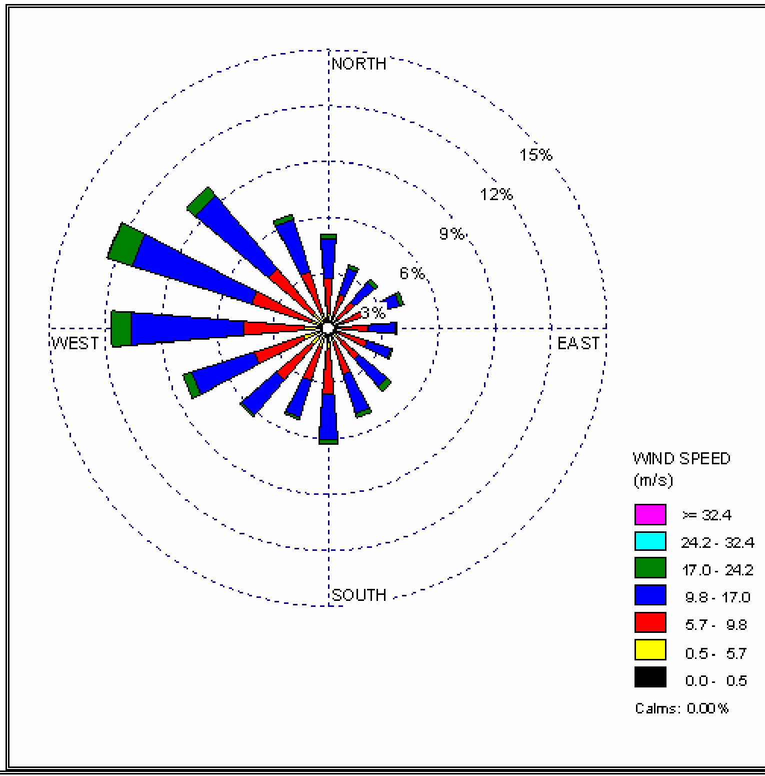

Wind Speed Percentage Occurrence
Grid Point 7966
September
Percentage Occurrence (%)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

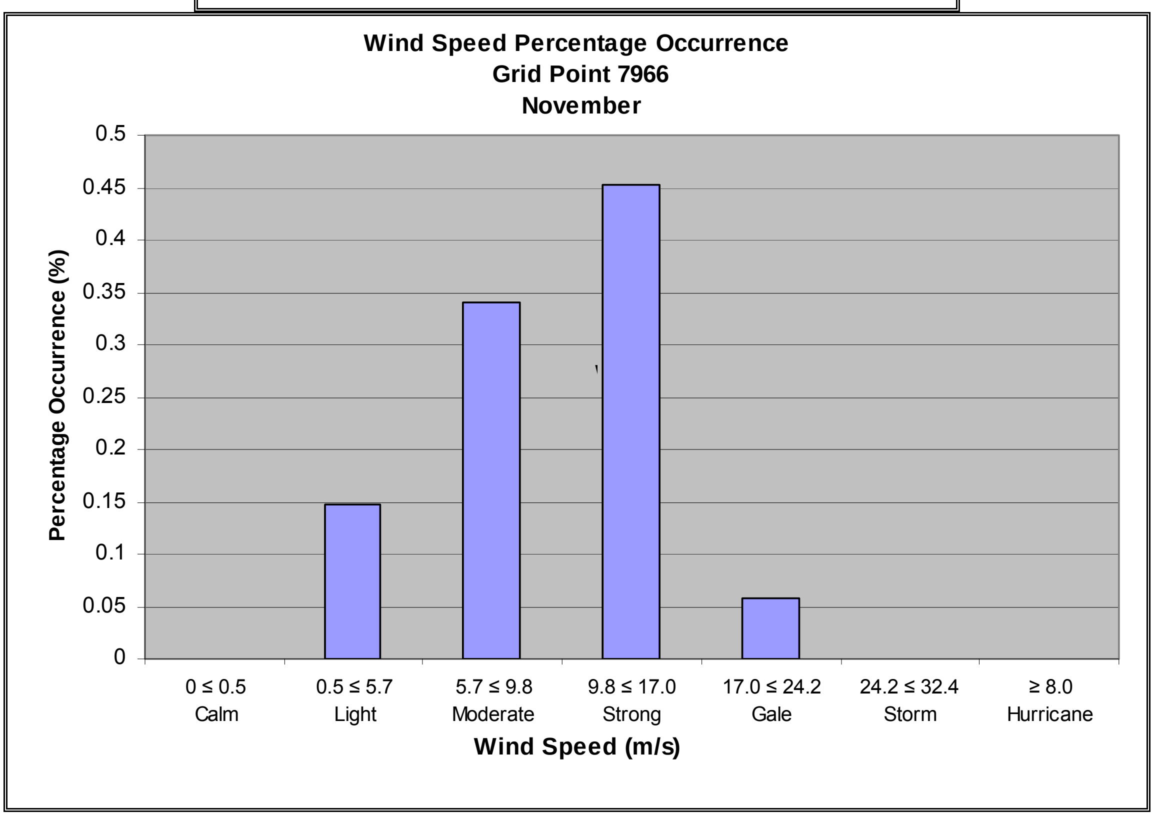
October


NORTH
SOUTH
WEST
EAST
3%
6%
9%
12%
15%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%


Wind Speed Percentage Occurrence
Grid Point 7966
October
Percentage Occurrence (%)
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

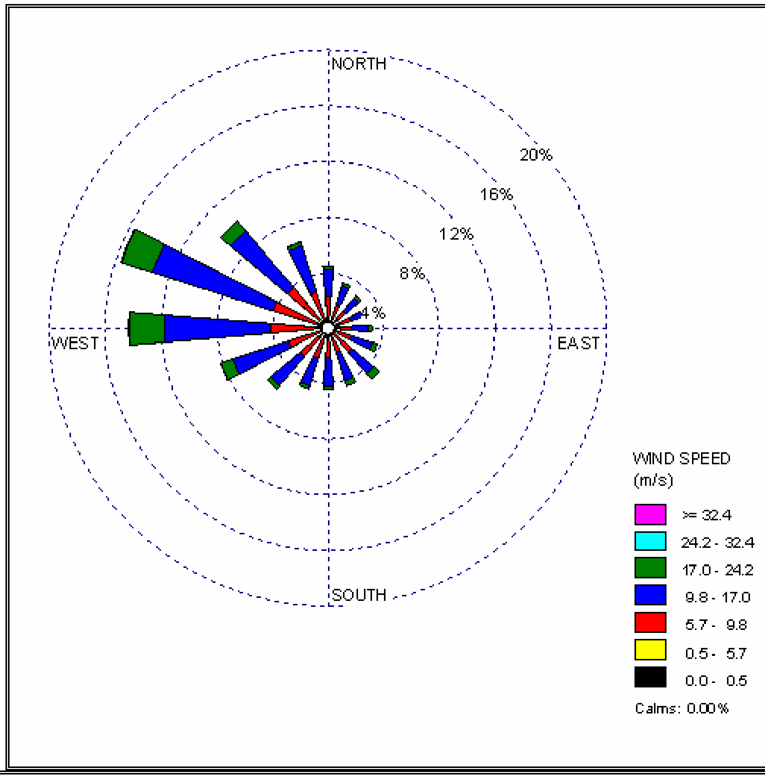
November

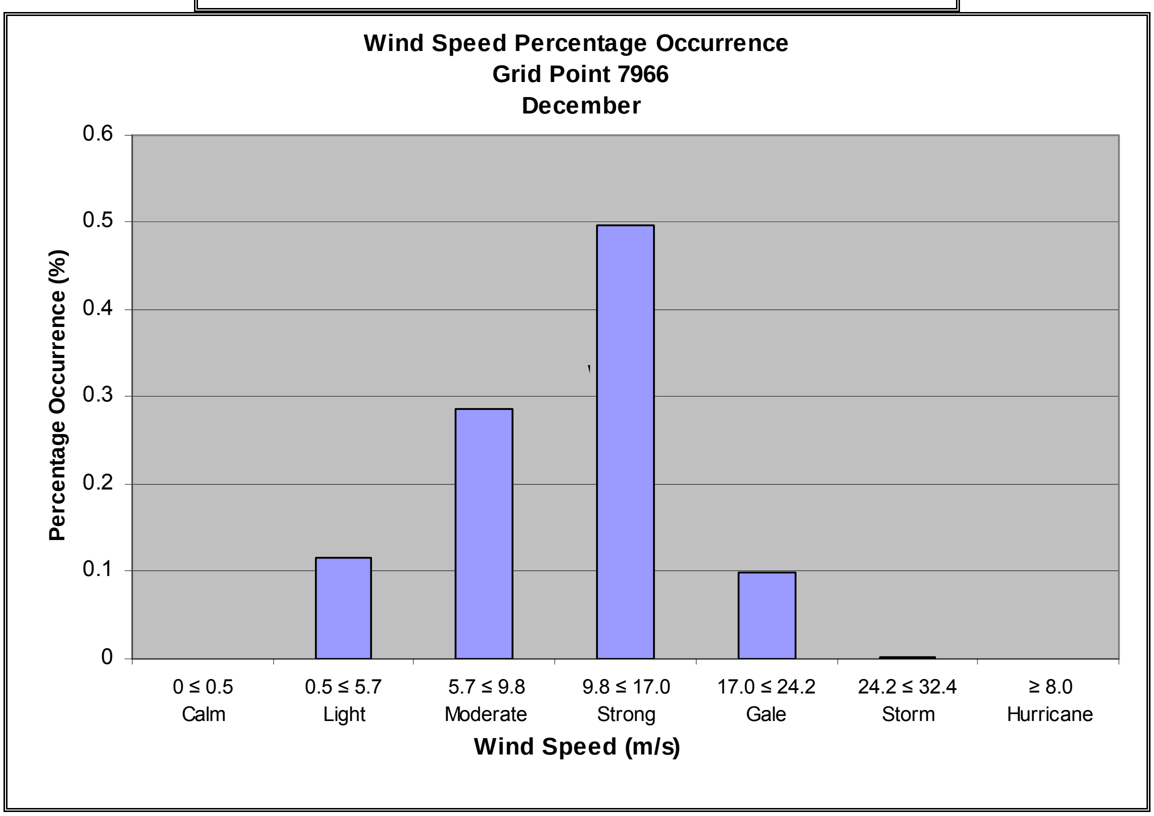




Oceans LTD.

December


NORTH
SOUTH
WEST
EAST
4%
8%
12%
16%
20%
WIND SPEED
(m/s)
>= 32.4
24.2 - 32.4
17.0 - 24.2
9.8 - 17.0
5.7 - 9.8
0.5 - 5.7
0.0 - 0.5
Calms: 0.00%

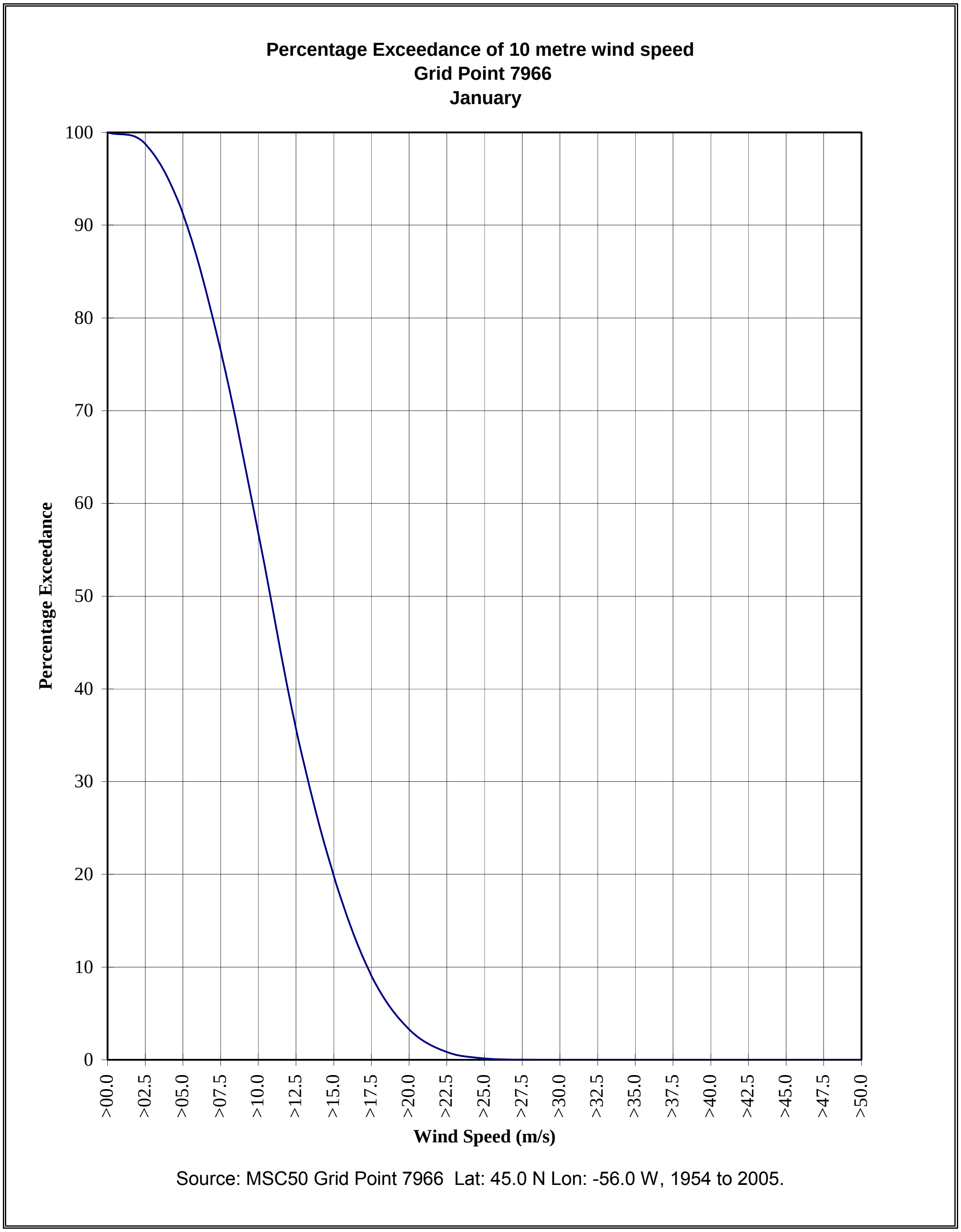

Wind Speed Percentage Occurrence
Grid Point 7966
December
Percentage Occurrence (%)
0.6
0.5
0.4
0.3
0.2
0.1
0
0 ≤ 0.5
Calm
0.5 ≤ 5.7
Light
5.7 ≤ 9.8
Moderate
9.8 ≤ 17.0
Strong
17.0 ≤ 24.2
Gale
24.2 ≤ 32.4
Storm
≥ 8.0
Hurricane
Wind Speed (m/s)

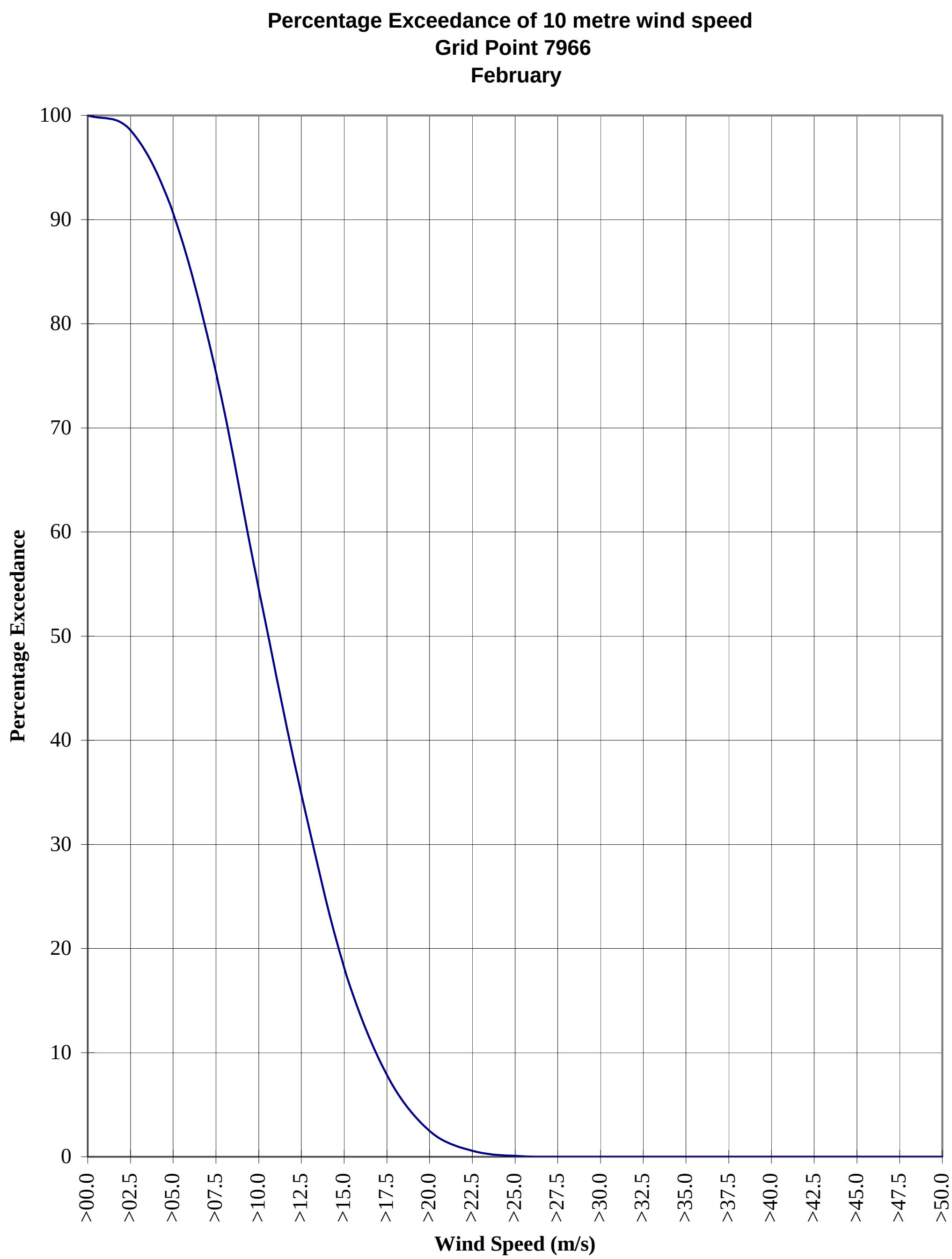
Appendix 1b

Percentage Exceedance

of Wind Speed

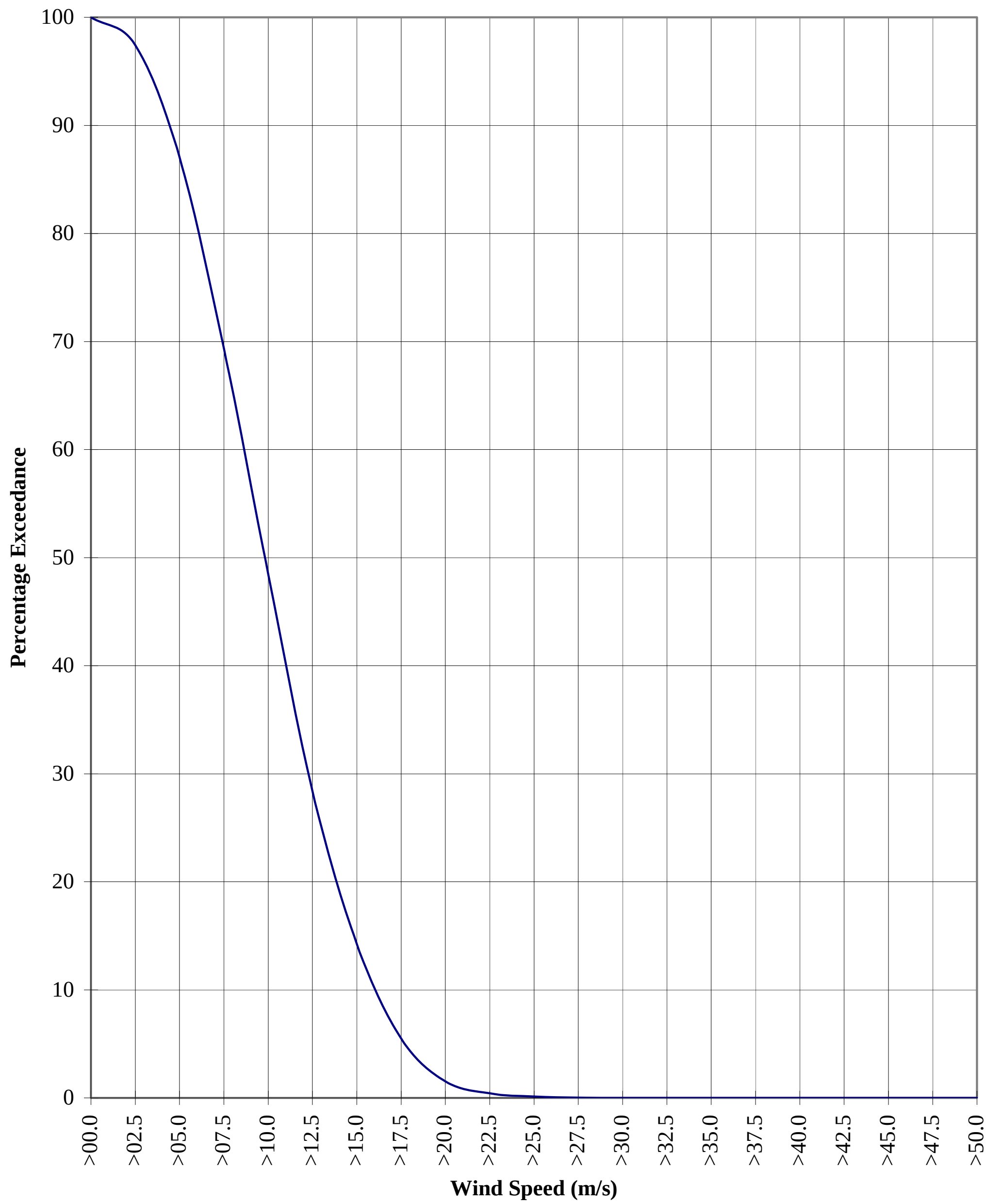
for MSC50 GridPoint 7966


Percentage Exceedance of 10 metre wind speed
Grid Point 7966
January
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

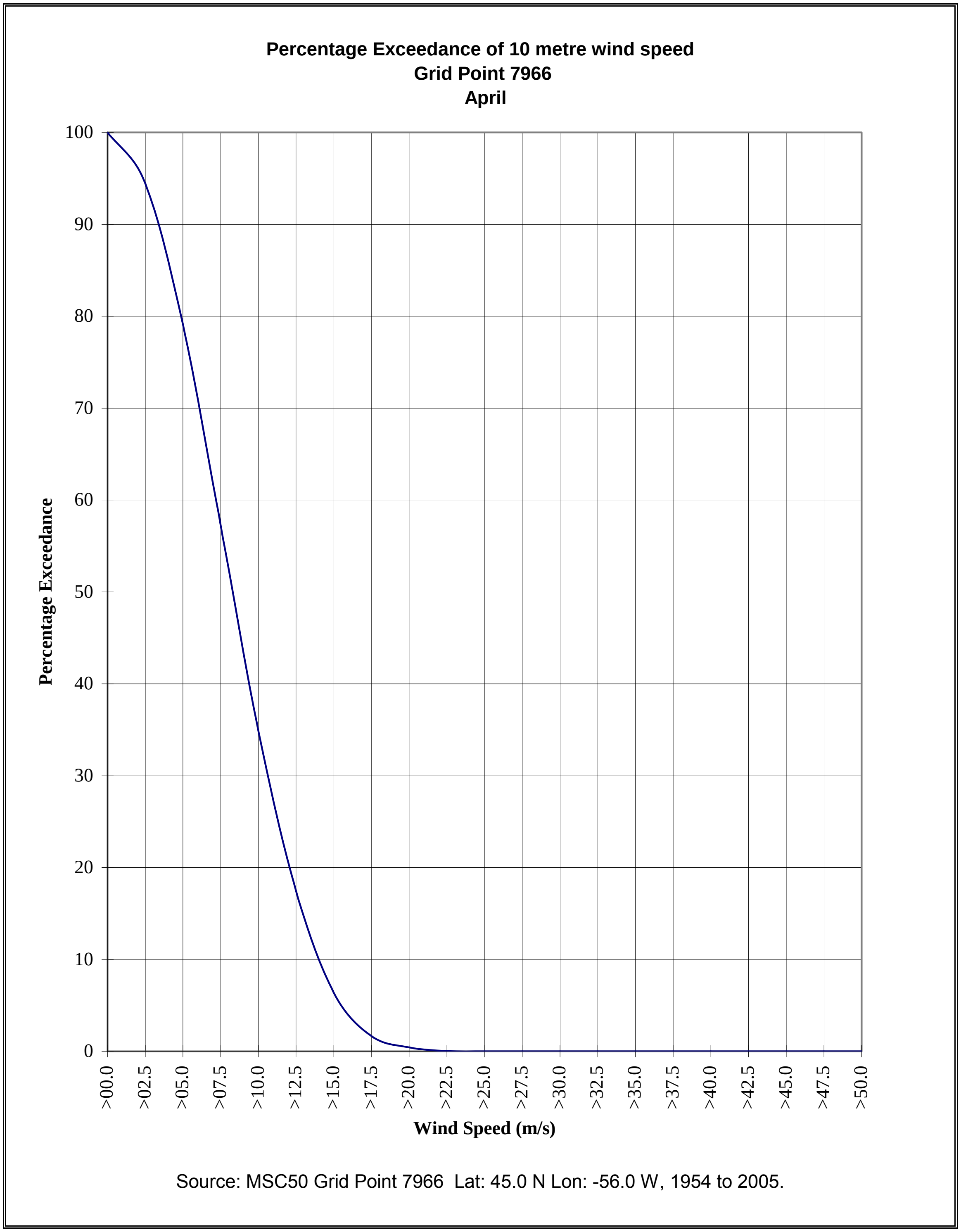


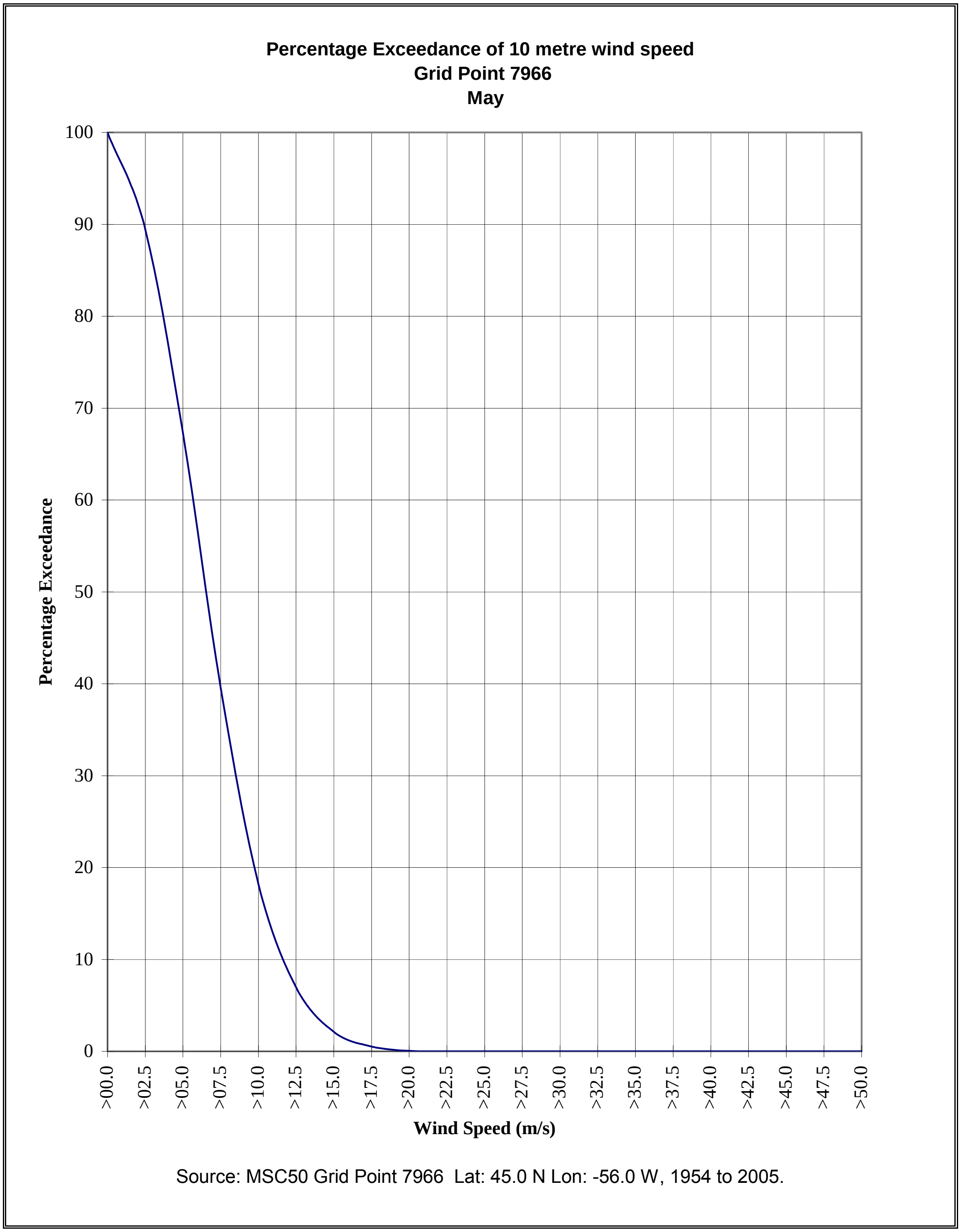
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

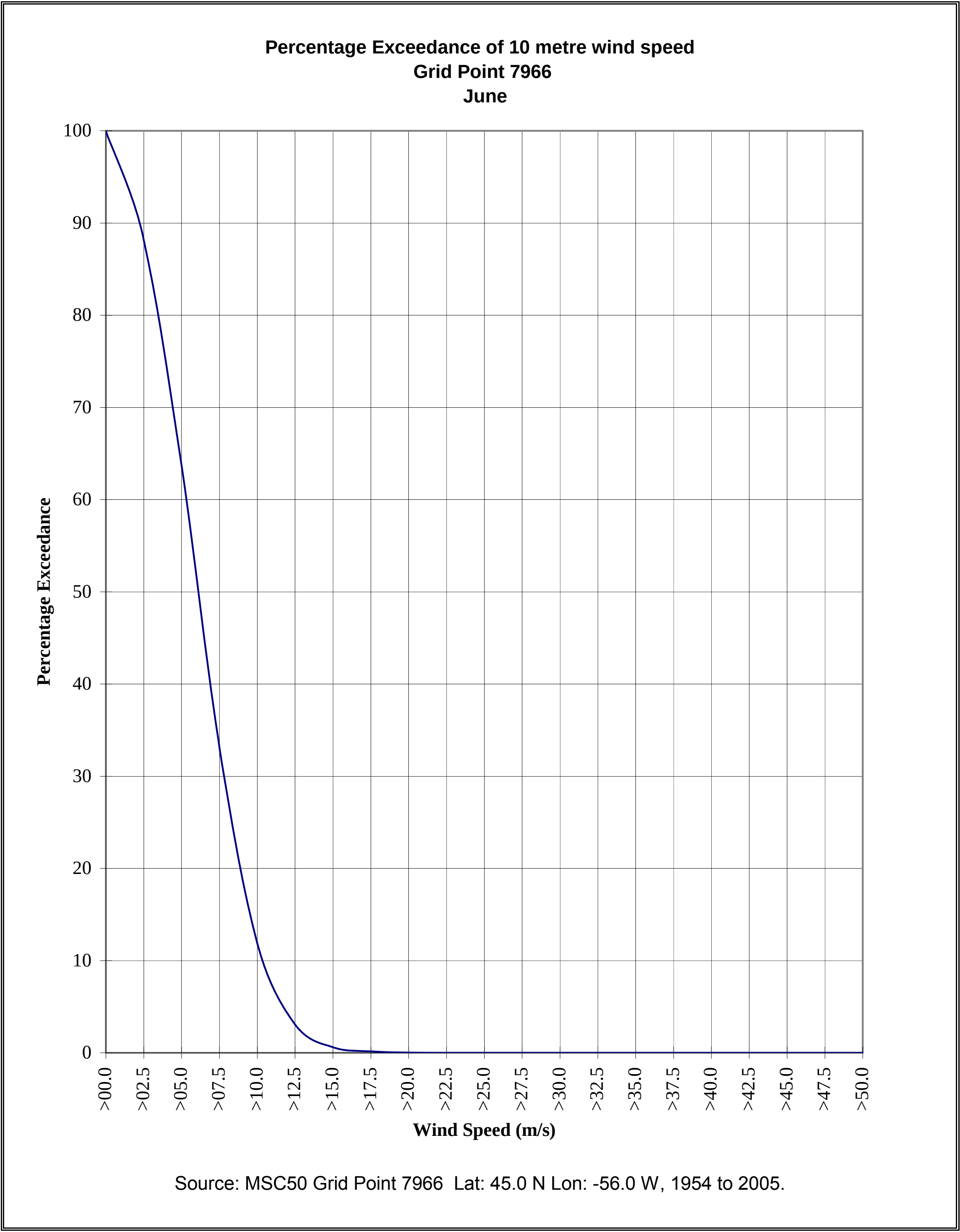
Percentage Exceedance of 10 metre wind speed
Grid Point 7966
March

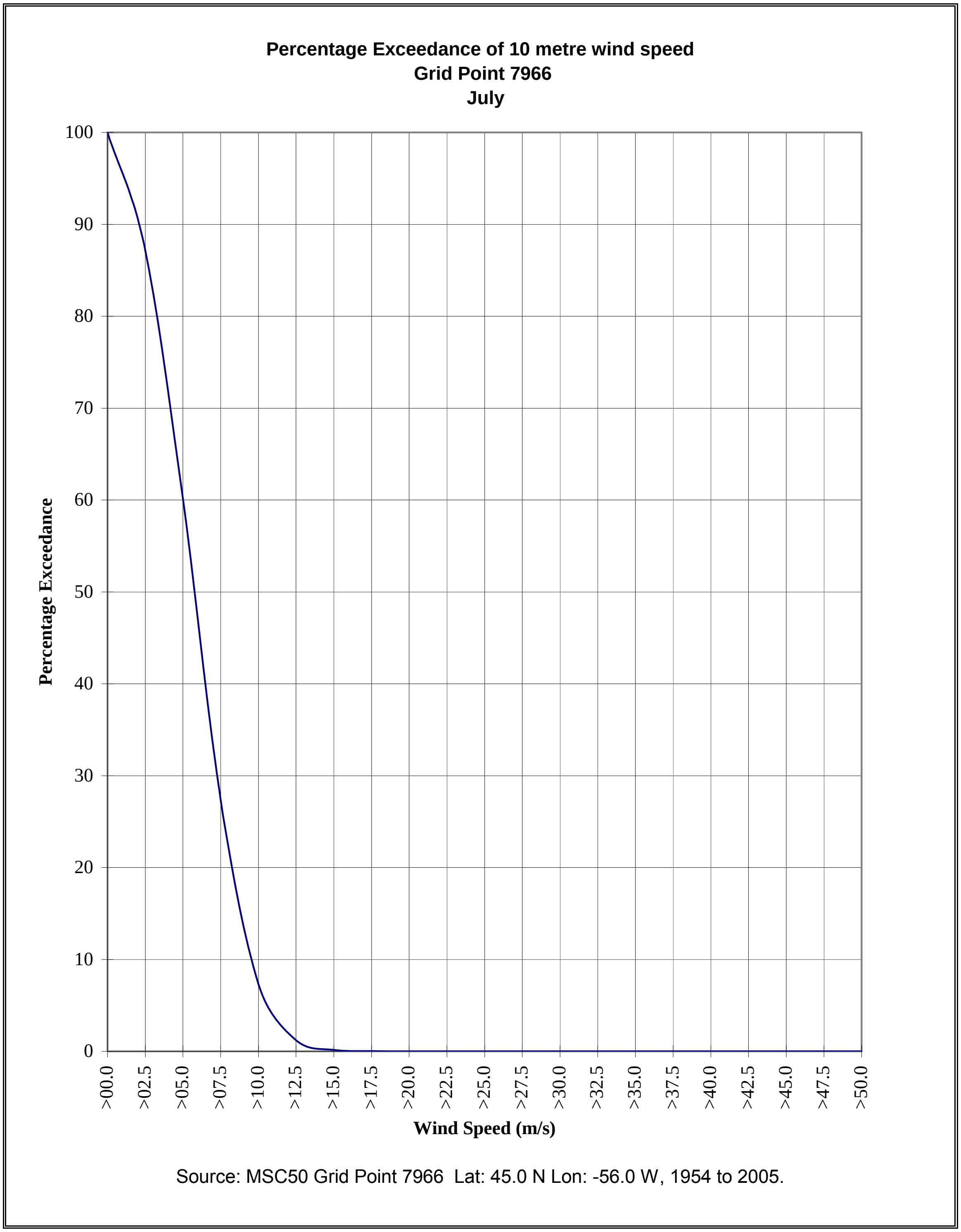


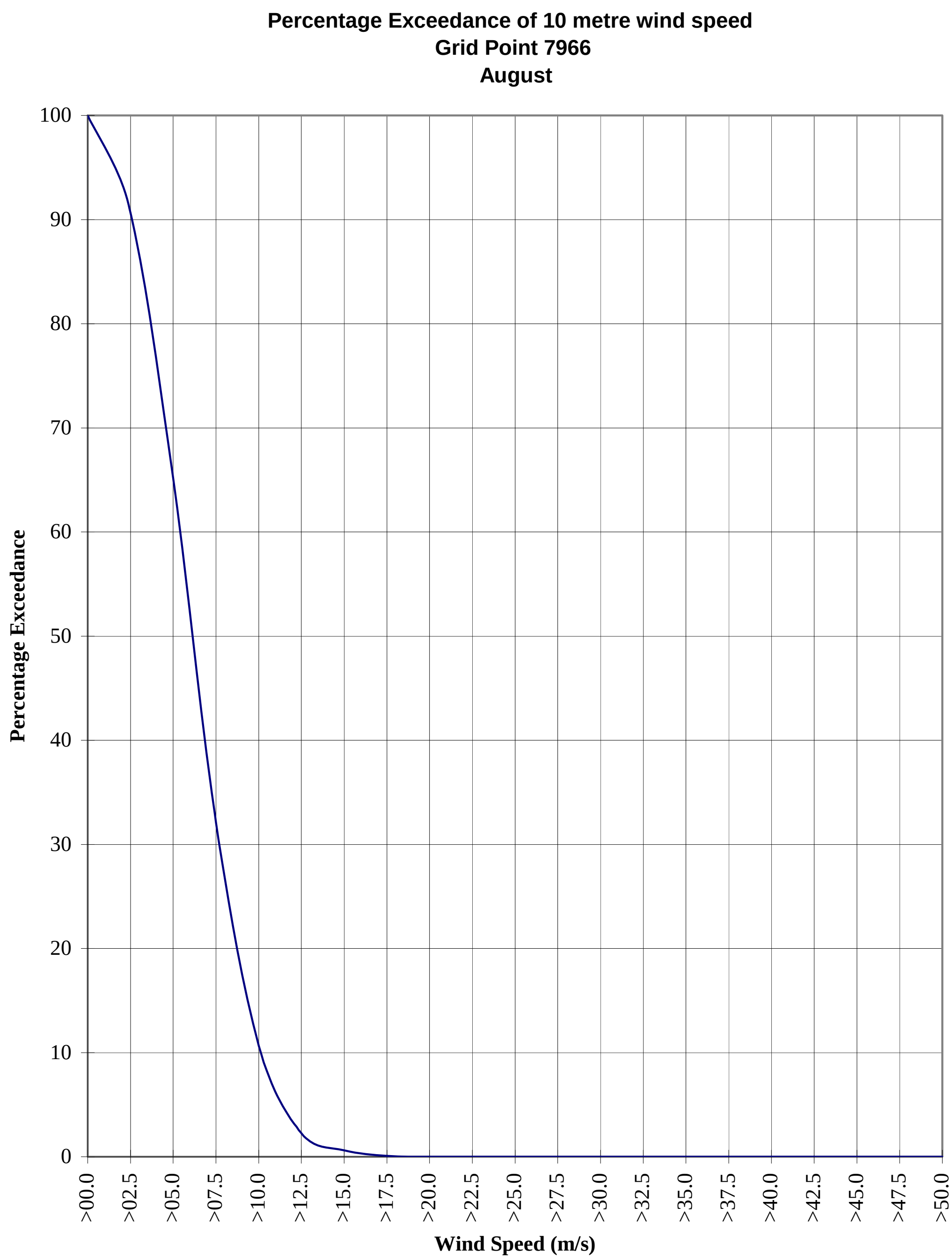
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.


Percentage Exceedance of 10 metre wind speed
Grid Point 7966
April
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

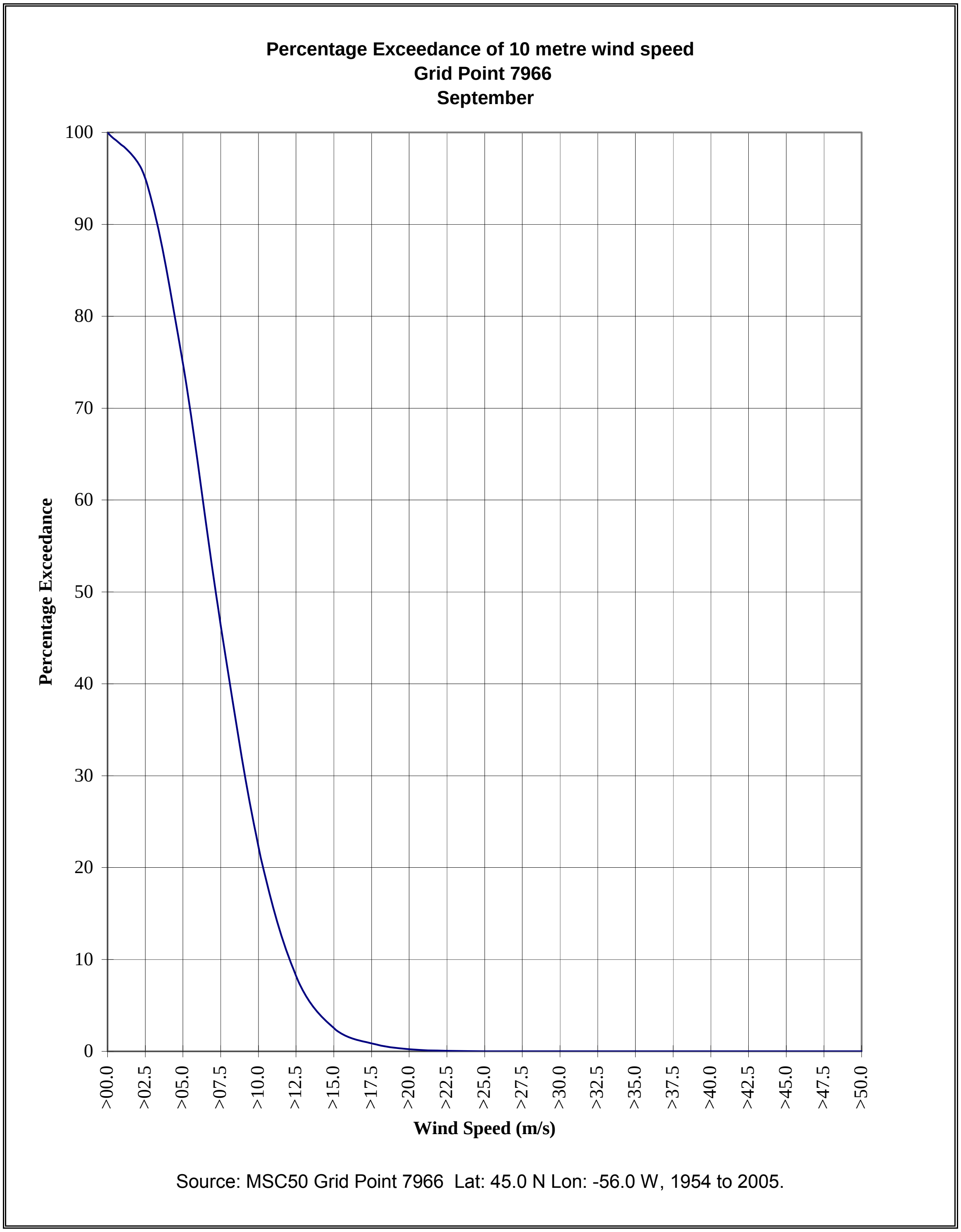

Percentage Exceedance of 10 metre wind speed
Grid Point 7966
May
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.


Percentage Exceedance of 10 metre wind speed
Grid Point 7966
June
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

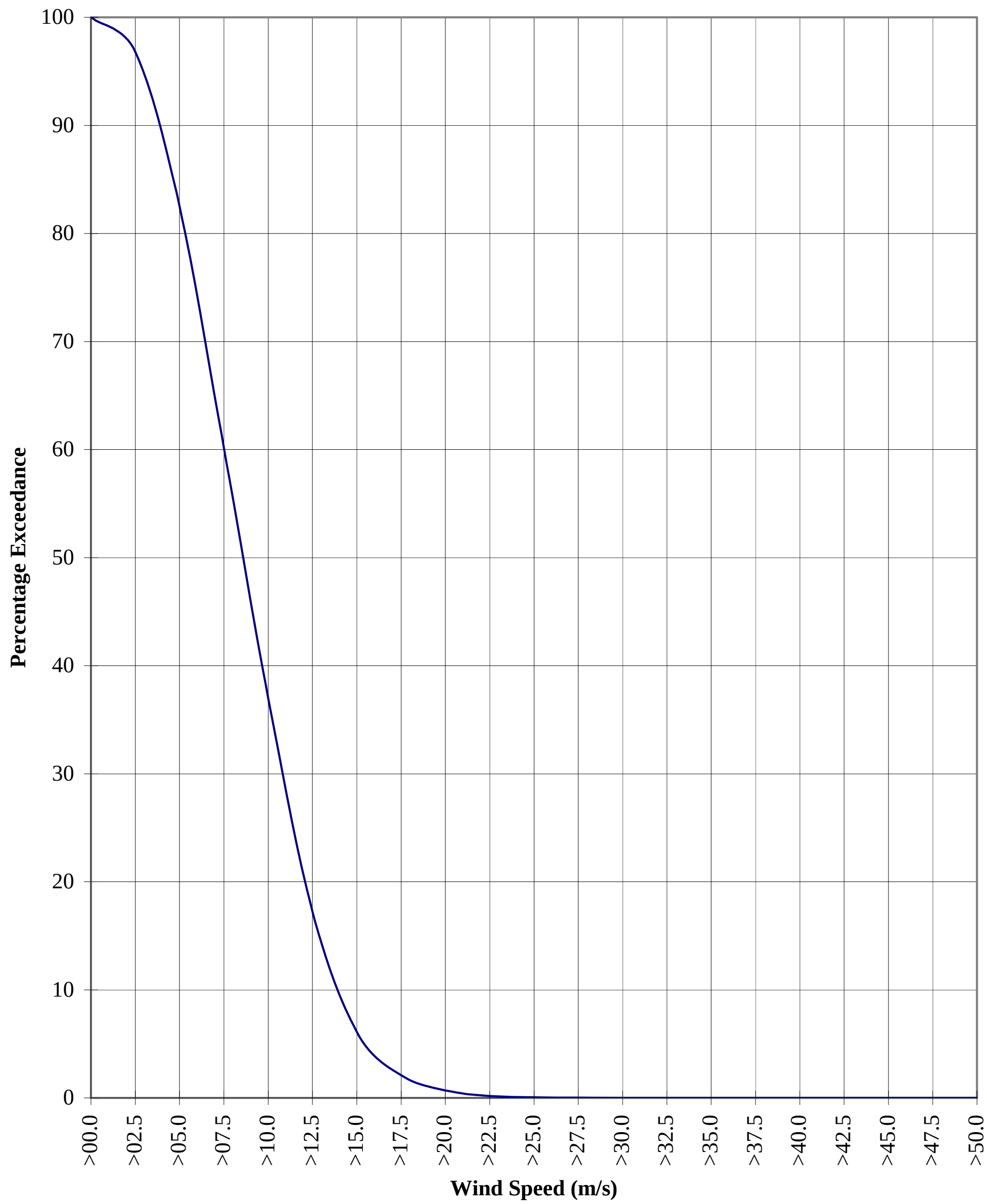

Percentage Exceedance of 10 metre wind speed
Grid Point 7966
July
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.



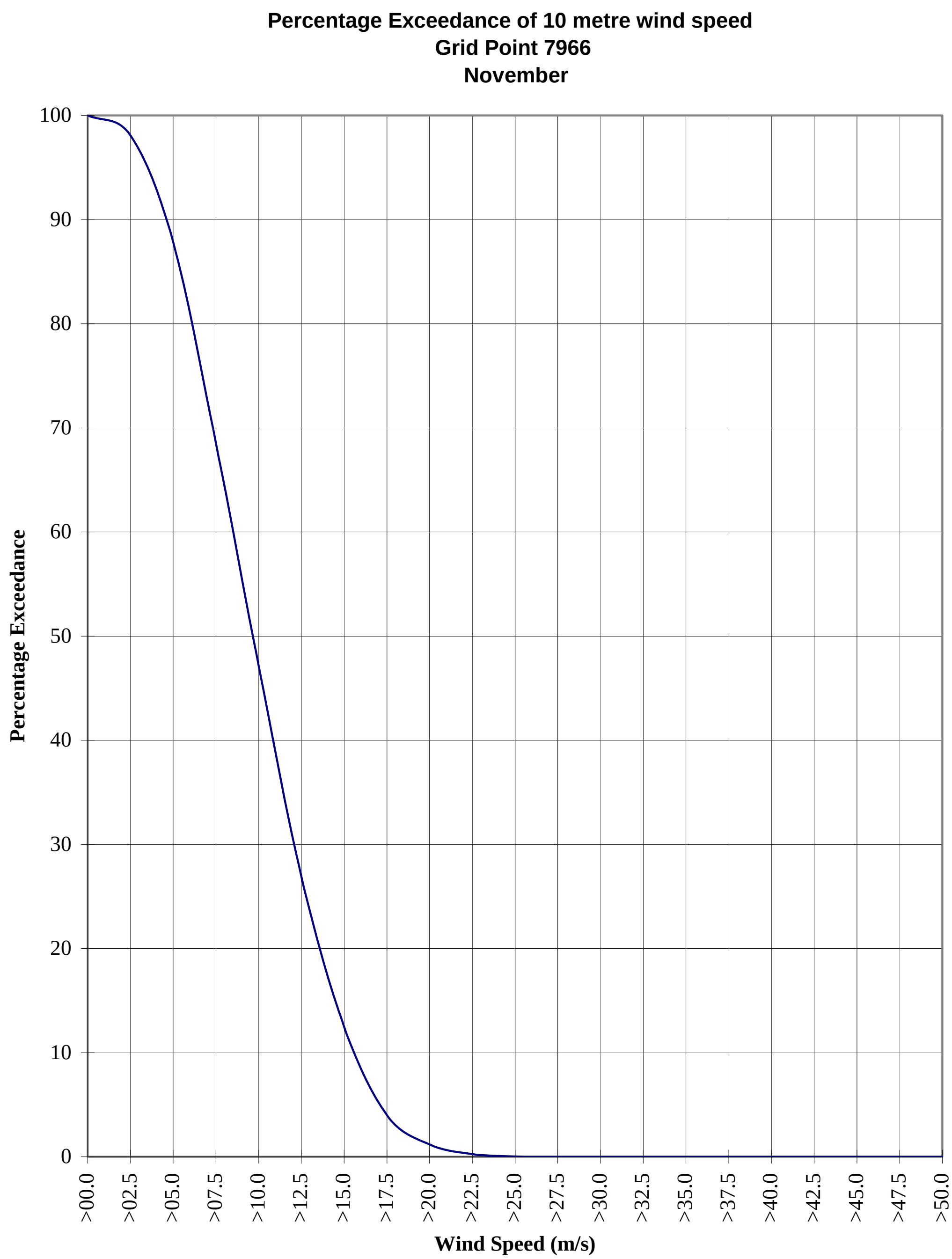
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.


Percentage Exceedance of 10 metre wind speed
Grid Point 7966
September
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>02.5
>05.0
>07.5
>10.0
>12.5
>15.0
>17.5
>20.0
>22.5
>25.0
>27.5
>30.0
>32.5
>35.0
>37.5
>40.0
>42.5
>45.0
>47.5
>50.0
Wind Speed (m/s)
Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

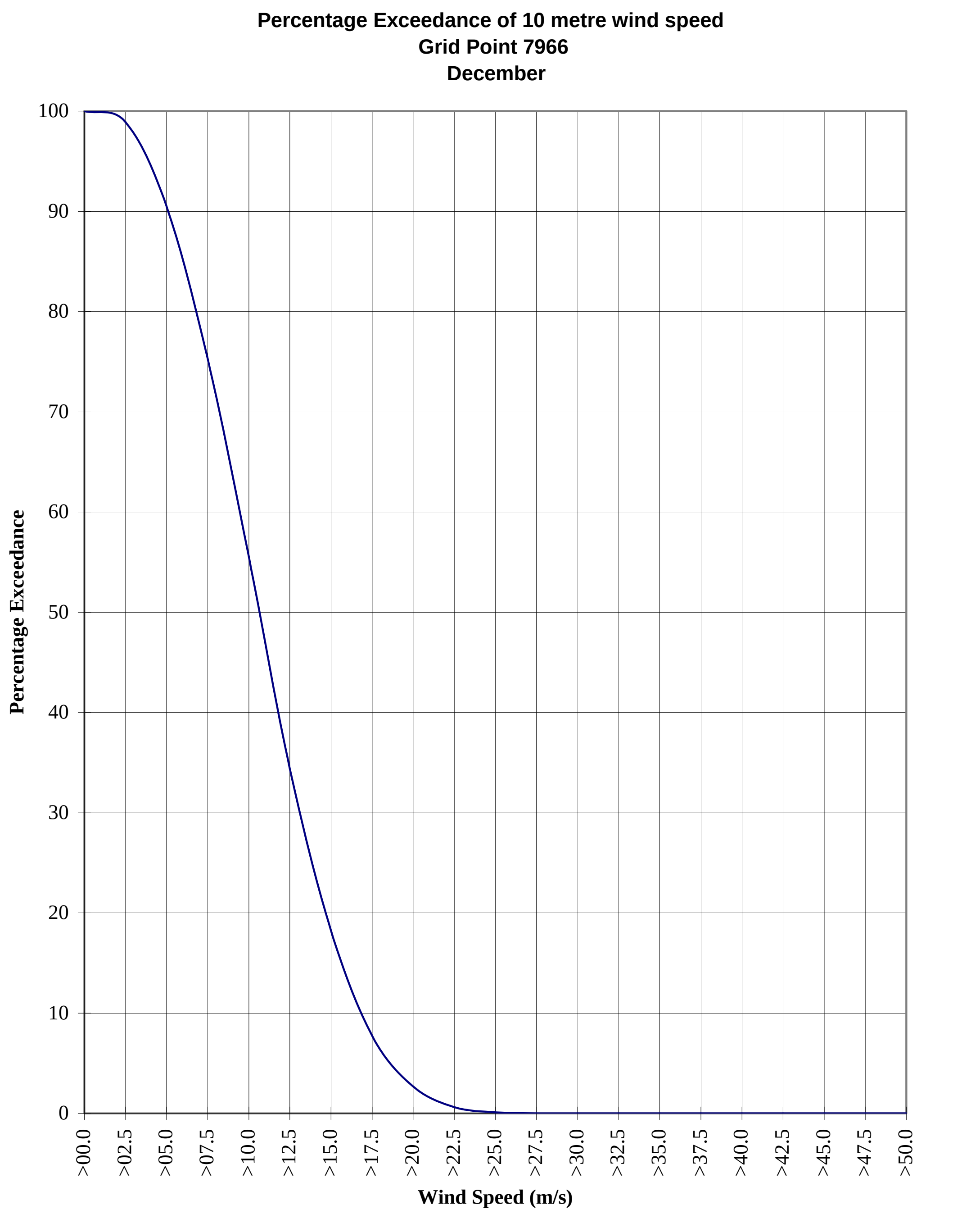
Percentage Exceedance of 10 metre wind speed
Grid Point 7966
October



Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.



Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.



Source: MSC50 Grid Point 7966 Lat: 45.0 N Lon: -56.0 W, 1954 to 2005.

Appendix 1c

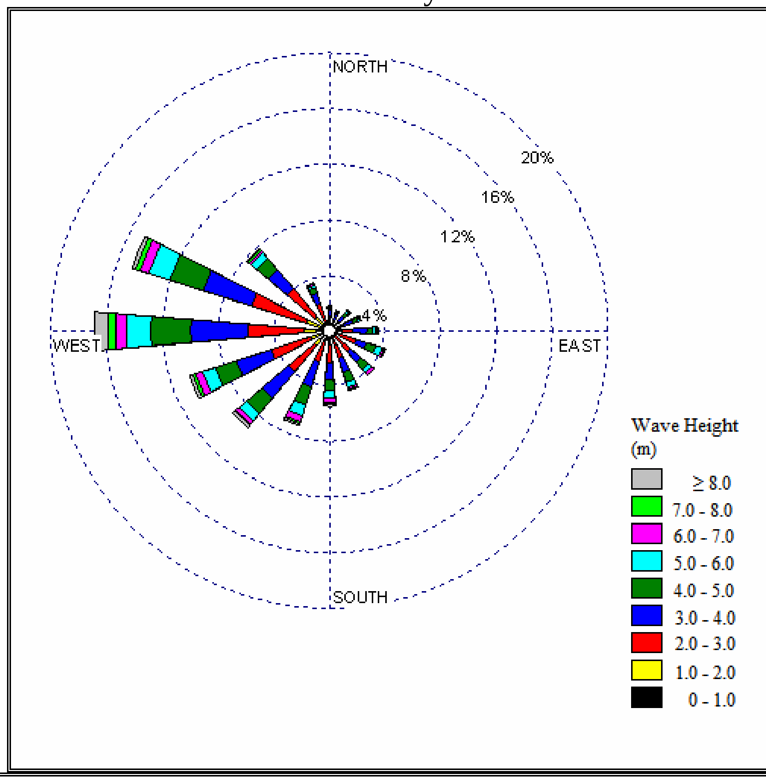
Wave Roses

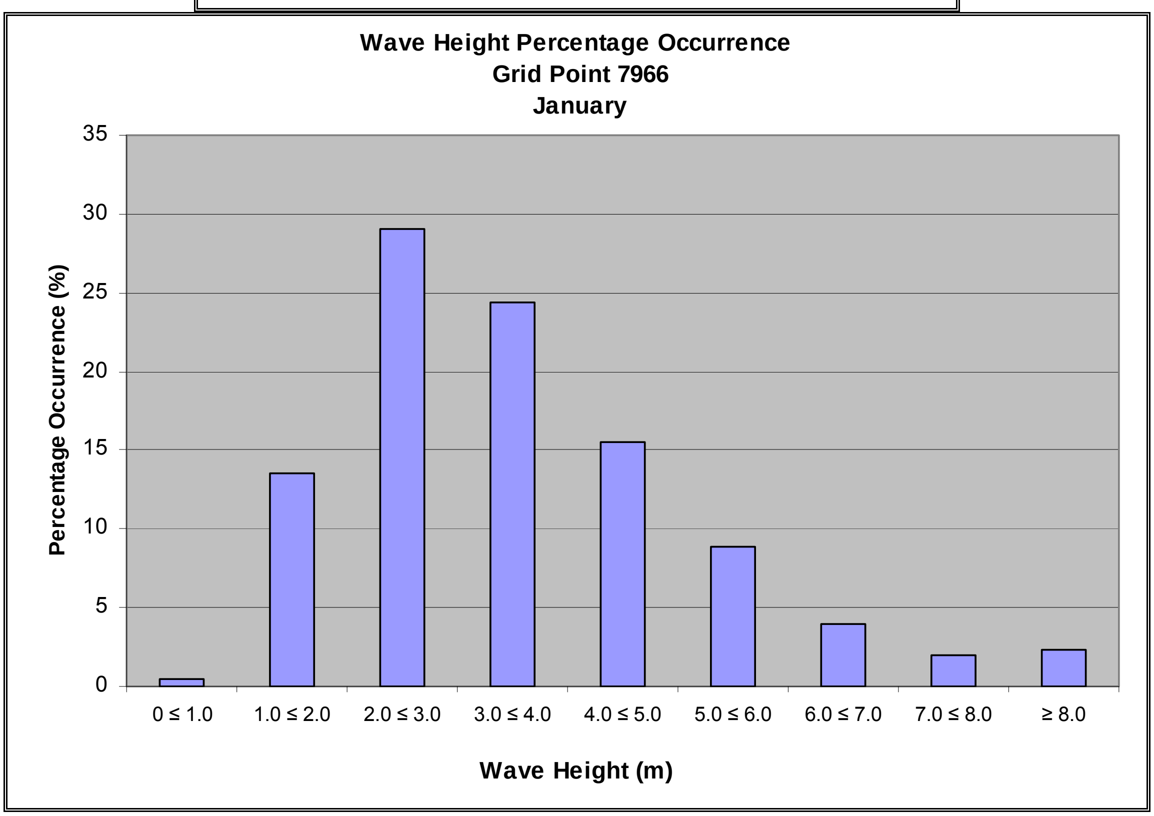
And

Wave Height Frequency Distributions

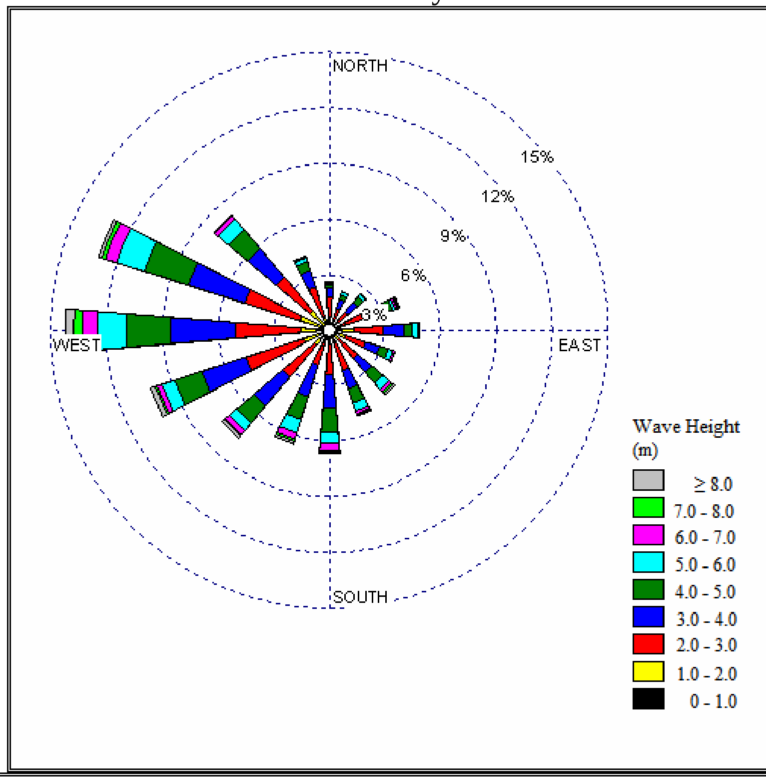
for MSC50 GridPoint 7966

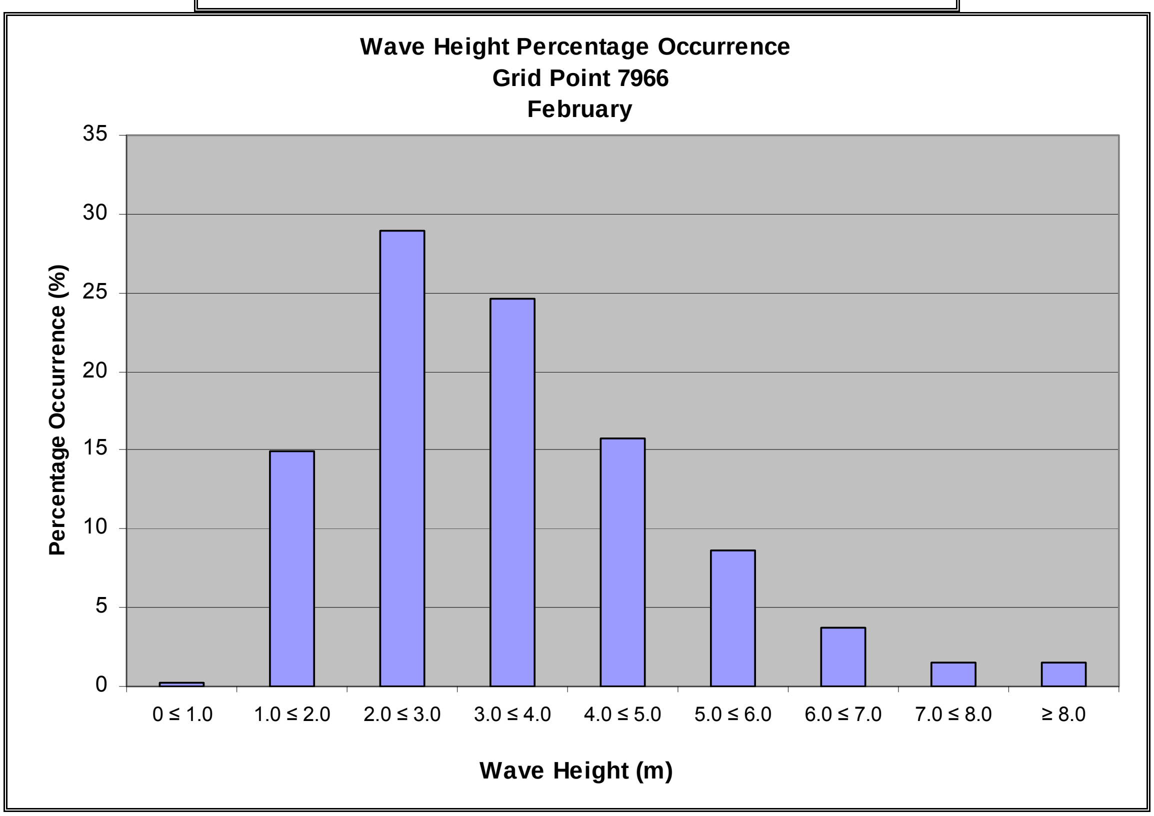
January


NORTH
EAST
SOUTH
WEST
4%
8%
12%
16%
20%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

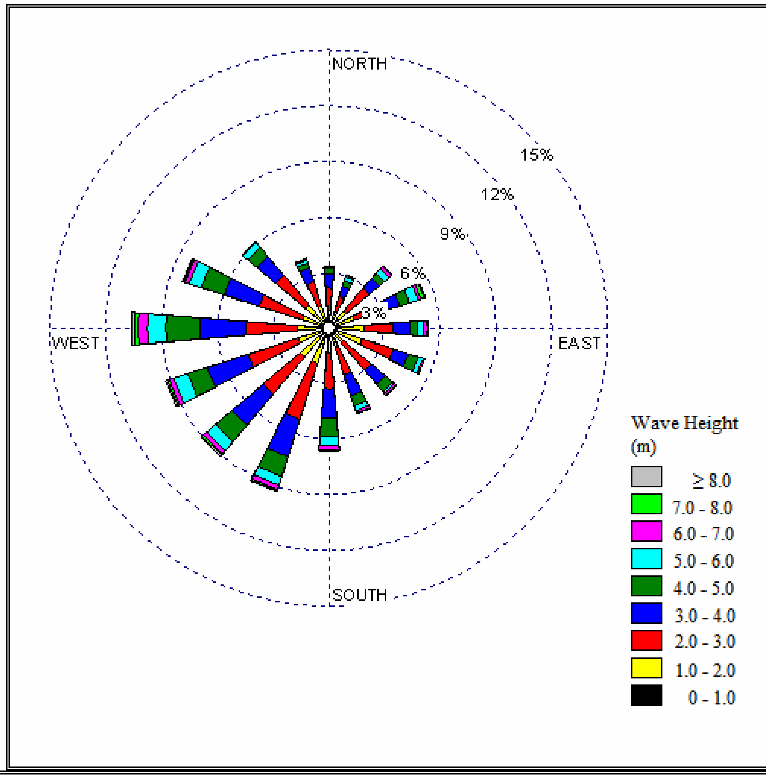

Wave Height Percentage Occurrence
Grid Point 7966
January
Percentage Occurrence (%)
0
5
10
15
20
25
30
35
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

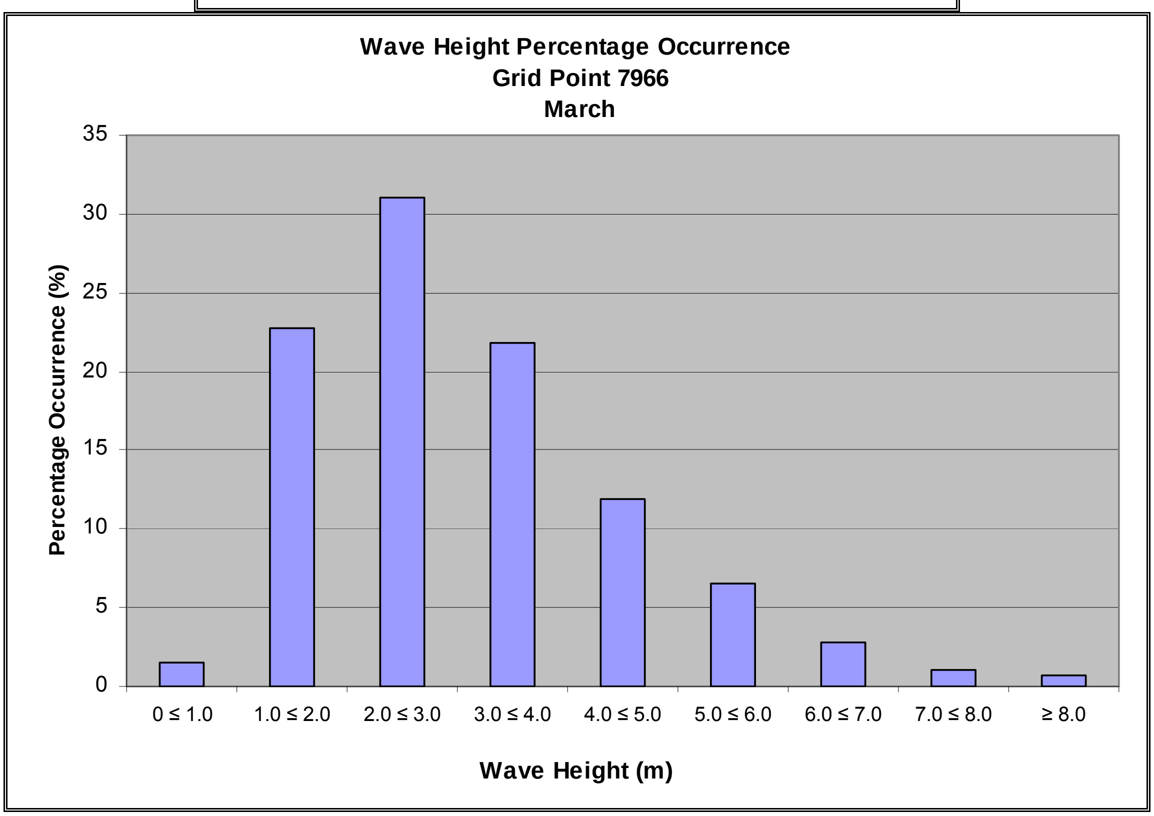
February


NORTH
SOUTH
WEST
EAST
3%
6%
9%
12%
15%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

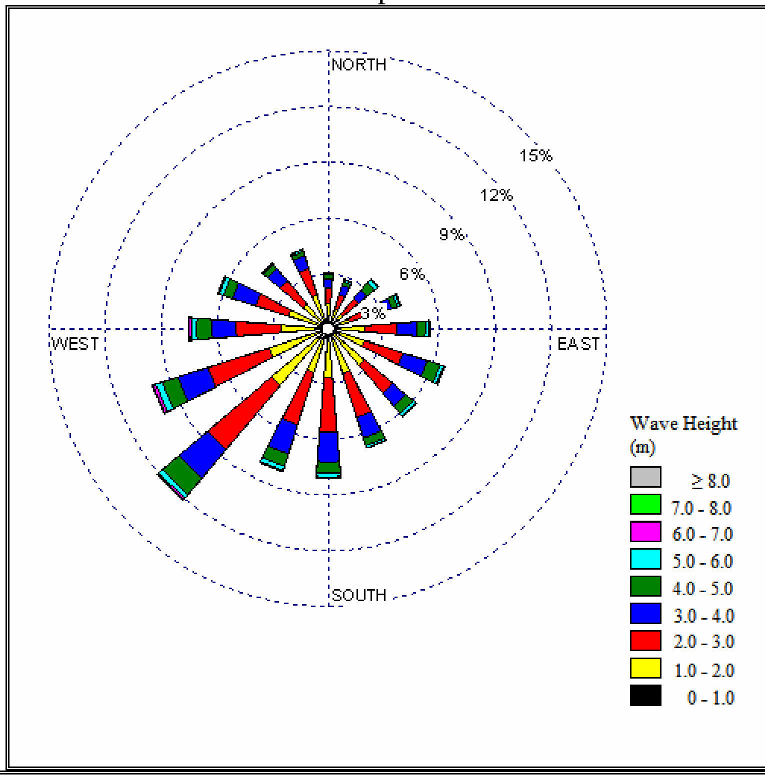

Wave Height Percentage Occurrence
Grid Point 7966
February
Percentage Occurrence (%)
35
30
25
20
15
10
5
0
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

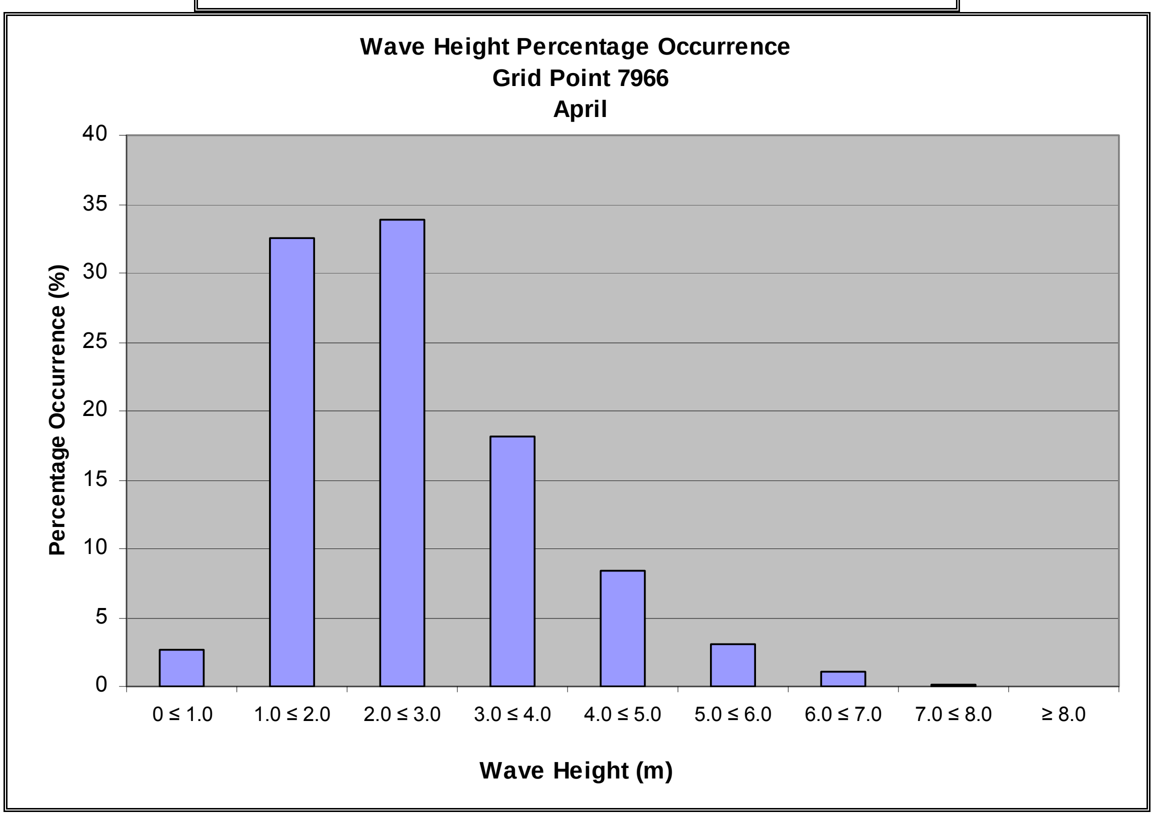
March


NORTH
WEST
EAST
SOUTH
3%
6%
9%
12%
15%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

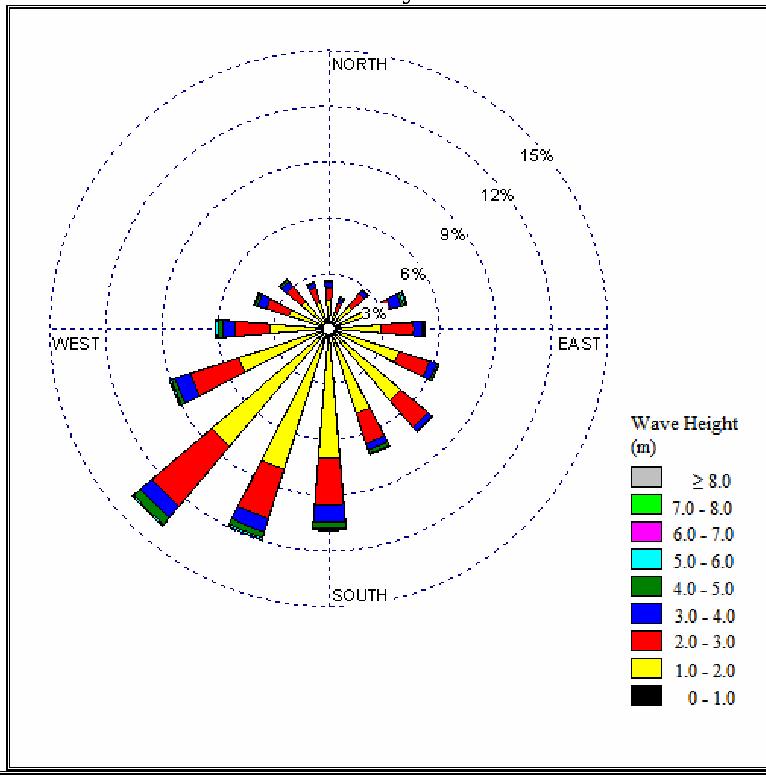

Wave Height Percentage Occurrence
Grid Point 7966
March
Percentage Occurrence (%)
35
30
25
20
15
10
5
0
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

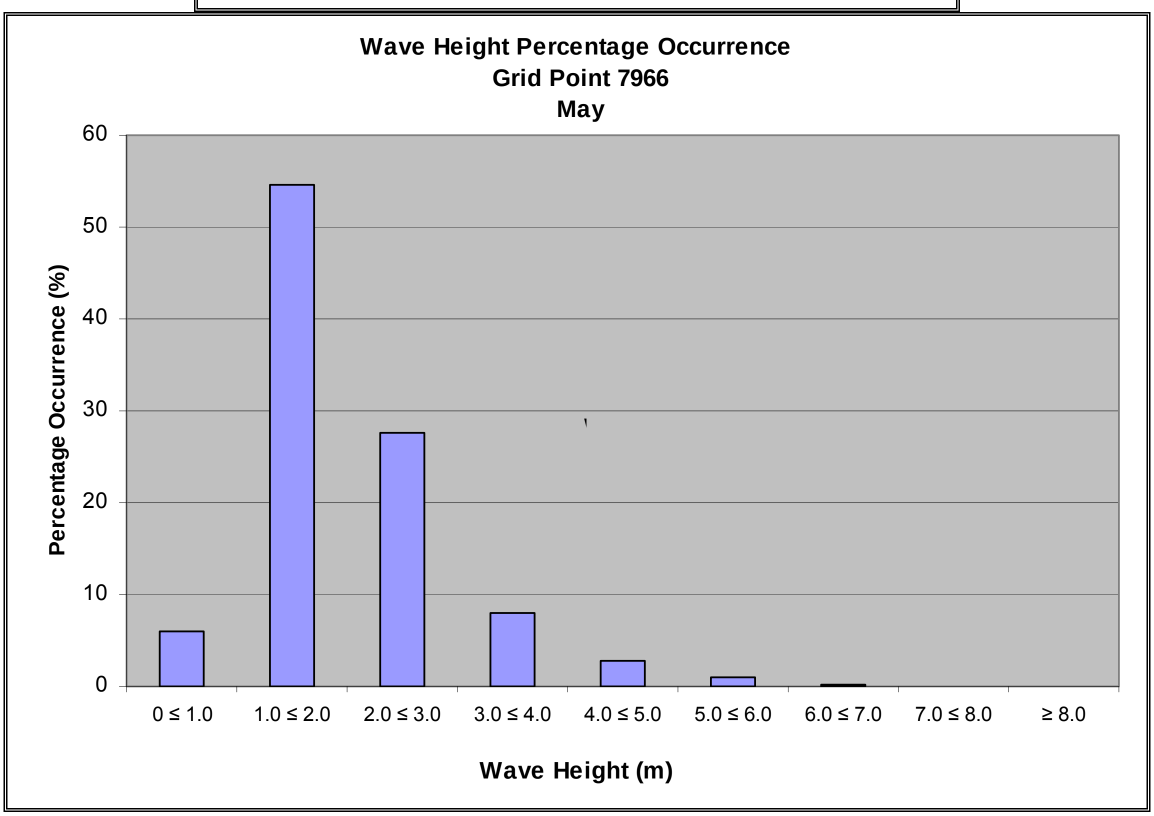
April


NORTH
SOUTH
WEST
EAST
15%
12%
9%
6%
3%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

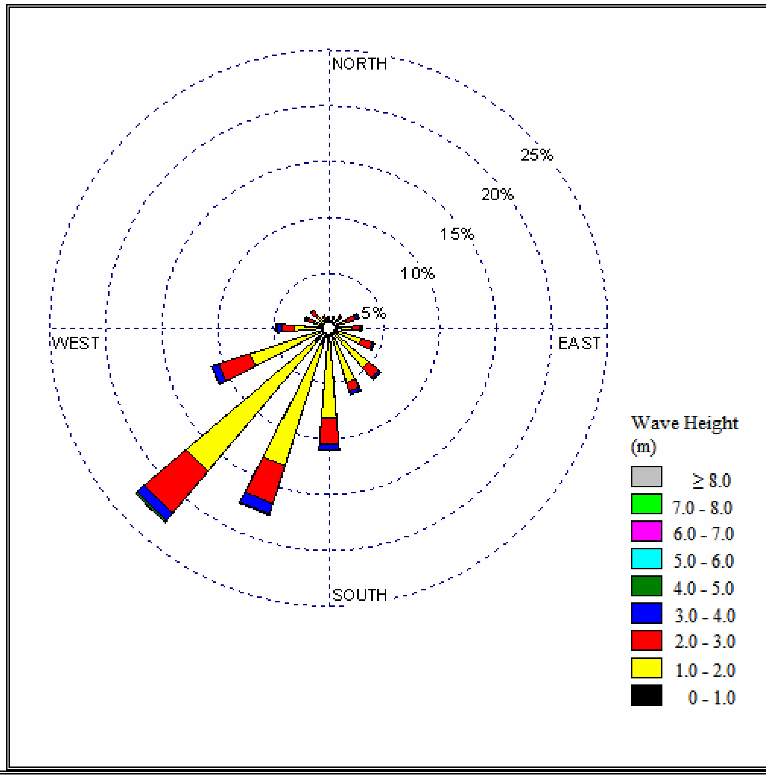

Wave Height Percentage Occurrence
Grid Point 7966
April
Percentage Occurrence (%)
40
35
30
25
20
15
10
5
0
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

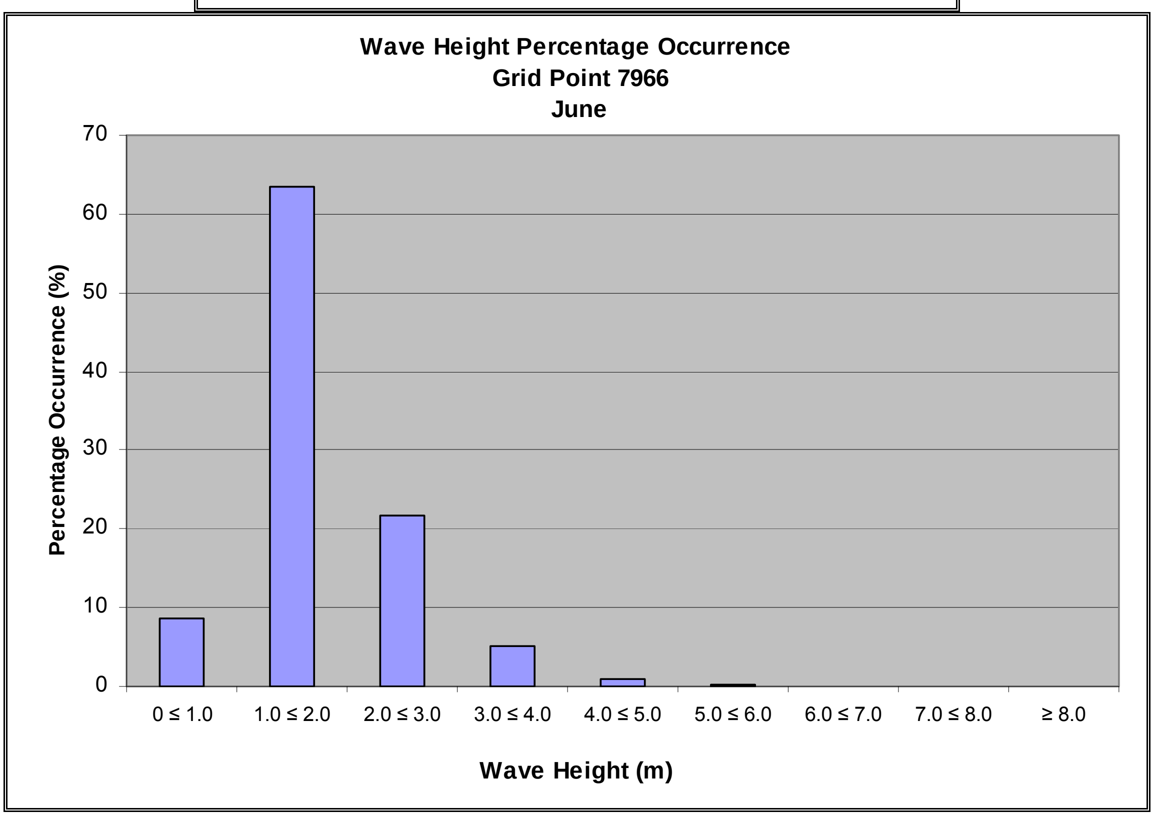
May

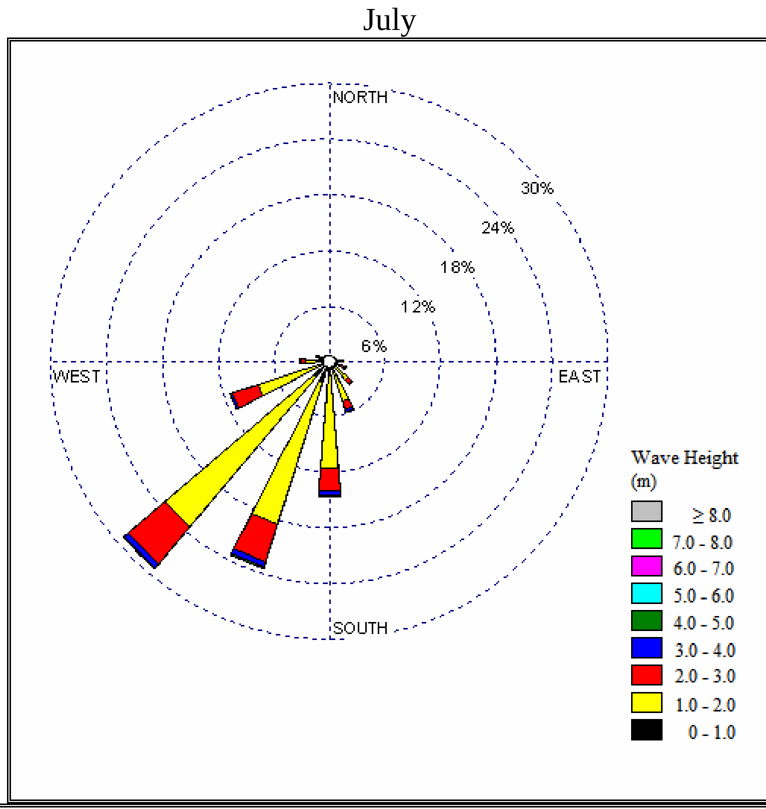

NORTH
SOUTH
WEST
EAST
15%
12%
9%
6%
3%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

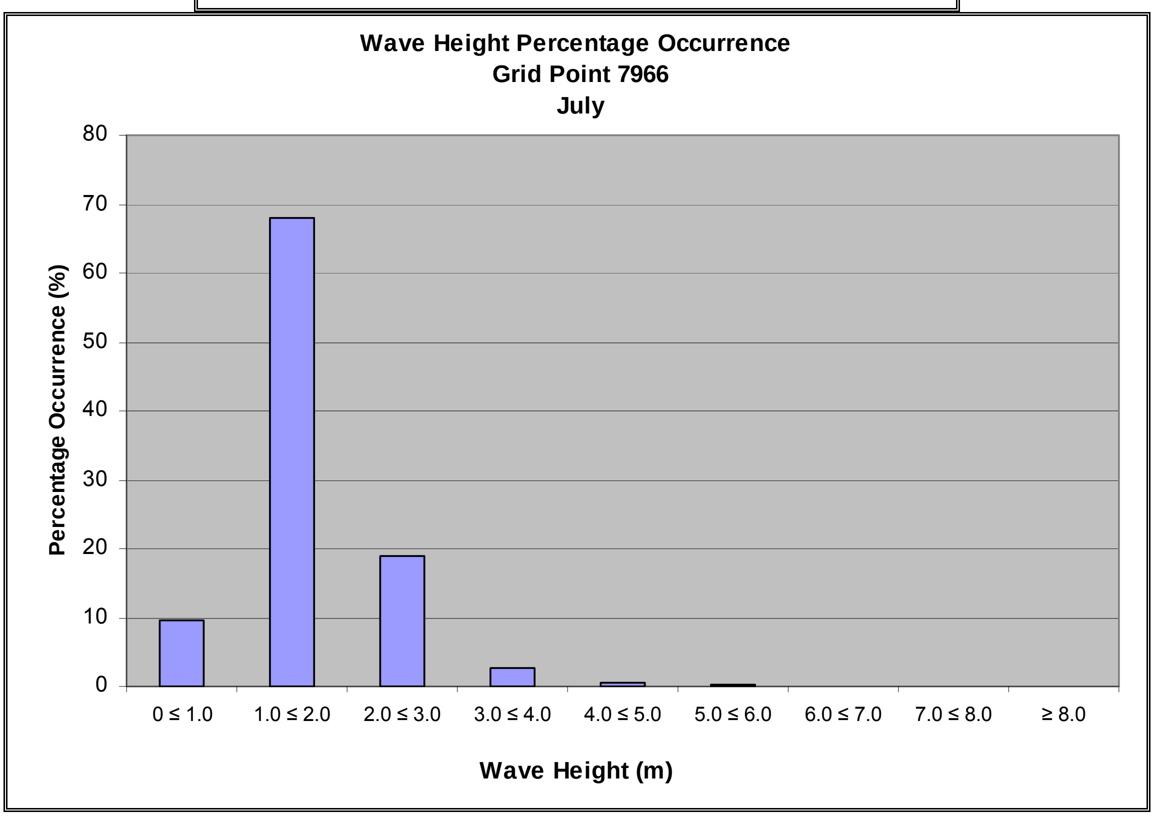

Wave Height Percentage Occurrence
Grid Point 7966
May
Percentage Occurrence (%)
60
50
40
30
20
10
0
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

June

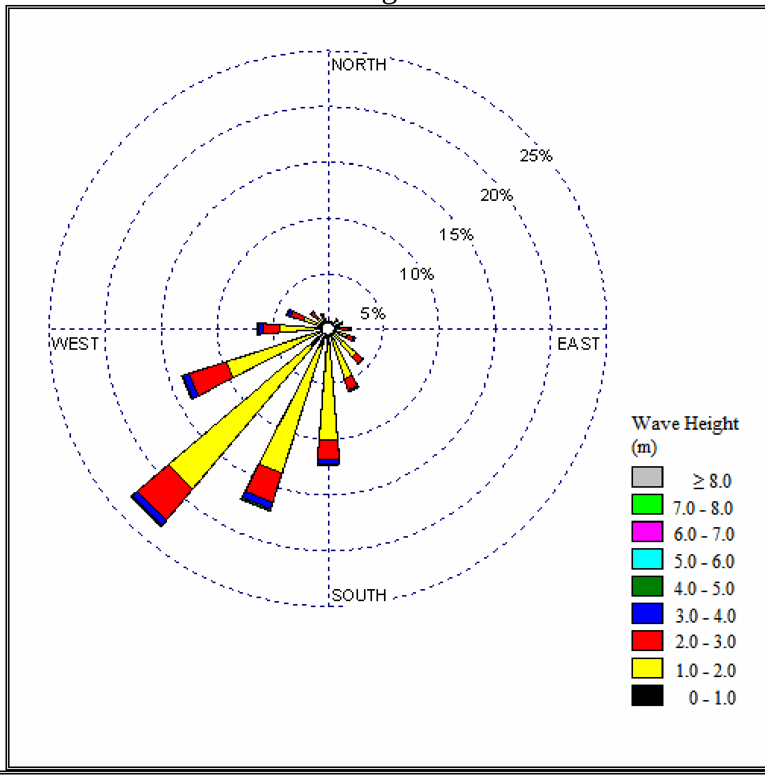

NORTH
SOUTH
EAST
WEST
5%
10%
15%
20%
25%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

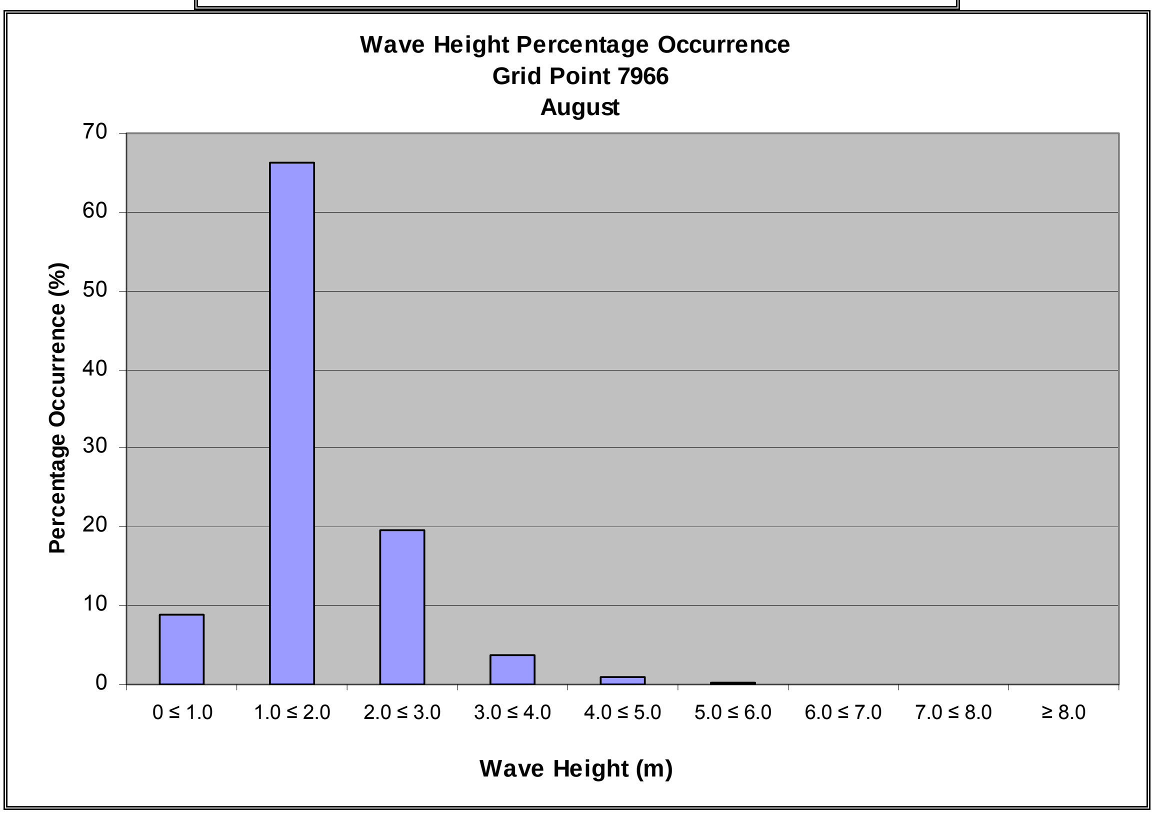

Wave Height Percentage Occurrence
Grid Point 7966
June
Percentage Occurrence (%)
0
10
20
30
40
50
60
70
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)


July
NORTH
SOUTH
EAST
WEST
6%
12%
18%
24%
30%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

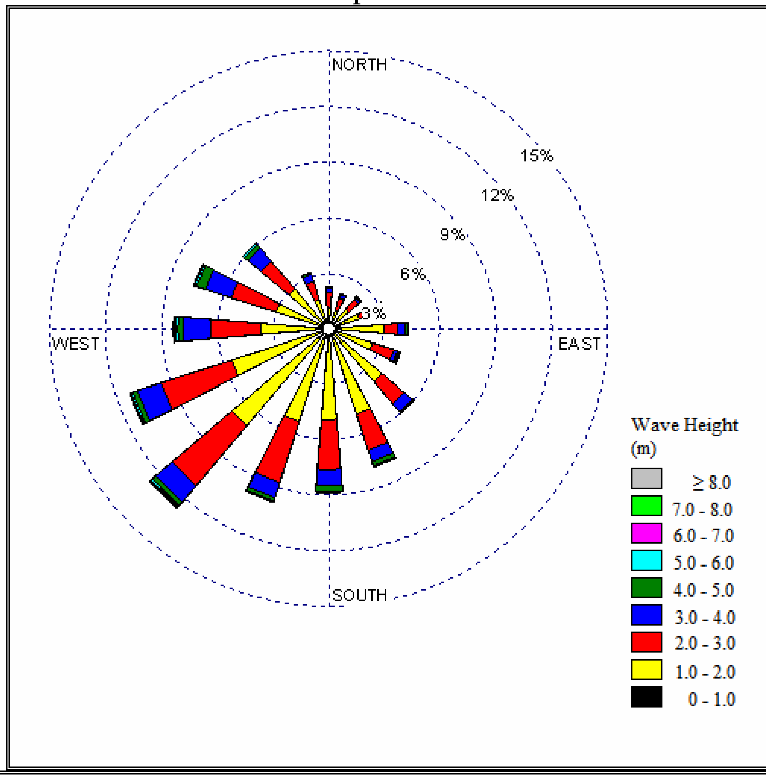

Wave Height Percentage Occurrence
Grid Point 7966
July
Percentage Occurrence (%)
0
10
20
30
40
50
60
70
80
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

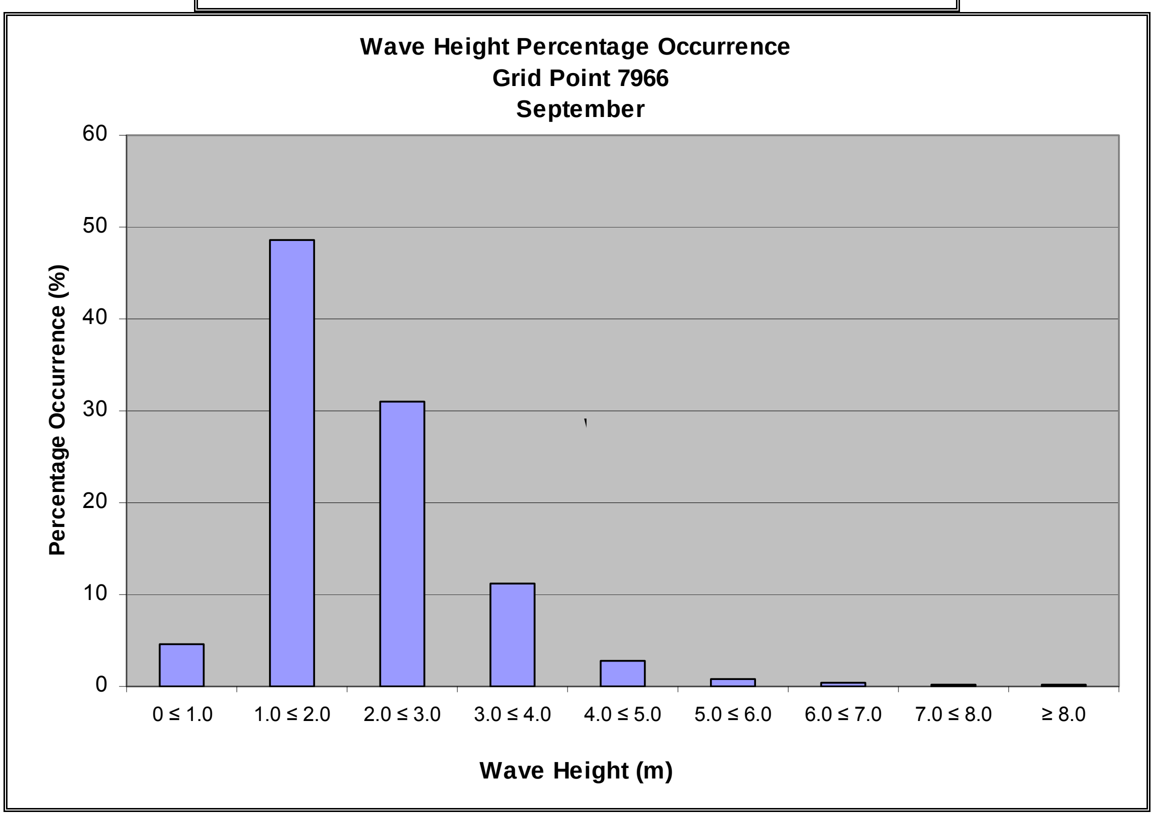
August


NORTH
WEST
EAST
SOUTH
5%
10%
15%
20%
25%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

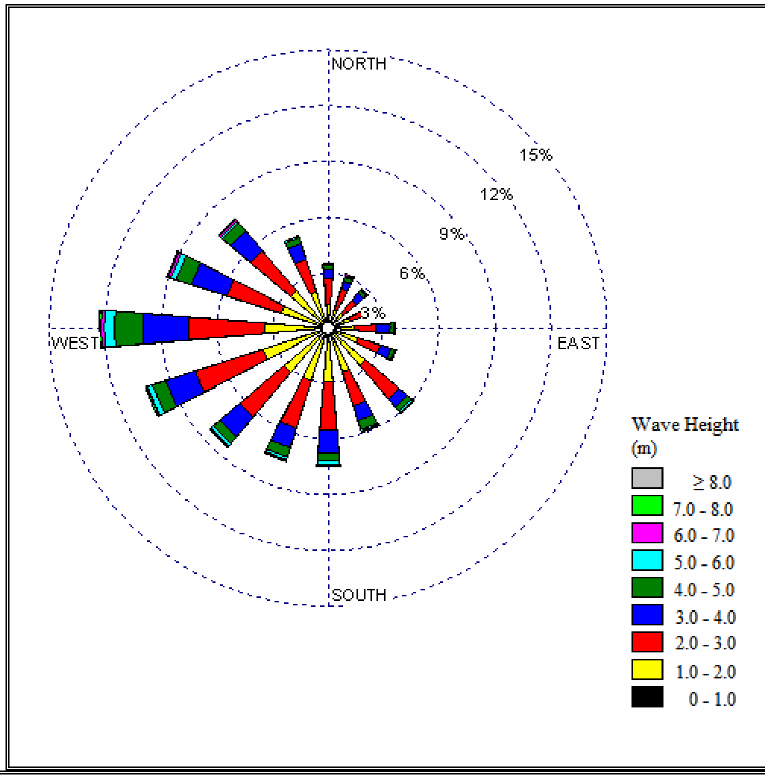

Wave Height Percentage Occurrence
Grid Point 7966
August
Percentage Occurrence (%)
0
10
20
30
40
50
60
70
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

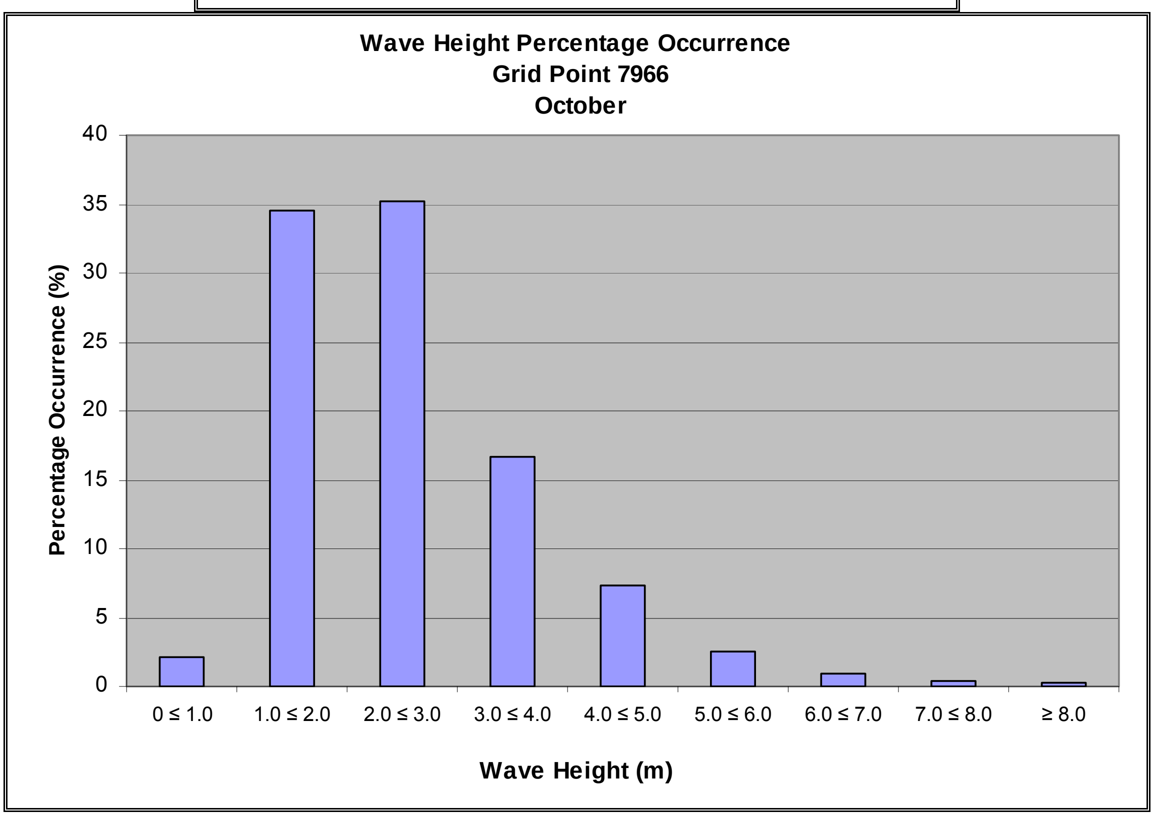
September


NORTH
SOUTH
WEST
EAST
15%
12%
9%
6%
3%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

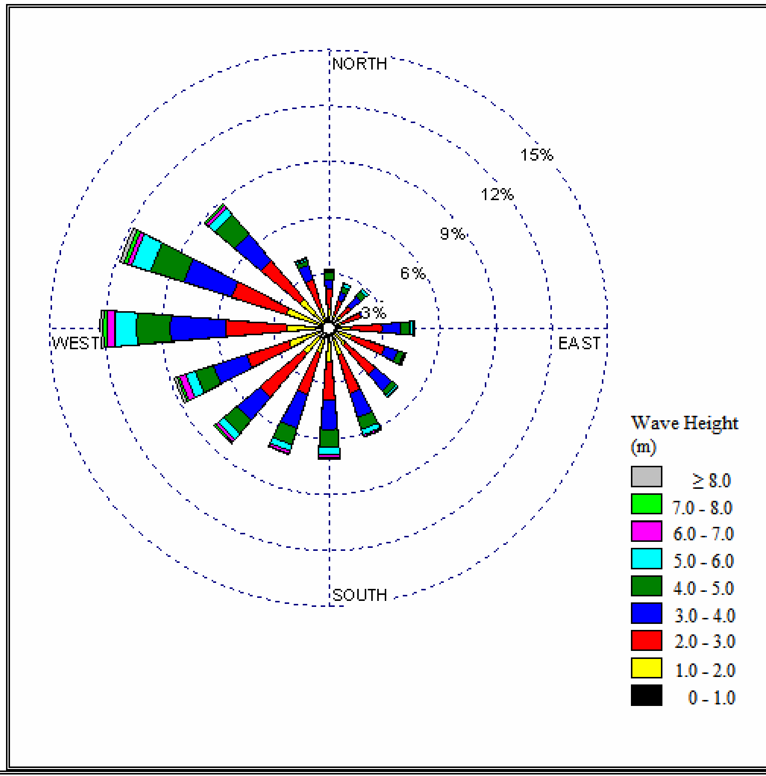

Wave Height Percentage Occurrence
Grid Point 7966
September
Percentage Occurrence (%)
60
50
40
30
20
10
0
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

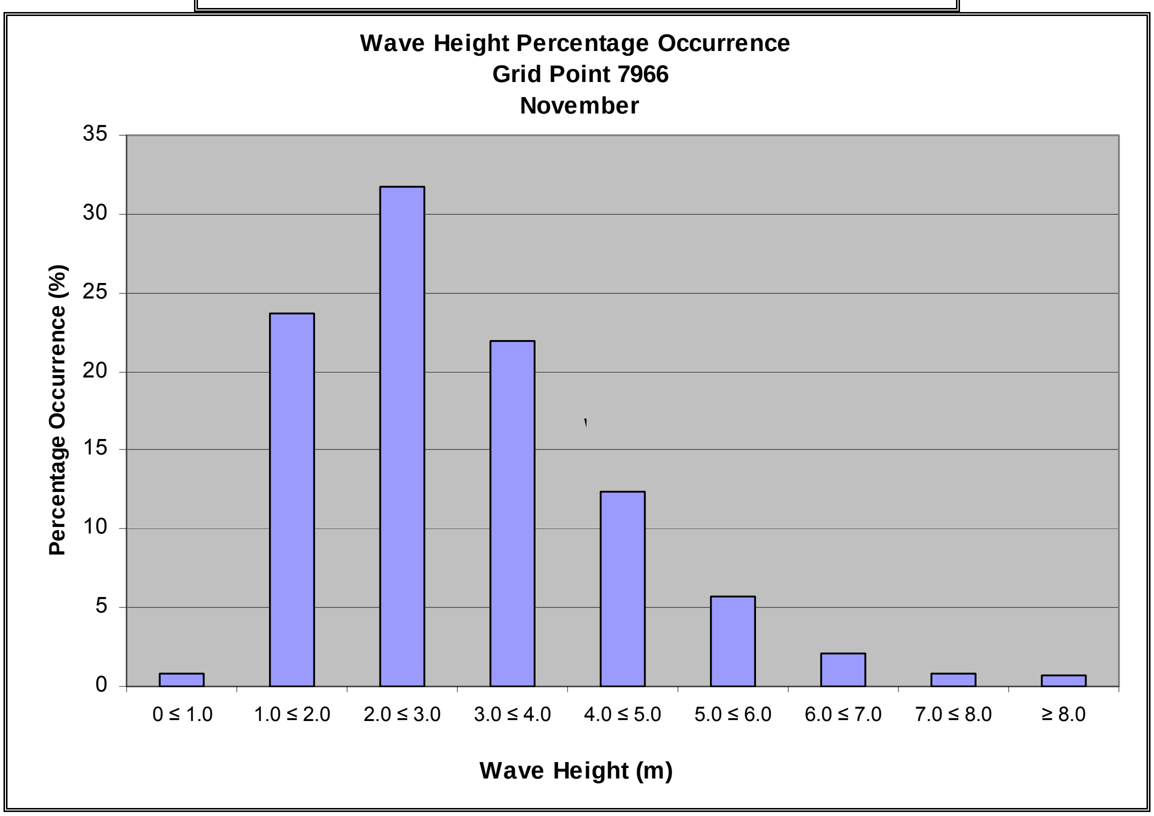
October


NORTH
EAST
SOUTH
WEST
3%
6%
9%
12%
15%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

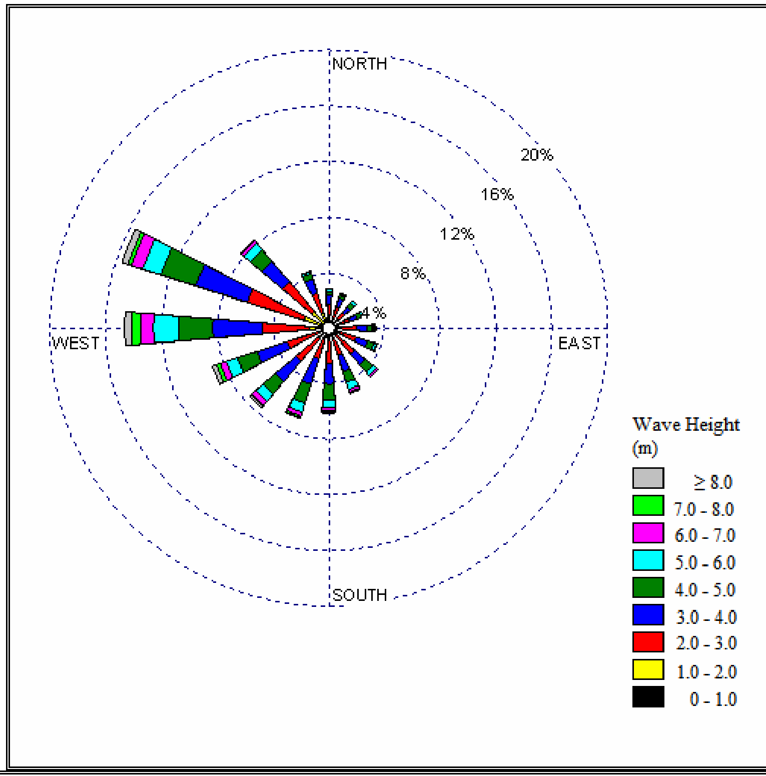

Wave Height Percentage Occurrence
Grid Point 7966
October
Percentage Occurrence (%)
0
5
10
15
20
25
30
35
40
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

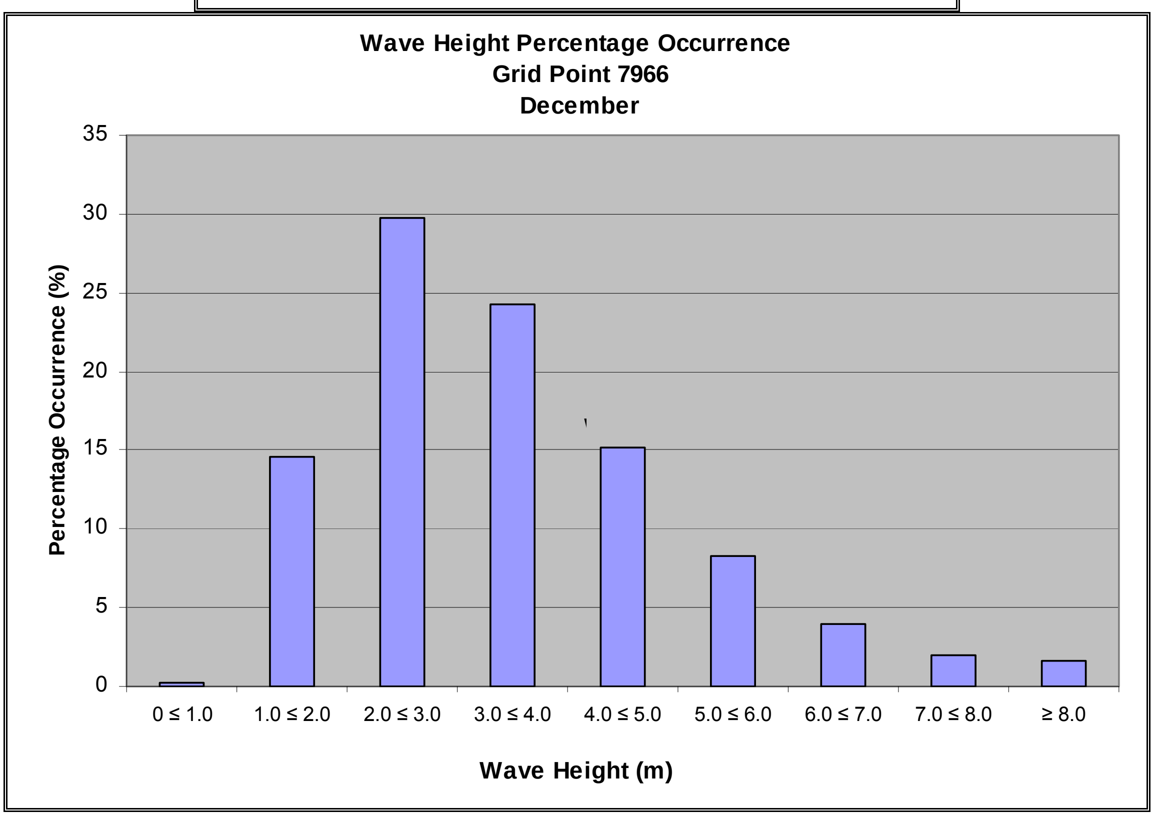
November


NORTH
SOUTH
EAST
WEST
3%
6%
9%
12%
15%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0


Wave Height Percentage Occurrence
Grid Point 7966
November
Percentage Occurrence (%)
0
5
10
15
20
25
30
35
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

December


NORTH
WEST
EAST
SOUTH
4%
8%
12%
16%
20%
Wave Height (m)
≥ 8.0
7.0 - 8.0
6.0 - 7.0
5.0 - 6.0
4.0 - 5.0
3.0 - 4.0
2.0 - 3.0
1.0 - 2.0
0 - 1.0

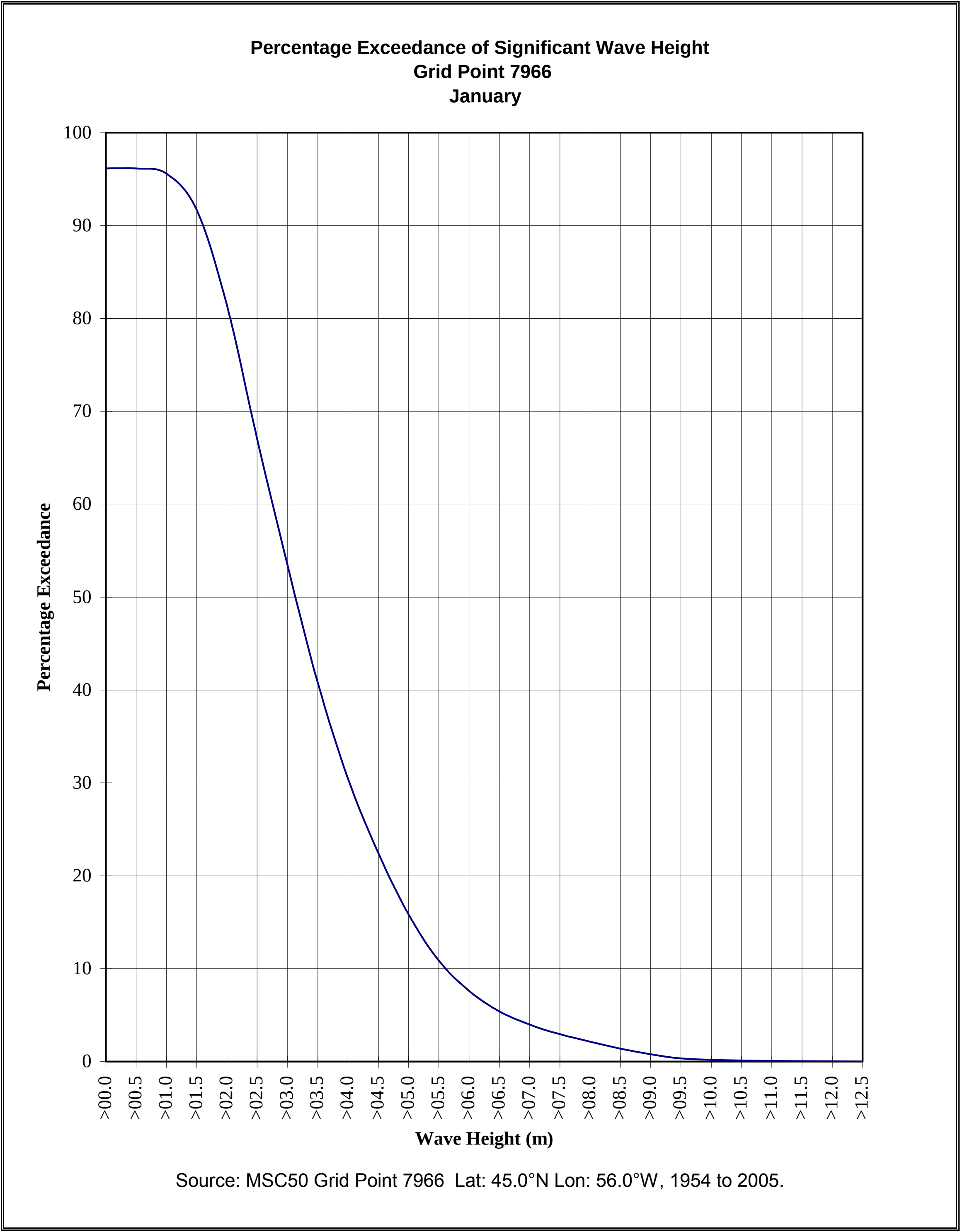

Wave Height Percentage Occurrence
Grid Point 7966
December
Percentage Occurrence (%)
0
5
10
15
20
25
30
35
0 ≤ 1.0
1.0 ≤ 2.0
2.0 ≤ 3.0
3.0 ≤ 4.0
4.0 ≤ 5.0
5.0 ≤ 6.0
6.0 ≤ 7.0
7.0 ≤ 8.0
≥ 8.0
Wave Height (m)

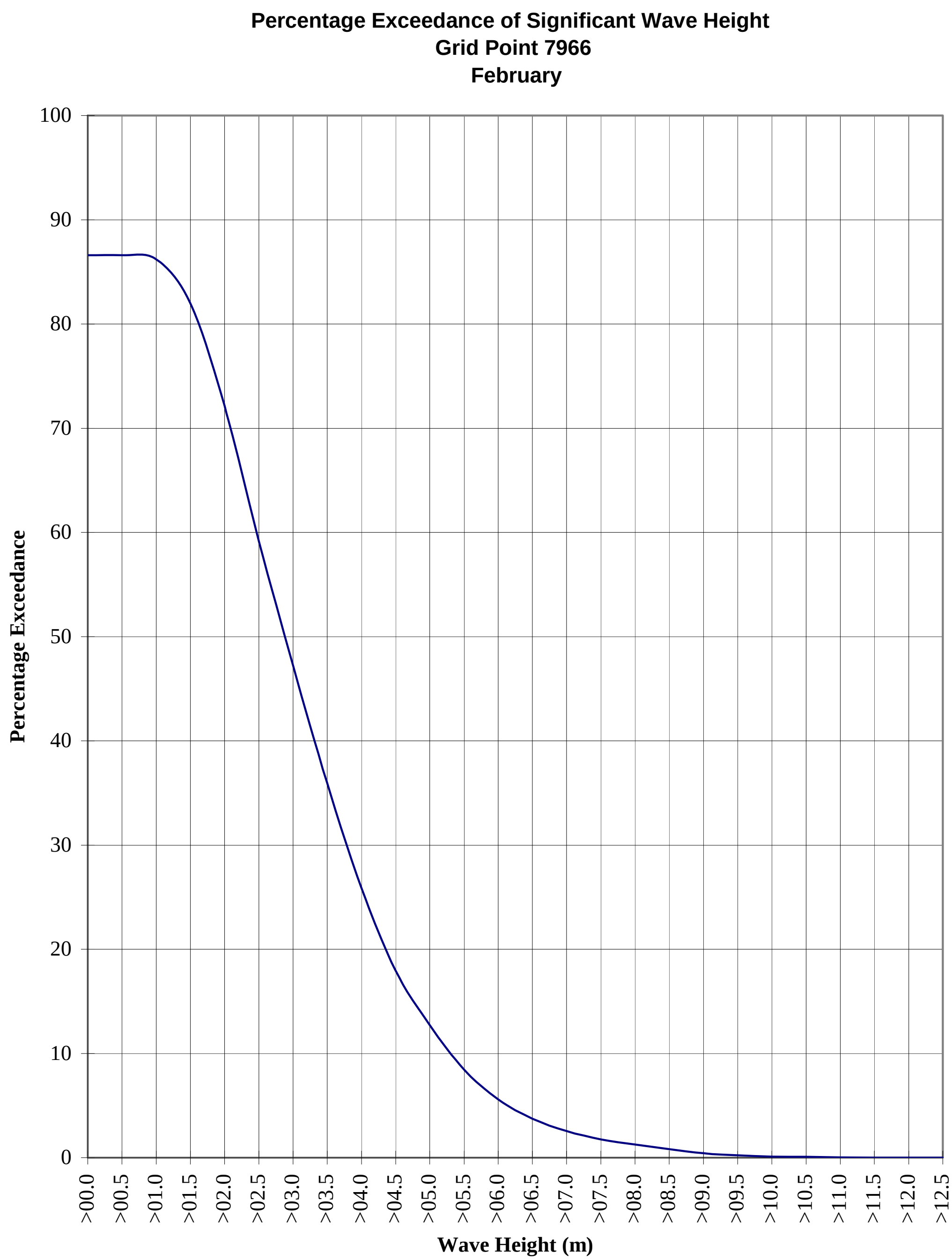
Appendix 1d

Percentage Exceedance

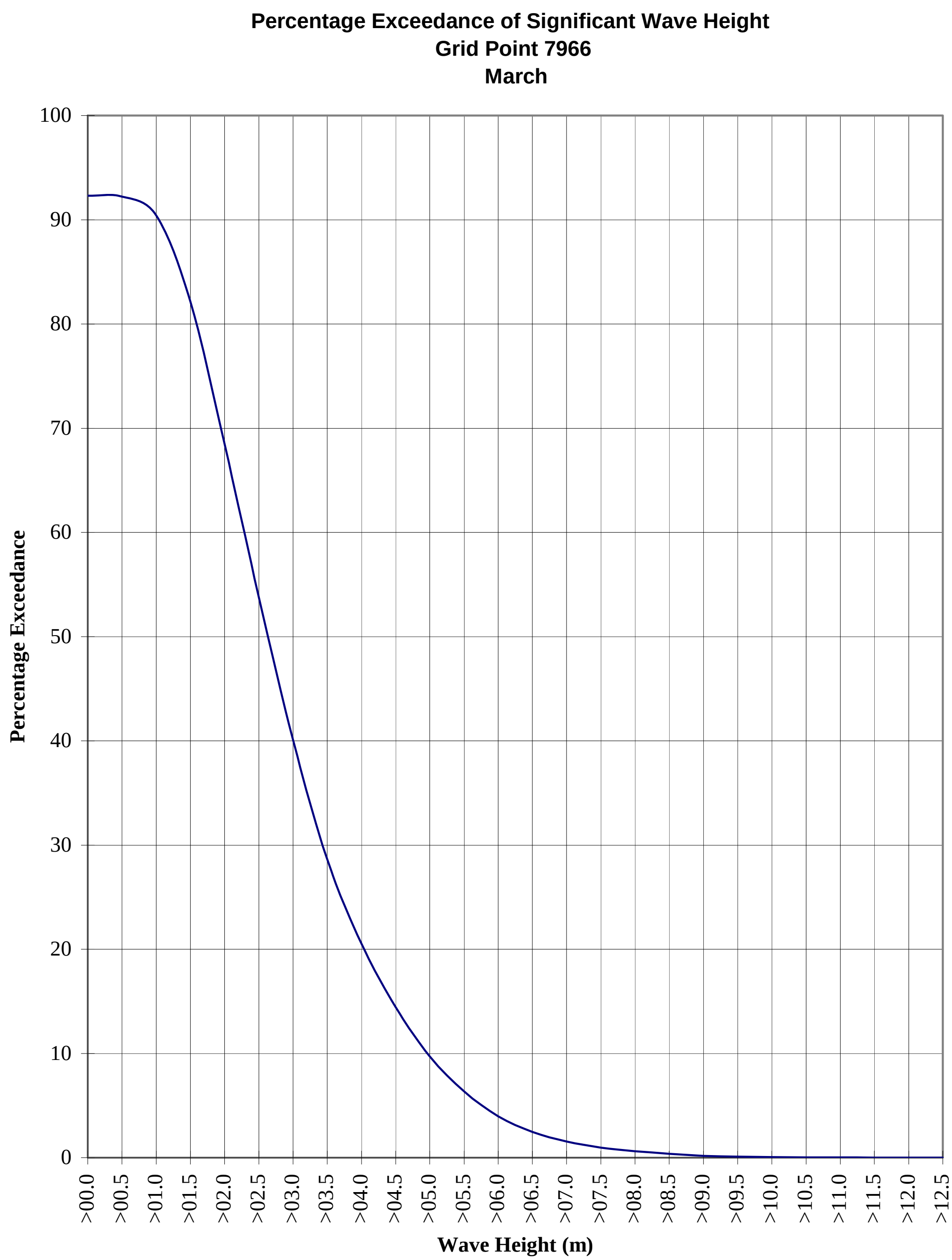
of Wave Height

for MSC50 GridPoint 7966

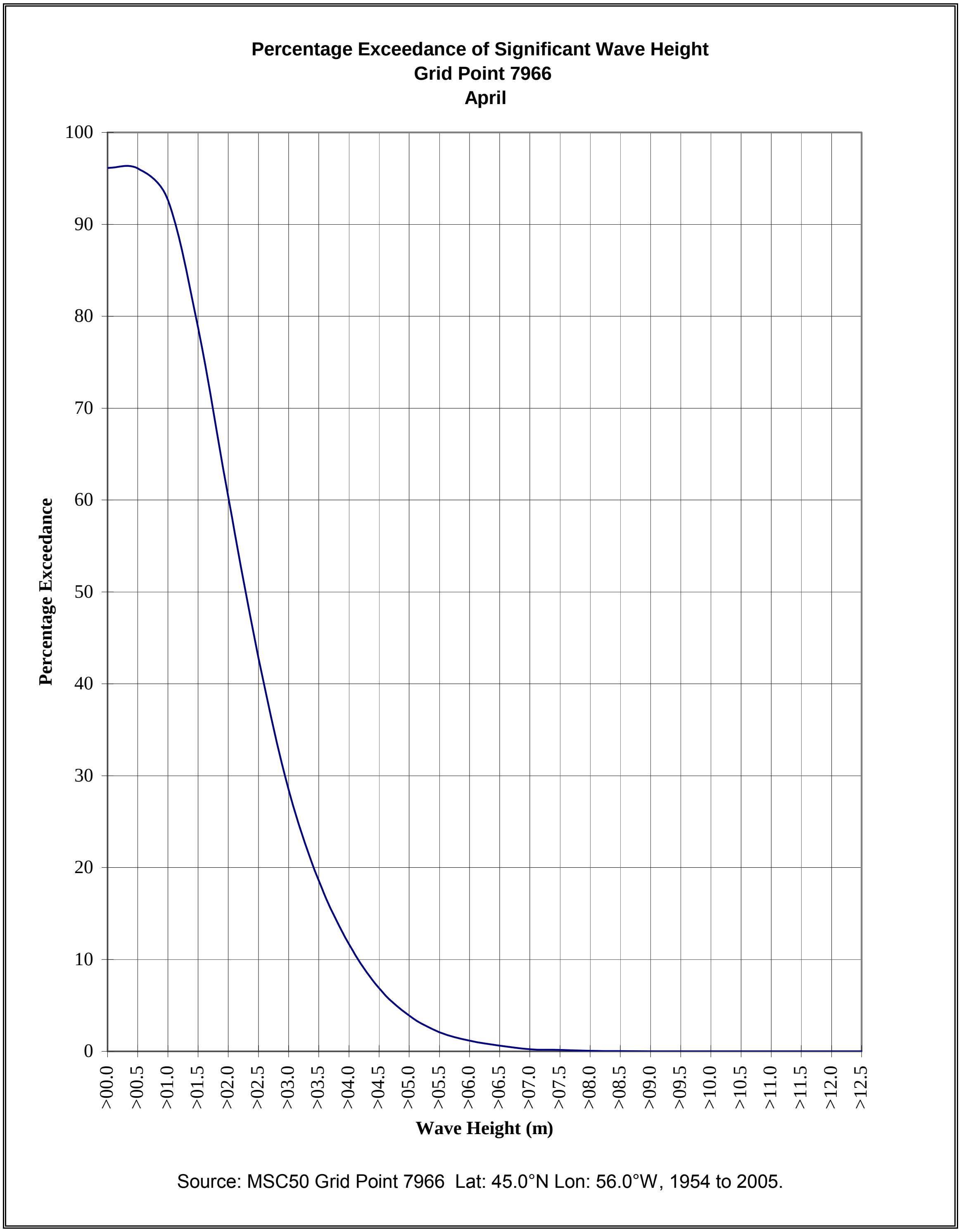

Percentage Exceedance of Significant Wave Height
Grid Point 7966
January
Percentage Exceedance
0
10
20
30
40
50
60
70
80
90
100
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

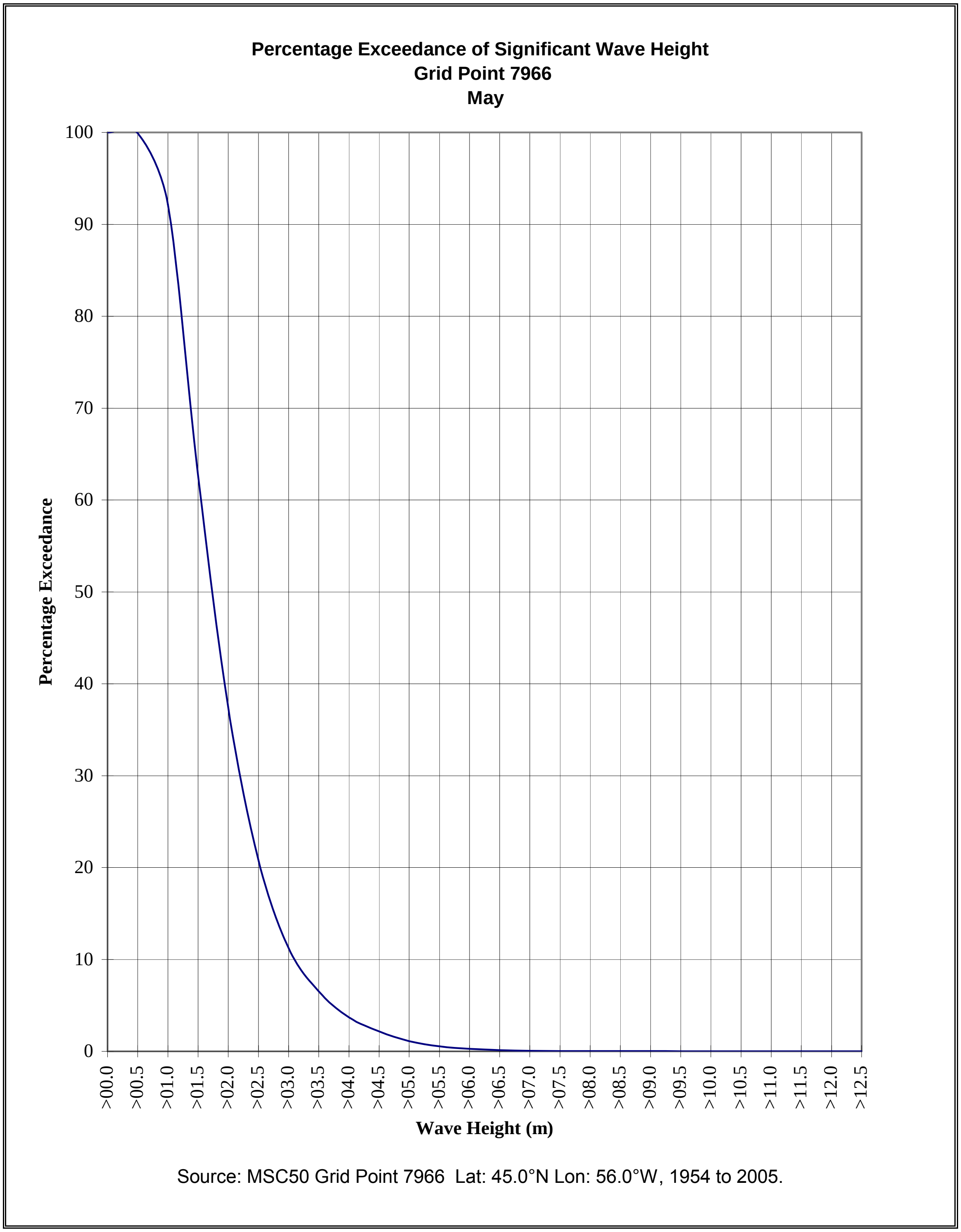


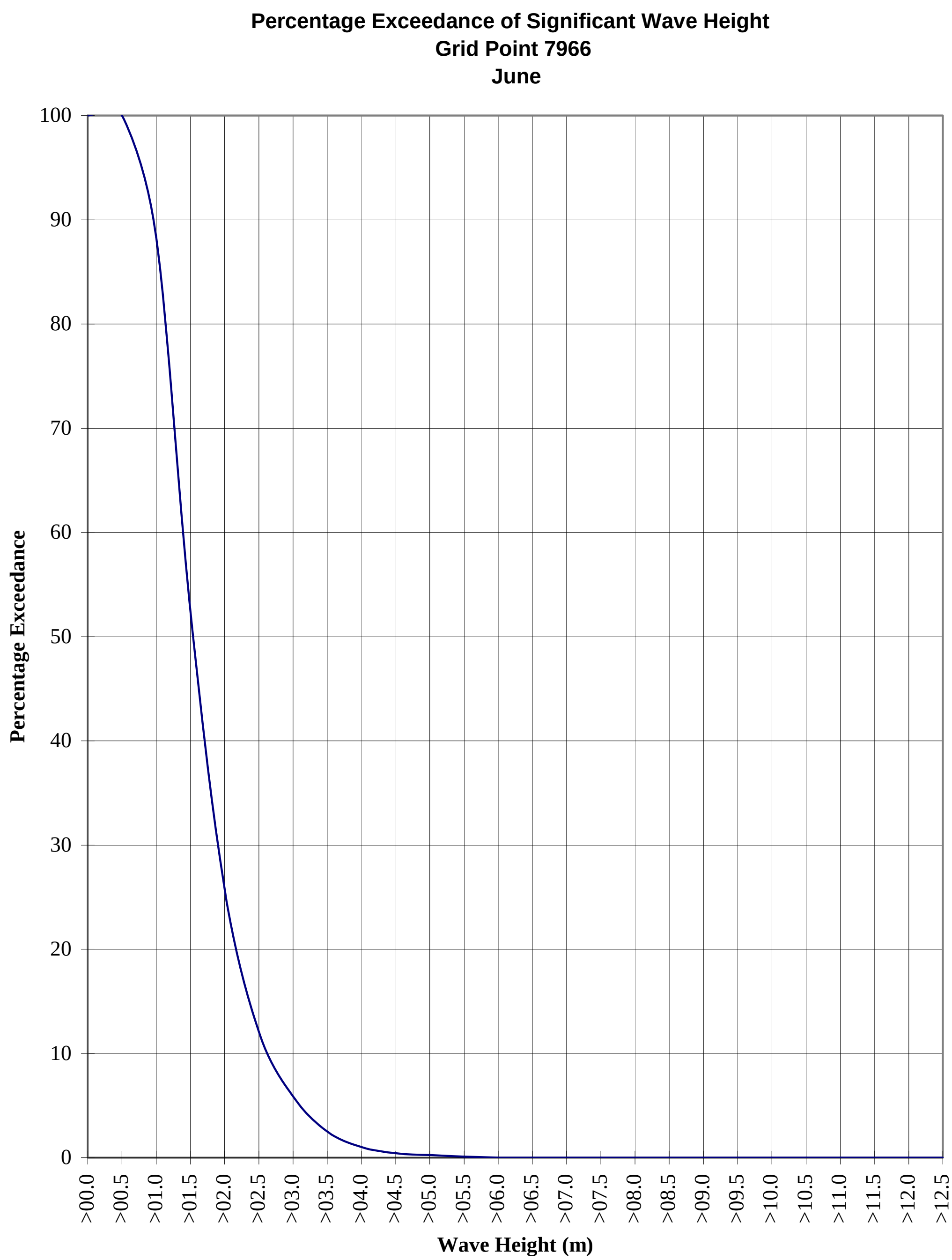
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.



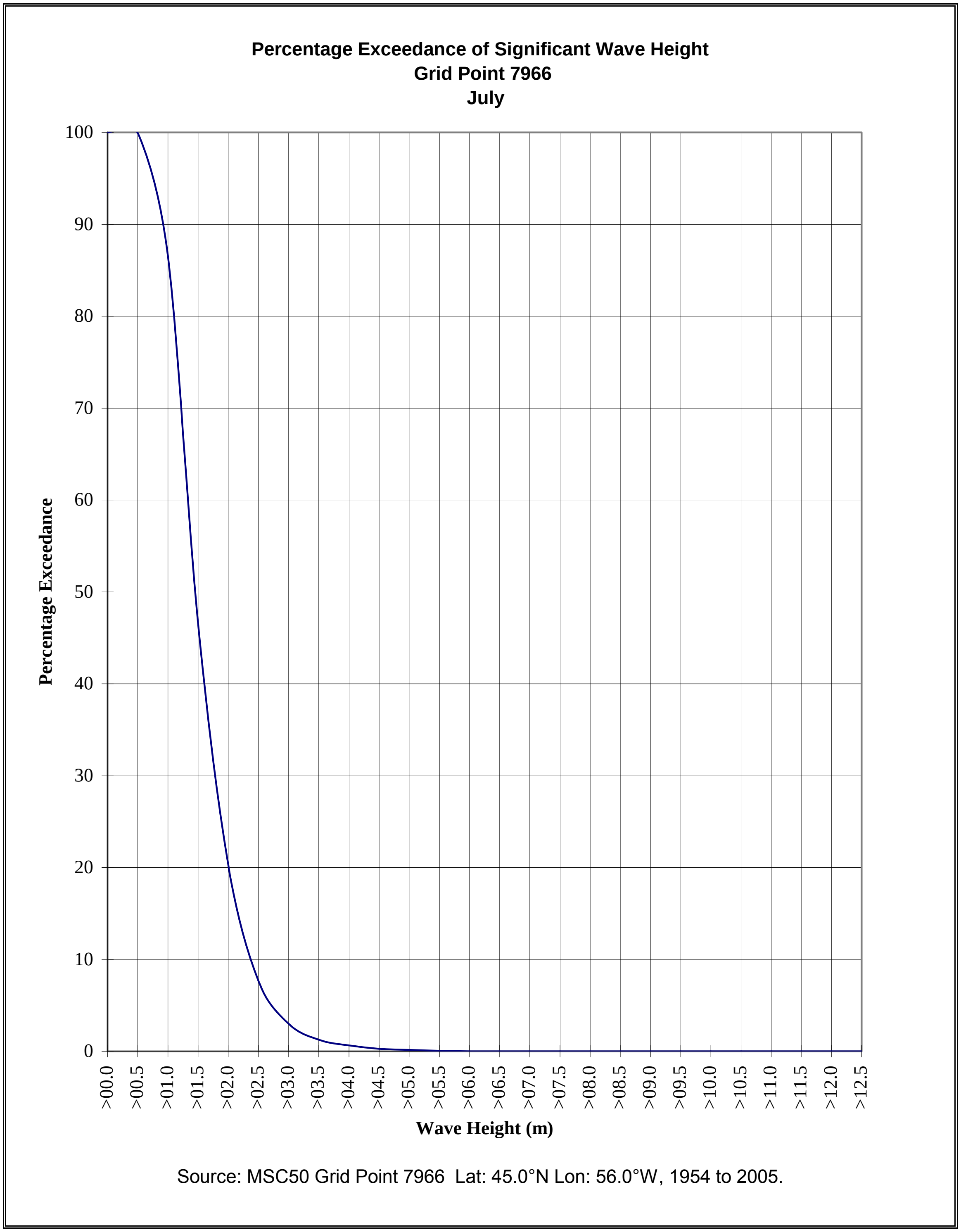
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

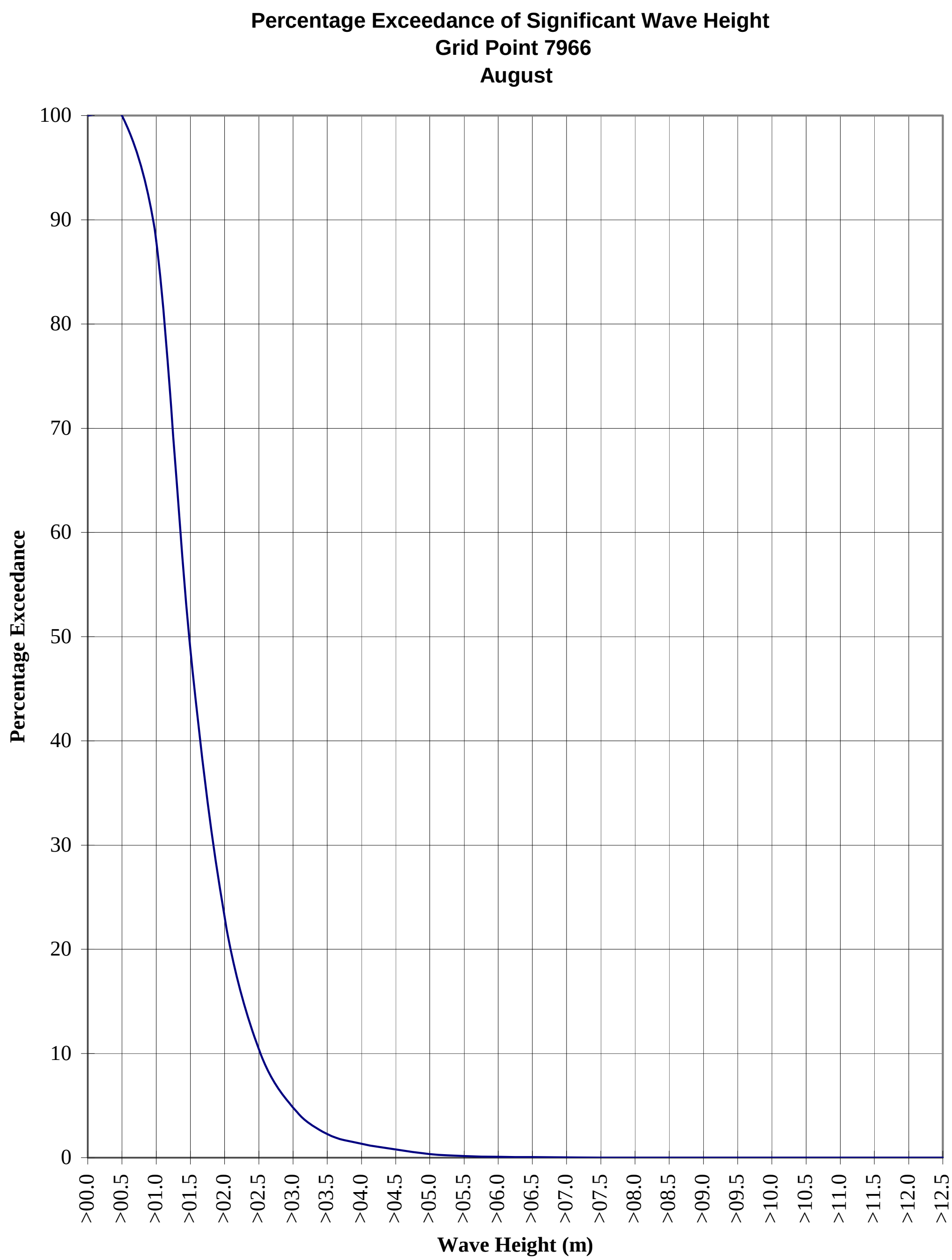

Percentage Exceedance of Significant Wave Height
Grid Point 7966
April
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.


Percentage Exceedance of Significant Wave Height
Grid Point 7966
May
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

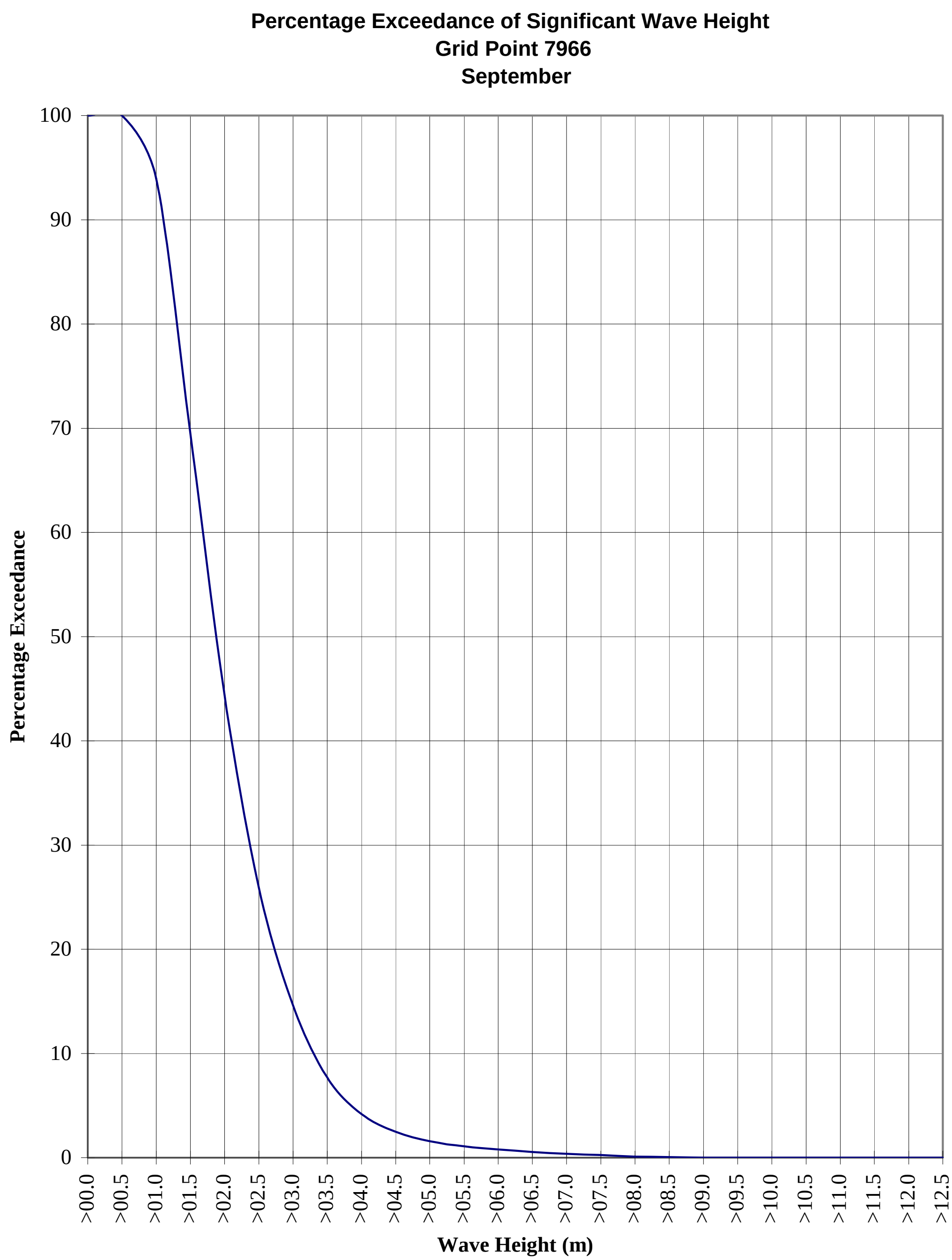


Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

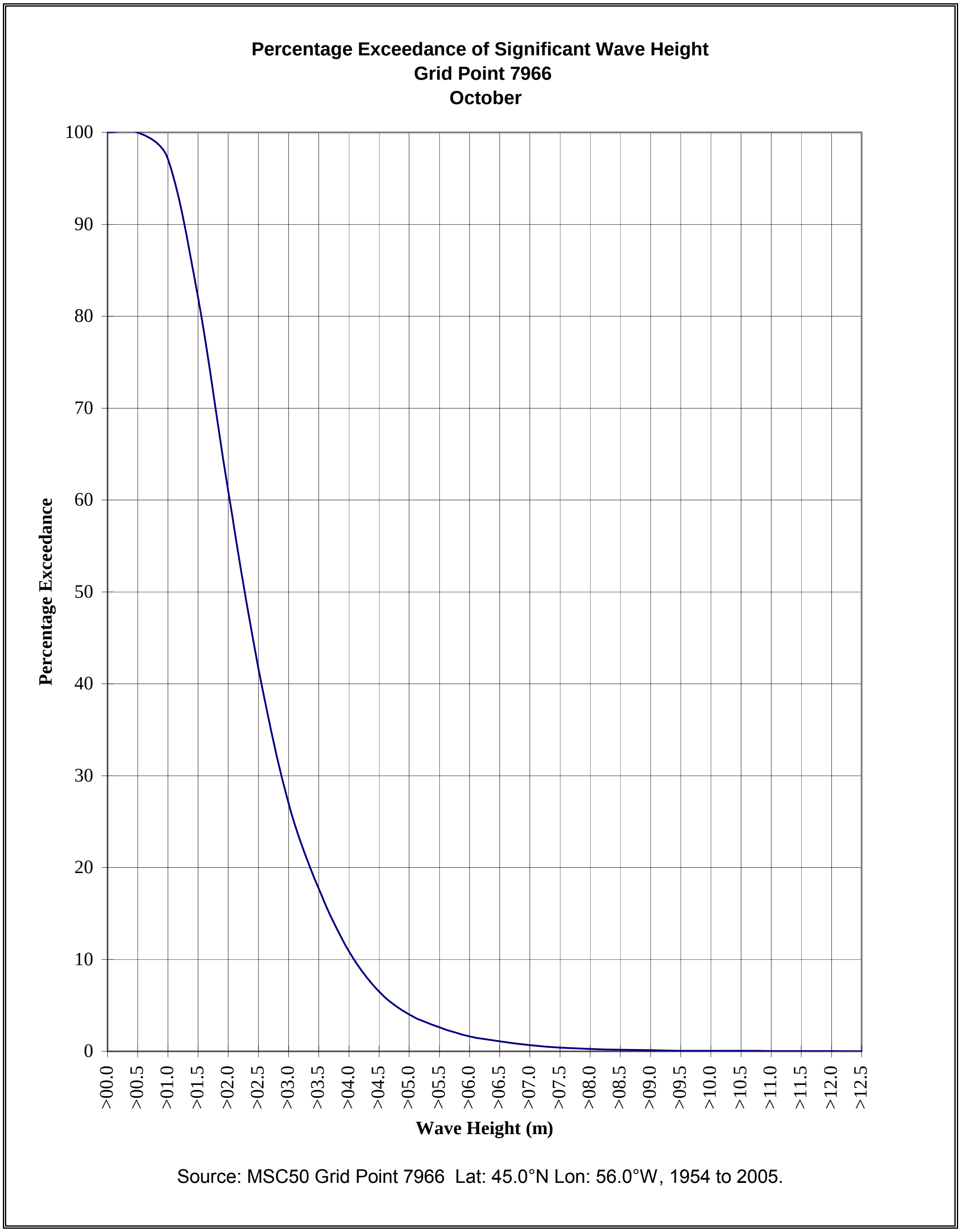

Percentage Exceedance of Significant Wave Height
Grid Point 7966
July
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.

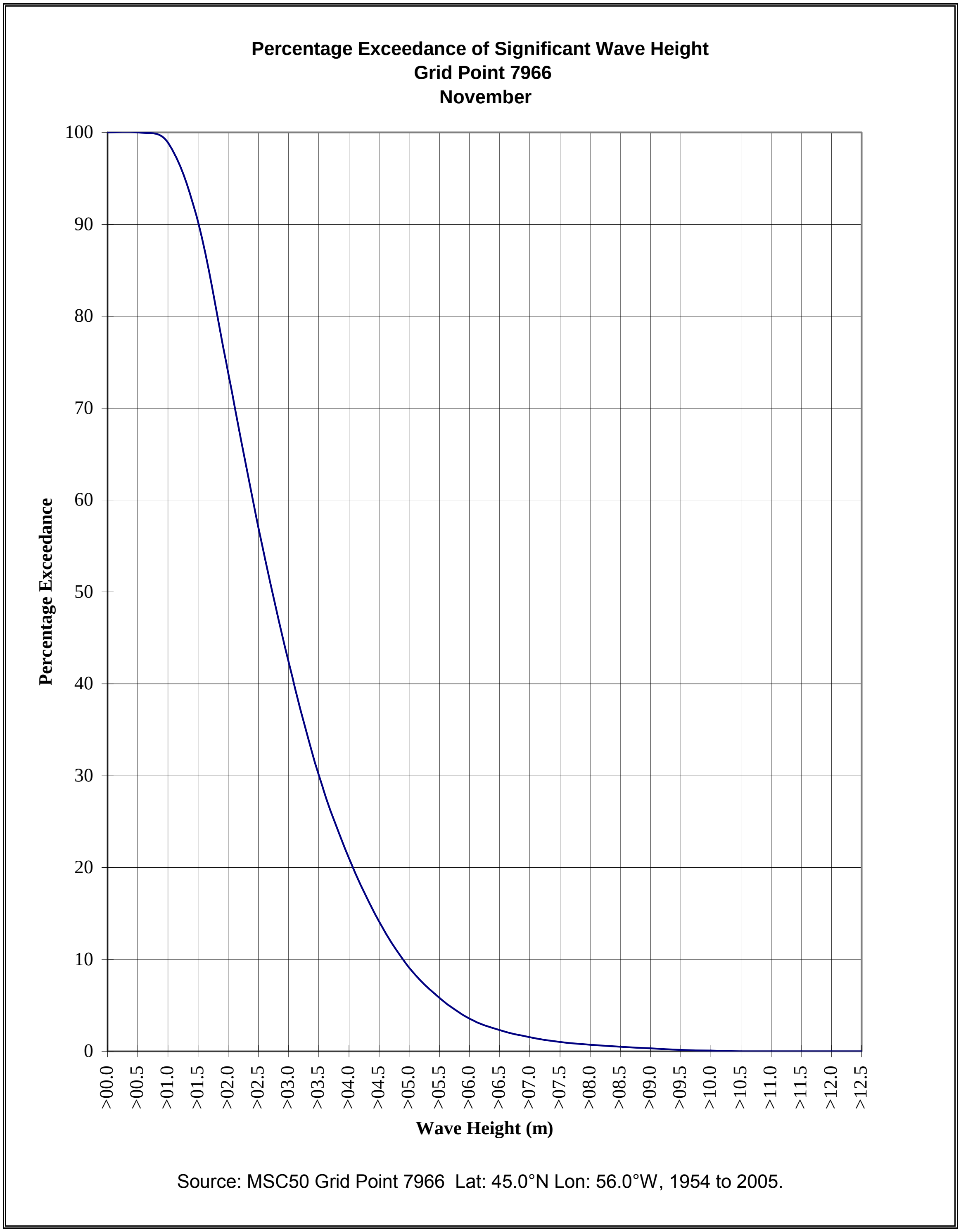


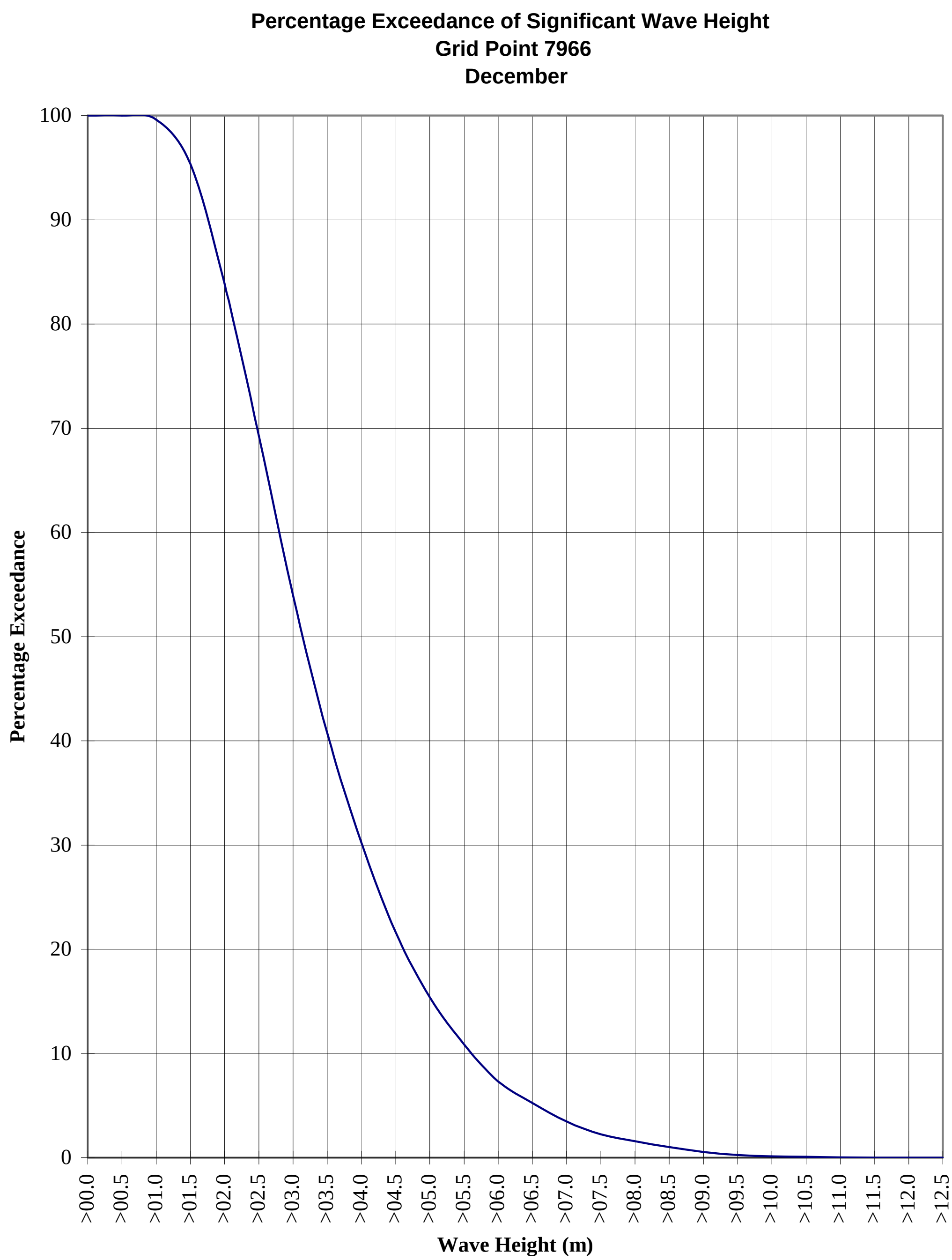
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.



Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.


Percentage Exceedance of Significant Wave Height
Grid Point 7966
October
Percentage Exceedance
100
90
80
70
60
50
40
30
20
10
0
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.


Percentage Exceedance of Significant Wave Height
Grid Point 7966
November
100
90
80
70
60
50
40
30
20
10
0
Percentage Exceedance
>00.0
>00.5
>01.0
>01.5
>02.0
>02.5
>03.0
>03.5
>04.0
>04.5
>05.0
>05.5
>06.0
>06.5
>07.0
>07.5
>08.0
>08.5
>09.0
>09.5
>10.0
>10.5
>11.0
>11.5
>12.0
>12.5
Wave Height (m)
Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.



Source: MSC50 Grid Point 7966 Lat: 45.0°N Lon: 56.0°W, 1954 to 2005.