Biological Assessment
for a
Blue Mussel Ocean Aquaculture Experiment
in Rhode Island Sound

Porter Hoagland[†], Hauke Kite-Powell[†], Walter Paul[‡], and George Hampson*

Woods Hole Oceanographic Institution
Woods Hole, Massachusetts 02543

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† Marine Policy Center, phoagland@whoi.edu and hauke@whoi.edu.
‡ Department of Applied Ocean Physics and Engineering, wpaul@whoi.edu.
* Department of Biology, ghampson@whoi.edu.

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1. Introduction

This report assesses the potential biological impacts on certain protected species of the deployment of a longline for growing blue mussels (*Mytilus edulis*) in Rhode Island Sound. The proposed project is a scientific research experiment designed to test the feasibility of offshore aquaculture from engineering, biological, and economic perspectives. The proposed project is small in scale, limited in duration, and located in an area of the ocean that is known to be only a minor, nonessential habitat for the protected species of concern. Of crucial significance to the relevant protected species and to the project, the project's geographic location is not believed to be critical habitat in even the broadest sense of the term. The project does not involve feeding mussels or treating the mussels with any type of pharmaceuticals. The project relies upon a set of spat from naturally occurring stocks in the region. As a result, the project principal investigators believe that the potential for adverse effects on individuals or stocks of protected species or on their environment is extremely small.

Even with the small probability of adverse impacts, the project incorporates several features designed to minimize the threat of entanglements, should any individual of a protected species come into contact with the longline. The project meets or exceeds all regulatory requirements for fishing gear promulgated to minimize entanglements of protected species, especially large whales, in marine fisheries. Further, both aerial and waterborne monitoring of the site will occur on a regular basis. Finally, a rapid response strategy, involving the use of emergency beacon technology, has been incorporated into the design of the project.

This report incorporates by reference and borrows from both the structure and content of the *Biological Assessment of the Dutra Sea Scallop Aquaculture Proposal* (Smith *et al.* 1995). However, the report advances the discussion in the Dutra Assessment significantly by incorporating the latest results of scientific research on the protected species of concern, including more comprehensive and updated information of the known distribution of the relevant protected species.

2. Description of Proposed Activity

Principal investigators at the Woods Hole Oceanographic Institution (WHOI) have applied for a permit under Section 10 of the U.S. Rivers and Harbors Act of 1899 (33 U.S.C. § 403) to deploy a longline aquaculture structure in the U.S. territorial sea off the coast of Massachusetts. The deployment is a scientific research project, funded with grant monies from U.S. federal, state, and private sources. The primary purposes of the deployment are to test the engineering feasibility, biological productivity, and survivability of a longline for ocean culture of the blue mussel (*Mytilus edulis*). The principal investigators plan to deploy the experimental longline for a period of two years, after which it will be removed.

The deployment is part of a scientific research project involving a collaboration between principal investigators at WHOI, project consultants and advisors, and BlueGold

International, a harvester and processor of blue mussels and other seafood products headquartered in New Bedford, Massachusetts.

Engineering concept. The basic engineering concept is a subsurface longline mooring, combined with a mussel growout harness, separate surface buoys for servicing, and separate surface guard buoys for site identification and protection (Figure 1). The longline and its legs will have a "footprint" of approximately 200m from anchor to anchor; the longline itself will be suspended with subsurface moorings about 5m below the surface. Subsurface moorings avoid most of the sea state generated heave and surge motions of gear moored at the surface; they also limit biofouling, predation by birds, and interference with surface vessels and protected species. The longline's upper portion is designed so that it can be raised to sea level, permitting inspection and harvest (Figure 2).

Alternative growout configurations. Off-bottom longline mussel farming operations in Quebec have used engineering designs similar in concept to that proposed here (Bonardelli 1997, 1996).[1] The project principal investigators plan to test several different configurations for blue mussel growout. These include (1) a string of parallel suspended grow ropes with equally spaced horizontal mussel weight support bars; (2) a continuous string of socking material hung in loops of variable length—each loop will be equipped with a weak link (tensile strength of about 25 lbs) located at the bottom of each loop; (3) possibly other configurations. Although the project principal investigators believe that the threat of entanglement is low, each configuration is designed to ensure minimal impacts on protected species and to determine mussel growth rates, response to currents, stability under increasing mussel growout weight loads, and serviceability--either at the sea surface using a support vessel or with divers. Flotation will be added to the longline as the weight of the mussel strings increases with the growth of mussels.[2]

Engineering research. Engineering research has been funded by the Office of Naval Research and the MIT Sea Grant program and will involve both computer modeling and prototype testing (Grosenbaugh and Paul 1997; Weller *et al.* 1996). Offshore sites are exposed to any and all weather and sea states, requiring engineering systems that can survive the largest wave formations at a site. The engineering effort will develop proper design, fabrication, deployment, service, and retrieval techniques for growing systems. Important technical issues include low-tension cable dynamics and snap loading, position stability, and excursions of the system under sea state and current forcing. Relevant engineering questions include the design of a commercially feasible and survivable longline; optimizing the geometry and configuration of a harness to facilitate commercial operations (deployment, maintenance, harvest) while minimizing stress; orientation of the longline with respect to ocean current forces; development of weak links to minimize

[1] Currently, commercially viable offshore mussel farms in unprotected waters in other parts of the world are beginning to be developed, including the systematic harvest and temporary storage of the Mediterranean mussel (*Mytilus galloprovincialis*) from the legs of offshore oil rigs off the California coast (Abbott 1994) and the open ocean surface culture of the green mussel (*Perna caniculacus*) in New Zealand (Thomson 1996).

[2] Typical mussel weight after an 18-24 month growout is 10 lbs/ft in air (3.5 lbs/ft in seawater). The mussels form a continuous cylinder of about 6" in diameter.

Figure 1: Planned submerged longline sytem with mussel growout harness options

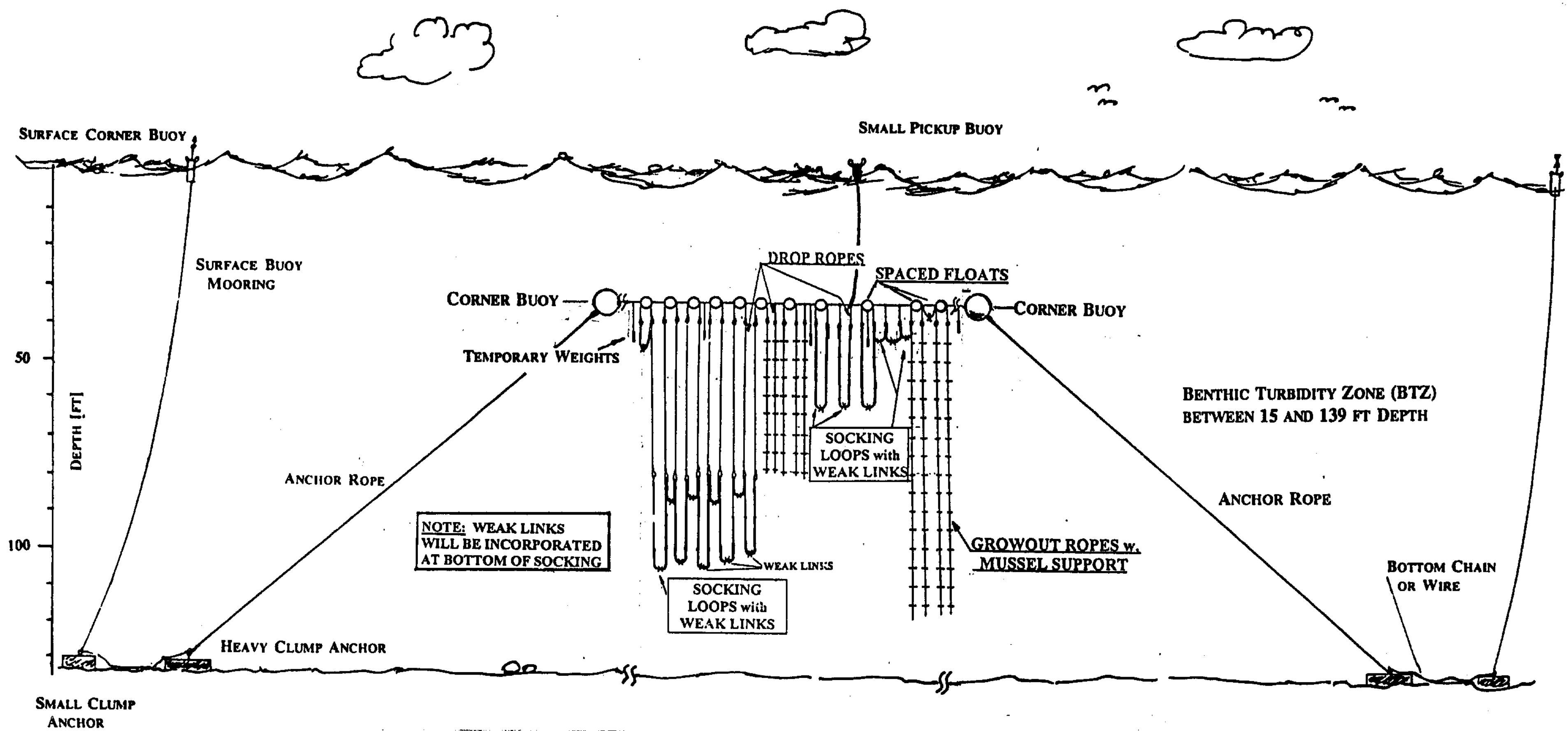
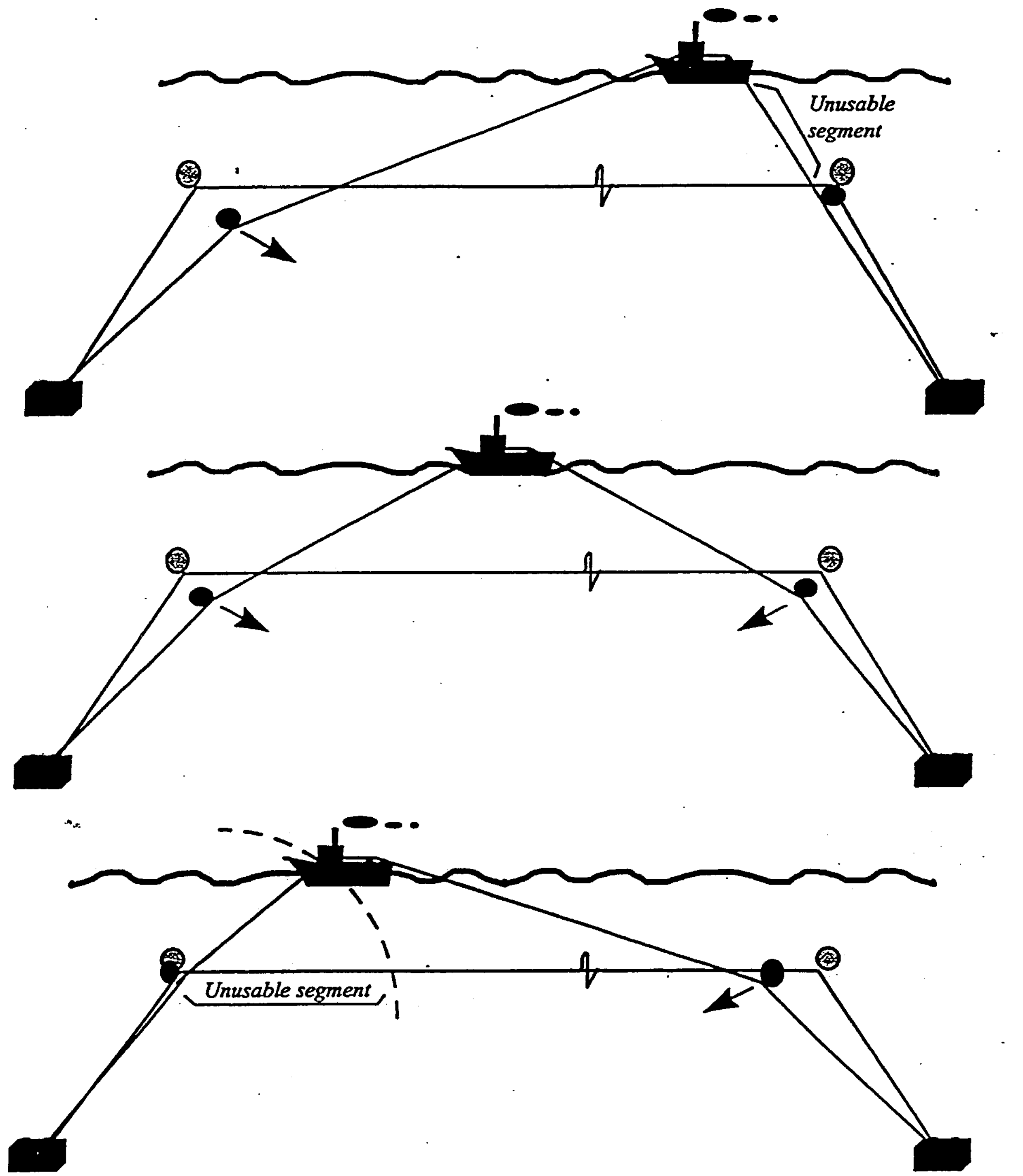


Figure 2: Flexibility of submerged longline at surface (Bonardelli, p.c., 1998)



The change in geometry of a longline with good structural tension as it is manoeuvred from the surface. Arrow (→) indicates mouvement of corner buoys as the geometry of the longline changes. The length of the unusable segment depends on the depth from the surface.

impacts on protected species without compromising system strength; and development of methods to remove unwanted biological growth; among others. The research team may add engineering and environmental sensors with data storage capabilities to the longline structure, allowing comparisons of modeled and observed performance.

Biological research. The Commonwealth of Massachusetts, through its Massachusetts Aquaculture Grants (MAG) Program, is sponsoring biological research on offshore mussel growth on the longline (Hampson *et al.* 1997). Scientific research on the tidal resuspension of soft sediments in coastal embayments, known as the "benthic turbidity zone" (BTZ), has shown that the resuspension contains rich organic mineral aggregates high in particulate carbon and nitrogen (Rhoads *et al.* 1984; Hampson *et al.* 1989). These energy-rich aggregates are excellent food sources for mollusks, often exceeding food concentrations found in the near sea or intertidal waters (Rhoads 1973; Rhoads, Tenore and Brown 1975; Rhoads *et al.* 1984). The BTZ exists as well in offshore areas where the bottom consists of soft muddy sediments resuspended by tidal or wave scour, as is the case at the proposed site.

The specific biological hypothesis to be addressed by this project is that secondary bioproductivity in the BTZ results in enhanced growth rates of blue mussel on a longline suspended at an offshore location. The project principal investigators hypothesize that appreciable growth of high quality mussels can be realized by suspending the shellfish off the bottom, exposing them to the suspended particulates in the BTZ. The project principal investigators expect to find that mussels suspended in the BTZ do not contain pearls from grit contamination or parasites, and have reduced levels of pea crab infestation and predation, compared to mussels grown on the seafloor.

The primary biological questions to be addressed include: (1) analysis of the availability and survival rate of wild mussel set on a longline at the offshore location; (2) investigation of the potential for transplantation of wild mussel sets from nursing areas; (3) compilation of data to construct mussel condition indices to evaluate somatic and shell growth of mussels at different locations in the water column; (4) analysis of seasonal BTZ zone nutrients (POC, PON, chlorophyll); and (5) analysis of the degree of commensalism, predation, mortality, and related destruction from pea crabs or other predators.

Monitoring mussel growth. The mussel growing process will be monitored carefully. Seasonal weights will be obtained for shell and somatic tissue of the mussel. A mussel "condition index" will be determined (both wet and dry basis) as described by Baird (1958). Comparisons between sample populations will be made using a distribution-free small sample test. These data will be collected at various critical seasonal times (Apr-May, Jul-Aug, Sep-Oct, Dec-Jan) over a two-year growout cycle, when the longline is raised for inspection. The sampling will involve collecting mussels from the growout lines from selected depths based on observed gradients in mussel size and density. These samples will be compared with growth of natural populations from the shallower waters in Buzzard's Bay, outside the BTZ.

Economic and policy analysis. The WHOI Sea Grant program is funding economic and policy analysis research focusing on optimizing the offshore aquaculture of blue mussels and other species (Hoagland *et al.* 1997). The project principal investigators plan to develop a framework for evaluating the commercial viability of offshore farming using longline technology, including a spreadsheet-based model of project economics, methods of risk assessment, and a model of supply and demand in the blue mussel market.

3. Description of Environment

3.1. Physical Conditions

The proposed project is planned for deployment at a scientific testing area in Rhode Island Sound known as the "WHOI Buoy Farm," which is located at 41°16'N latitude, 71°01'W longitude. The Buoy Farm is clearly marked as a "surface and subsurface scientific testing area" on U.S. Coast and Geodetic Survey nautical chart No. 13218 (Figures 3 and 4). The Buoy Farm is an exposed site 10 nm from the entrance to Vineyard Sound and 5 nm to the southeast of the Buzzards Bay Inbound Traffic Lane. It is located within the territorial sea of the United States but beyond the territories and submerged lands of Massachusetts and Rhode Island.

The proposed project site is located beyond the 40 m isobath where the bottom begins to deepen gradually off the entrance to Vineyard Sound. Water depth at the site is approximately 42 m.

The most recent current measurements at the proposed project site were taken during April-May 1995 using an S-4 current meter (Paul, p.c., 1998). Average current speeds near the surface are less than half a knot (20 cm/sec). Currents may increase to a maximum of 1.5 knots (70 cm/sec) during severe storm events. In the absence of severe weather, the currents are tidal, but they do not follow a typical tidally influenced pattern. Currents rotate clockwise from the north, travelling through 360° during one tidal cycle.

Table 1 displays the known sediment characteristics from Rhode Island Sound (41.00-41.58 N latitude; 70.67-71.58 W longitude) contained in the U.S. Geological Survey database. Samples located nearest the proposed project site range from gravel to silty sand. No data have been added to the USGS database in the area of the proposed project site in more than 30 years. In March 1998, the project team took grab samples (0.04 m^2 in area) of the surface sediments at the proposed project site. The sediment is fine-grained and soft. Small amounts of sand are present in the samples, occurring possibly due to current movements or storm activity.

VICINITY MAP

[redacted] Location of proposed project site in Rhode Island Sound (USC&GS No. 13218)

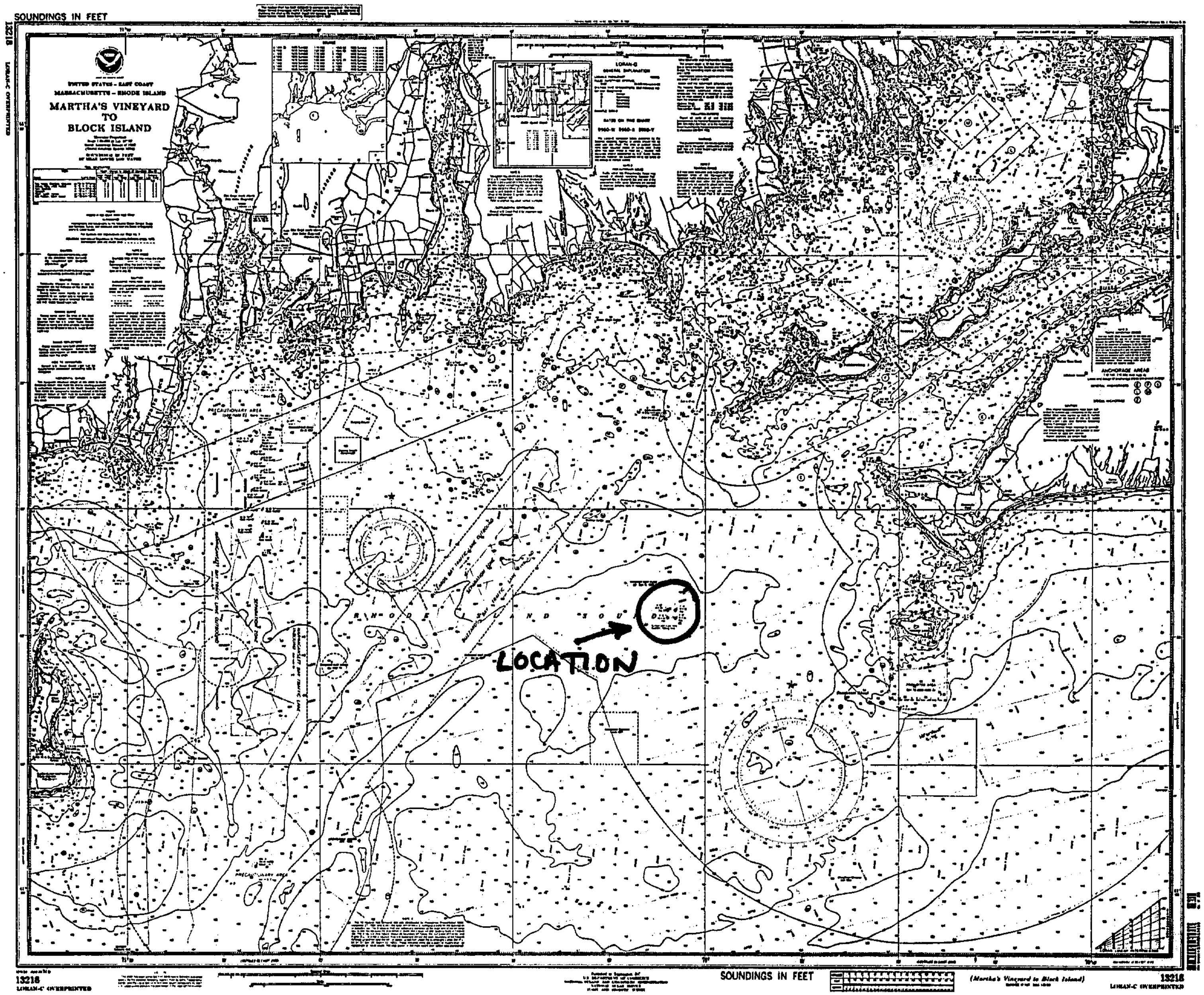


Figure 4: Blowup of proposed project site showing private aids to navigation

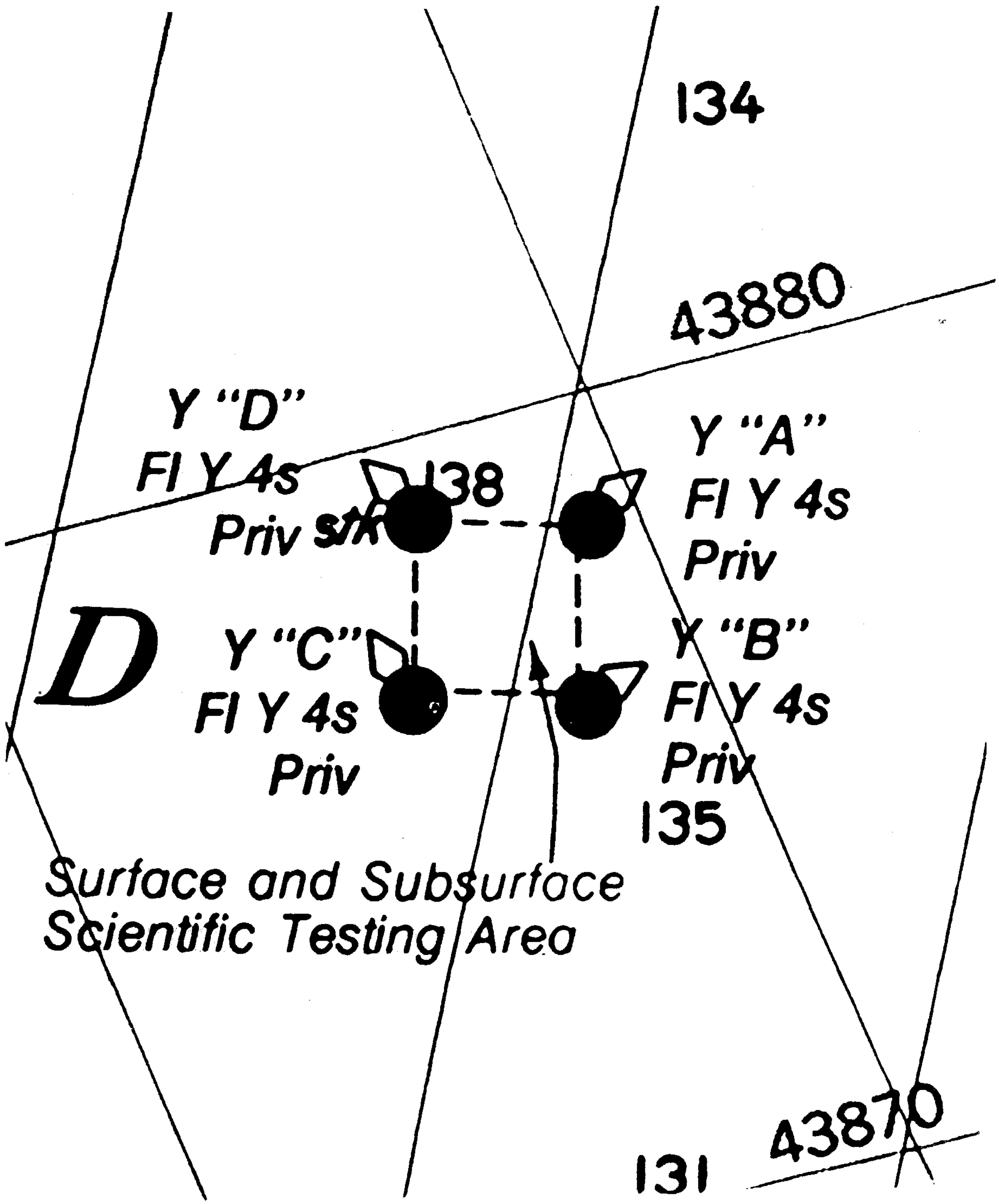


Table 1: Known sediment characteristics from Rhode Island Sound (41.00-41.58 N; 70.67-71.58 W)

Area	Lat.	Long.	Depth	Device	Year	Lithology	Gravel	Sand	Silt	Clay	Class-
BLOCK ISLAND (N.E. of)	41.23	71.53	34	SMITH-MCINTYRE W/0CAMERA	1964	BROWN,SILTY,VERY FINE SAND		97.00	3.00		SAND
BLOCK ISLAND (N.E. of)	41.30	71.36	35	CAMPBELL GRAB W/ CAMERA	1963	BROWN MEDIUM SAND.		100.00			SAND
BLOCK ISLAND (S.E. of)	41.11	71.44	38	CAMPBELL GRAB W/ CAMERA	1963	BROWN MED GRAINED WELL SORTED SAND AND BROKEN SHELLS.		100.00			SAND
BUZZARDS BAY	41.41	71.09	23	CAMPBELL GRAB W/ CAMERA	1963	MEDIUM SAND.		100.00			SAND
BUZZARDS BAY	41.46	70.86	22	CAMPBELL GRAB W/O CAMERA	1963	GRAY-BROWNISH GRAY SILTY MUD		55.40	26.30	18.30	SILTY SAND
BUZZARDS BAY	41.46	70.86	22	CAMPBELL GRAB W/O CAMERA	1963	FINE SAND +SILT, LIGHT BROWN SURFACE FILM, WORM TUBES		42.60	46.00	11.40	SANDY SILT
BUZZARDS BAY	41.54	70.78	18	CAMPBELL GRAB W/O CAMERA	1963	GRAY BROWN SILTY MUD, SOME FINE SAND + BROKEN SHELL FRAGMENTS		31.60	41.70	26.40	SAN SIL CLY
BUZZARDS BAY	41.54	70.73		OTHER				6.74	63.81	29.45	CLAYEY SILT
BUZZARDS BAY	41.54	70.73		OTHER				7.09	69.86	23.05	CLAYEY SILT
BUZZARDS BAY	41.54	70.73		OTHER				8.49	74.02	17.49	CLAYEY SILT
BUZZARDS BAY	41.54	70.73		OTHER				9.57	66.55	23.88	CLAYEY SILT
BUZZARDS BAY	41.54	70.73		OTHER				6.62	66.22	27.17	CLAYEY SILT
BUZZARDS BAY	41.54	70.73		OTHER				8.30	74.88	16.82	CLAYEY SILT
BUZZARDS BAY	41.55	70.80	15	BOX SAMPLER	1963	GREENISH BLACK MUD. H2S ODOR.		3.00	60.70	36.30	CLAYEY SILT
CAPE COD (shelf S. of)	41.02	71.27	47	SMITH-MCINTYRE W/OCAMERA	1962	RUSTY BROWN MD-FINE SAND		100.00			SAND
CAPE COD (shelf S. of)	41.07	70.75	46	DIETZ-LAFOND SNAPPER	1962	REDDISH BROWN MEDIUM SAND		100.00			SAND
CAPE COD (shelf S. of)	41.13	71.00	46	DIETZ-LAFOND SNAPPER	1962	TAN MEDIUM-FINE SAND		100.00			SAND
CAPE COD (shelf S. of)	41.17	71.25	38	SMITH-MCINTYRE W/OCAMERA	1962	TAN FINE SHELL SAND		100.00			SAND
CAPE COD (shelf S. of)	41.27	70.83	33	DIETZ-LAFOND SNAPPER	1962	RUSSET SAND		100.00			SAND
EASTONS BEACH,R.I.	41.49	71.29			1964	CLEAN FINE QUARTZ SAND		100.00			SAND
GAY HEAD	41.35	70.84			1966	GRAY CLAY FROM SMALL LENTICULAR MASSES IN MIOCENE GREEN SAND					
HORSENECK	41.51	71.06			1964	CLEAN FINE QUARTZ SAND		100.00			SAND
LAMBERTS COVE	41.44	70.71	37	CAMPBELL GRAB W/ CAMERA	1963	UNIFORM SAND WITH ORGANIC BLACK MATRIX CLAM FLAT MATERIAL 1/4 GRAVEL	46.50	41.60	6.70	5.30	
LONG ISLAND SOUND	41.20	71.48	35	VIBRA CORE			4.12	34.06	43.36	18.46	SANDY SILT
LONG ISLAND SOUND	41.20	71.48	35	VIBRA CORE			0.77	97.48	1.03	0.71	SAND
LONG ISLAND SOUND	41.20	71.48	35	VIBRA CORE			44.35	52.26	0.79	2.61	GRAVEL > 10%
LONG ISLAND SOUND	41.28	71.30	34	VIBRA CORE			0.03	80.51	12.68	6.77	SAND
LONG ISLAND SOUND	41.28	71.30	34	VIBRA CORE				10.70	77.50	11.80	SILT
LONG ISLAND SOUND	41.28	71.30	34	VIBRA CORE				6.97	86.80	6.24	SILT
MARTHAS VINEYARD	41.38	70.70			1964	MORAINE SAMPLE					
MARTHAS VINEYARD	41.42	70.69			1964	SAND					
MARTHAS VINEYARD	41.42	70.69			1964	VERY CLAYEY SAND					
MARTHAS VINEYARD	41.42	70.69			1964	SAND					
MARTHAS VINEYARD	41.42	70.69			1964	GRAVELLY SAND					
MARTHAS VINEYARD (S. of)	41.17	70.83	27	DIETZ-LAFOND GRAB	1965	COARSE BROWN SAND					
MARTHAS VINEYARD (S. of)	41.26	70.78	20	DIETZ-LAFOND GRAB	1965	LIGHT-BRWN MED SAND					
MARTHAS VINEYARD (Zacks)	41.32	70.81			1964	BEACH SAND,MID TIDE LEVEL		100.00			SAND
NARRAGANSETT BAY	41.48	71.41	13	SMITH-MCINTYRE W/CAMERA	1964	SHELLHASH OF WHOLE,SINGLE PELECYPOD SHLS,SOME SANDY + SILTY CLAY					
NAUSHON ISLAND	41.49	70.76			1967	BEACH SAND	5.00	95.00			SAND
NOMANS (10 MI WEST)	41.17	71.00	33	DREDGE,1 METER	1965	SANDY-GRAVEL					
NOMANS (10 MI WEST)	41.17	71.00	33	SCALLOP DREDGE	1965	COBBLES					
NOMANS (10 MI WEST)	41.17	71.00	33	RING NET	1965						
NOMANS (10 MI WEST)	41.17	71.00	33	PIPE DREDGE	1965	FINE SAND(BROWN).					
POINT JUDITH (off of)	41.33	71.57	21	SMITH-MCINTYRE W/CAMERA	1964	BROWN FINE-GRN,WELL-SRT QTZ SAND,ABOUT 1% SHELL DEBRIS 1-2 MM		100.00			SAND
TARPAULIN COVE	41.48	70.76	20	CAMPBELL GRAB W/O CAMERA	1963	CLAM FLAT MATERIAL, DARK GRAY SANDY GRV ,SCAT. PEBBLES 3-4 IN. DIAM.	42.30	51.50	3.70	2.50	
TARPAULIN COVE	41.48	70.77	21	CAMPBELL GRAB W/O CAMERA	1963	COARSE SAND+GRV ,FEW 2-3 IN. PEBBLES+BROKEN SHELLS		100.00			SAND
TARPAULIN COVE	41.48	70.76	10	CAMPBELL GRAB W/O CAMERA	1963	MEDIUM SORTED FINE-MEDIUM LIGHT BROWN SAND WITH PATCHES DARK GRAY MUD		85.90	10.30	3.70	SAND
VINEYARD SOUND	41.36	70.80	26	CAMPBELL GRAB W/ CAMERA	1963	LIGHT BROWN MEDIUM SAND WITH MANY BROKEN SHELLS OF COARSE SAND SIZE		93.20	2.70	1.50	SAND
VINEYARD SOUND	41.41	70.78	15	CAMPBELL GRAB W/ CAMERA	1963	LIGHT BROWN MEDIUM+COARSE SAND ALMOST GRAVEL SIZE WITH BROKEN SHELLS		102.00			SAND
VINEYARD SOUND	41.50	70.67	25	CAMPBELL GRAB W/ CAMERA	1963	MEDIUM TO COARSE BROWN QTZ.SAND, SCATTERED BROKEN SHELLS					
VINEYARD SOUND (off of)	41.28	70.99	37	DREDGE,1 METER	1965	GRAVEL,FEW COBBLES,BOULDER,MAX SIZE 10X 8X8 IN					
VINEYARD SOUND (off of)	41.28	70.99	37	SCALLOP DREDGE	1965	GRAVEL					
VINEYARD SOUND (off of)	41.28	70.99	37	RING NET	1965						
VINEYARD SOUND (South)	41.32	70.72	23	CAMPBELL GRAB W/ CAMERA	1963	BLACK SILTY SAND (H2S). BROWN SAND AND GRAVEL.		30.50	49.70	19.80	SANDY SILT
VINEYARD SOUND (South)	41.33	71.00	33	CAMPBELL GRAB W/ CAMERA	1963	GREENISH BROWN SILTY SAND.		86.50	10.60	2.90	SAND

3.2. Biological Conditions

3.2.1. Plankton

Little work has been done in the general location of the site to characterize the pelagic biota, particularly the plankton component (Davis, p.c., 1998; Sherman, p.c., 1998). Data on plankton concentrations from the MARMAP program have been collected at an aggregate scale, but sampling stations are probably too far apart to provide a useful description of plankton dynamics at the site. The proposed project site is located on the border of the "offshore Nantucket" subarea, a geographic unit used to map primary productivity on a large scale. Studies performed to measure primary productivity during 1977-82 reveal an intermediate level of productivity (310 gC/m^2) in the offshore Nantucket subarea relative to other subareas on the northeastern United States continental shelf (O'Reilly *et al.* 1987). This level of productivity is an average over the entire subarea, which extends nearly 200 km from Rhode Island Sound to Georges Bank. Because of the scale of the subarea, the average productivity measure is not necessarily representative of the proposed project site (Sherman, p.c., 1998).

Likewise, no specific work has been done in the area of the proposed project site to characterize the occurrence and distribution of zooplankton (Davis, p.c., 1998). Zooplankton dynamics are regulated locally by temperature, food (especially phytoplankton), and predation, but over much of the northeast continental shelf zooplankton production is likely to be food limited (Durbin and Durbin 1996). Zooplankton, particularly *Calanus* and *Pseudocalanus*, are an important food source for filter feeding whales, especially the right whale and the sei whale, and pelagic fish, including herring and mackerel. The pelagic fish, in turn, are an important food source for humpback whales and fin whales. The fact that large whales do not appear to feed extensively in Rhode Island Sound (see below) would seem to suggest that the conditions are not optimal for high zooplankton productivity near the proposed project site.

3.2.2. Benthic Community

Table 2 lists the results of a quick benthic sort analysis of sediment samples from the proposed project site, which revealed the presence of polychaetes, bivalves, and crustaceans (Hampson, p.c., 1998). The list is representative of a deposit feeding benthic community typical of that which is dominant at Station R in Buzzards Bay (Sanders 1960, 1958).

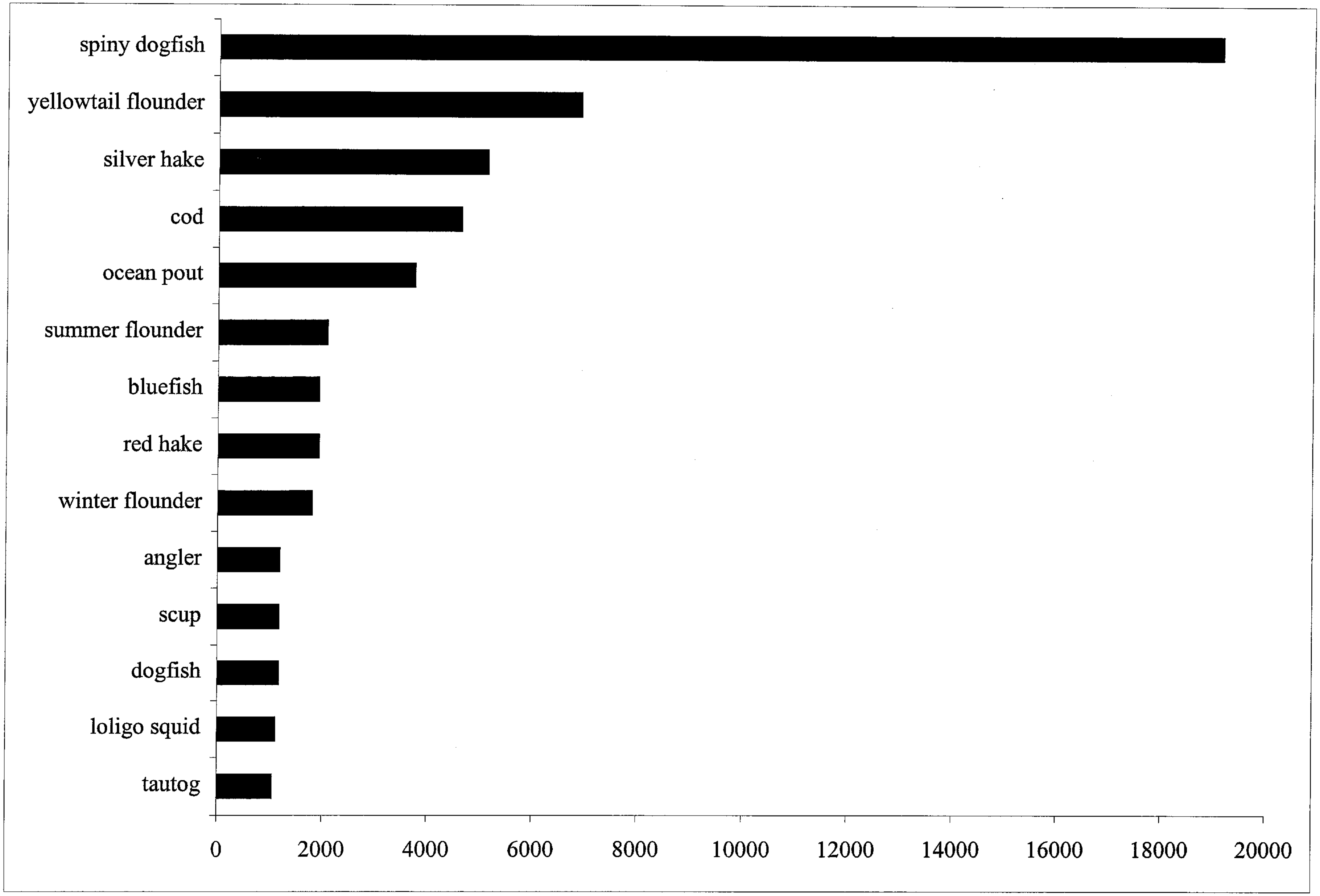
3.2.3. Fisheries Resources

Both commercial and recreational fisheries resources exist in Rhode Island Sound. The proposed project site falls within NMFS statistical area 537, but data on fishing within that area, which is quite large, are unlikely to be representative of fishery resources located at the site. Figure 5 displays the results of NMFS data (Gaipo, p.c., 1998) on fish from the "ten minute square" within which the proposed project site is located (the coordinates of the square are 71°00'-10' W longitude, 41°10'-20' N

Table 2: Results of a quick sort analysis of benthic fauna at the proposed project site on 26 March 1998 (Hampson, p.c., 1998)

Type	Genus and Species
Polychaetes	*Nephthy incisa*
	Scalibregma inflatum
	Polycirrus spp.
	Melinna cristata
Bivalves	*Nucula annulata*
	Yoldia limatula
	Pitar morrhuna
	Astarte borealis
Crustaceans	*Ampelisca verrilli*
	Unciola irrorata
	Ampelisca vadorum

Figure 5: Average catch of finfish near the proposed project site: 1990-1993 (lbs)



latitude).[3] The largest landings are of spiny dogfish, followed by much smaller catches of yellowtail flounder, silver hake, and cod. (Note that fish *catches* of some species—especially groundfish—may have been larger than *landings*, due to regulatory or economic discards.) Other species with annual landings averaging less than 1000 lbs include haddock, witch flounder, pollock, American shad, black sea bass, squeteague (weakfish), conger eel, sand-dab flounder, sea scallop, white hake, butterfish, Atlantic mackerel, and skates (Gaibo, p.c., 1998). There is also evidence at present of limited lobster fishing near the proposed project site (Paul, p.c., 1998).

3.2.4. Marine Mammals

The project principal investigators incorporate by reference the extensive written description and scientific surveys of the natural history, population distribution and trends, and stock assessments of the protected species of interest found in the *U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments—1996* (Waring *et* al. 1997); the *Environmental Assessment and Regulatory Impact Review of the Atlantic Large Whale Take Reduction Plan and Implementing Regulations* (NMFS 1997a); the *Draft Large Whale Take Reduction Plan* (Keystone Center 1997); the *1996 Biological Opinion and Conferences regarding the American Lobster Fishery Management Plan* (NMFS 1996); the *Biological Assessment of the Dutra Sea Scallop Aquaculture Proposal* (Smith *et al.* 1995); the *1994 Biological Opinion Regarding the American Lobster Fishery Management Plan* (NMFS 1994); the *Final Recovery Plan for the Northern Right Whale* (NMFS 1991a); and the *Final Recovery Plan for the Humpback Whale* (NMFS 1991b).

The project principal investigators summarize briefly here known stock assessment information (Table 3), known interactions with fixed fishing gear, known information about occurrences of protected marine mammals in Rhode Island Sound, new scientific results within the last two years, and the status of any ongoing scientific studies of relevance to the species of interest.

Several figures associated with the discussions of individual species (below) display the known geographic distribution of the species of interest in the New England region based upon actual recorded sightings. There have been no recorded sightings of large whales or harbor porpoise in the immediate area (within 3 nmi) of the proposed project.[4] There are no known commercial whalewatching operations in the vicinity of the site. A few sightings of individual whales from each of the species of interest have occurred in the general area of Rhode Island Sound during the last 30 years. Figure 6 shows marine mammal sightings recorded in the region during three years of intensive CeTAP (Cetacean and Turtle Assessment Program; URI 1982) observations. As shown in Figure 7, the proposed project area does not fall within one of the cetacean high-use habitat areas as determined in the 1978-83 CeTAP database, which has been corrected for sighting effort (Kenney and Winn 1986).

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[3] The NMFS data are actually "concentrated" at points that are 10' apart both longitudinally and latitudinally. The data for the relevant ten minute square are concentrated at 71°05' W longitude, 41°15' N latitude.

[4] In 1985, an adult right whale, which was not feeding, was sighted at 41°16'N, 70°58'W, about 3 nmi from the proposed project site (Kenney, p.c., 1998).

Table 3: Stock Assessment Statistics for Protected Marine Mammals

Species	Nmin	Nbest	Rmax	Fr	PBR	Mtot	Mfish	MMPA	ESA
North Atlantic Right Whale*	295	295	0.025	0.1	0.4	2.5	1.1	Strategic	Endangered
Humpback Whale*	4848	5543	0.040	0.1	9.7	4.1	4.1	Strategic	Endangered
Fin Whale*	1704	2700	0.040	0.1	3.4	0.0	0.0	Strategic	Endangered
Sei Whale*	--	1393-2248	0.040	0.1	--	0.0	0.0	Strategic	Endangered
		253							
Harbor Porpoise**	48289	54300	0.040	0.5	483	1834	1834	Strategic	--

*Western North Atlantic stock.
**Gulf of Maine/Bay of Fundy Stock.

Figure 6: Marine Mammal Sightings, 1979-81

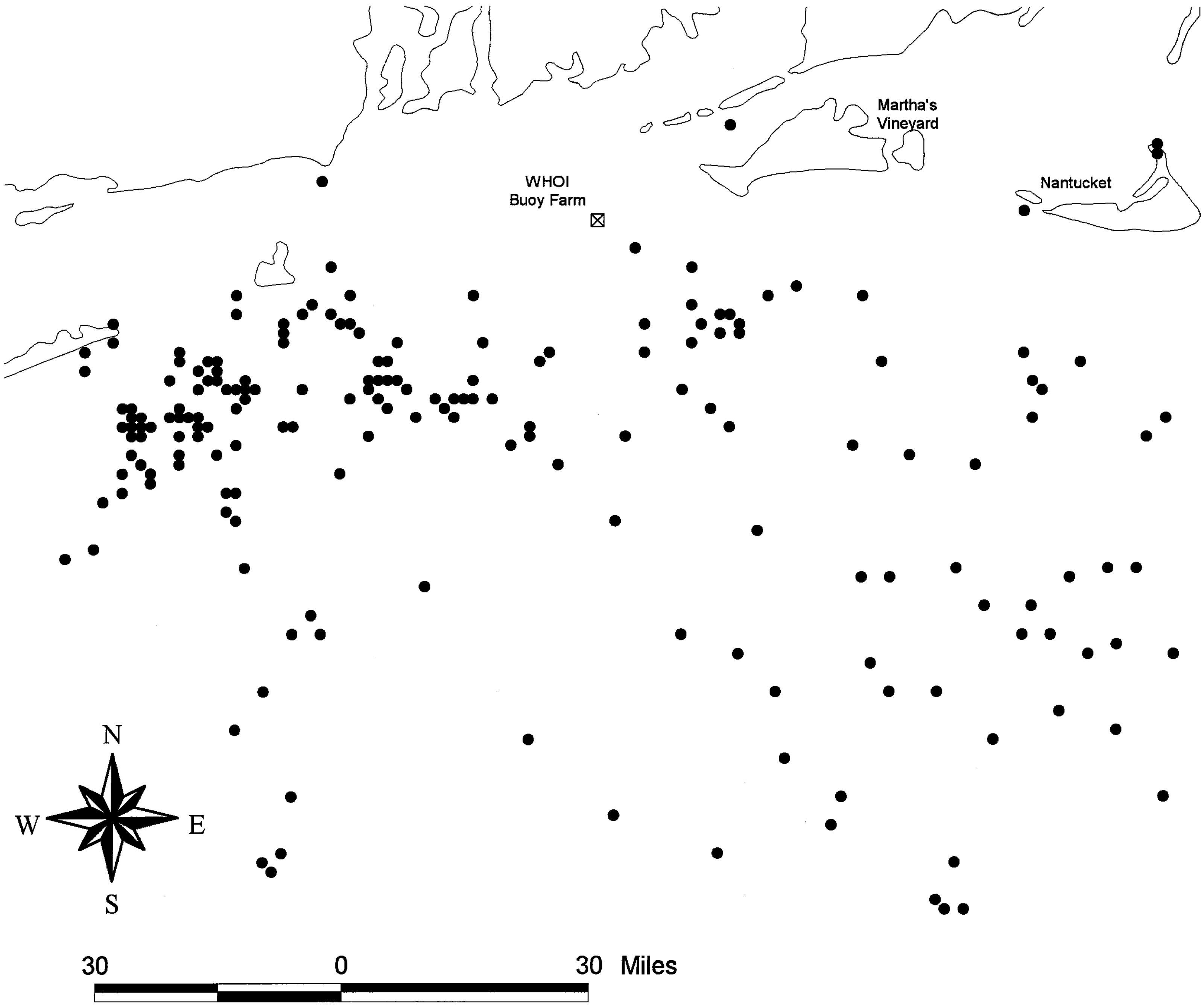
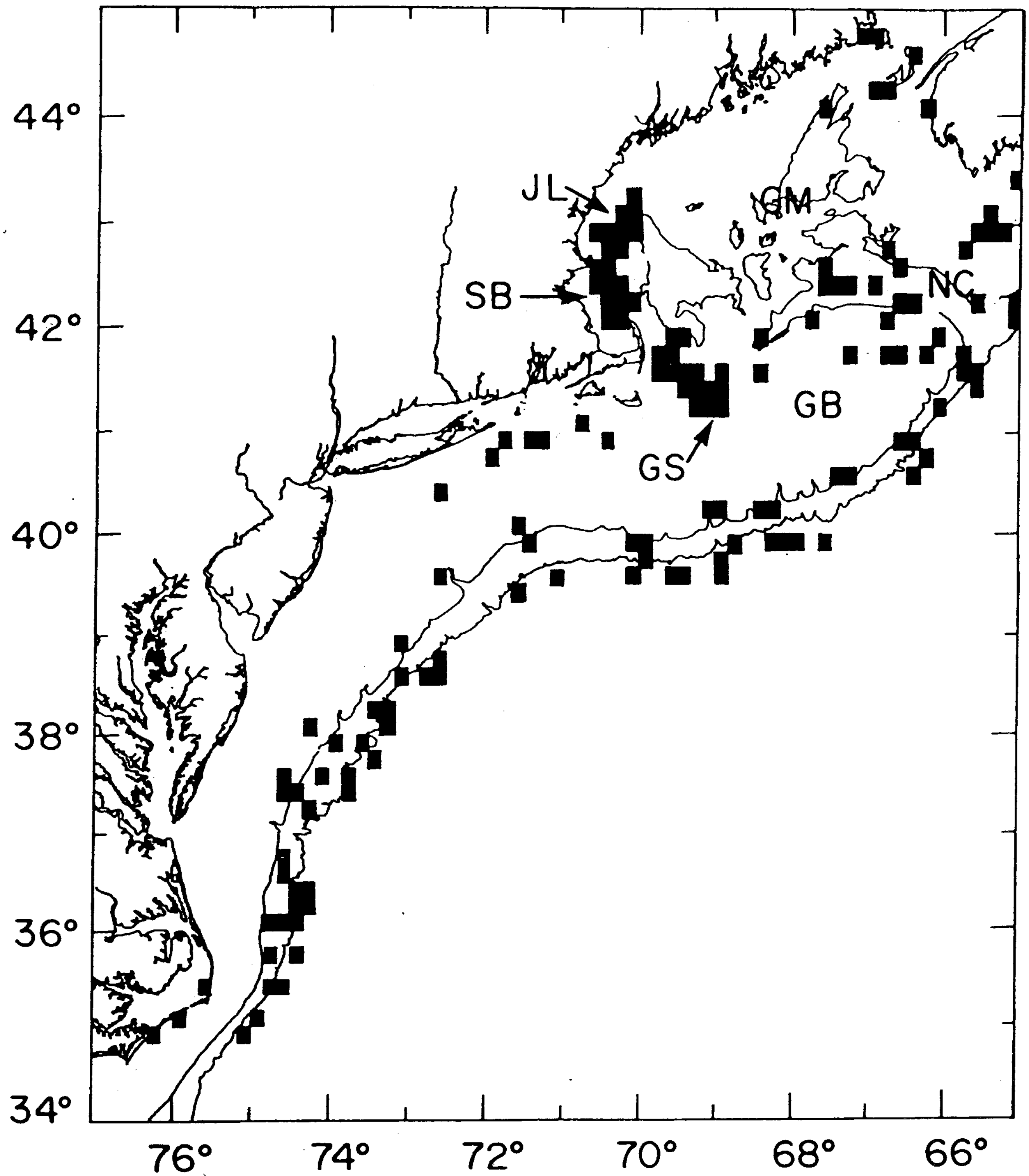


Figure 7: Cetacean "high use" habitat areas (Kenney and Winn 1986)



Plot of 10-minute blocks with total cetacean biomass per unit effort values in the top 10% of all blocks. GM = Gulf of Maine; GB = Georges Bank; NC = Northeast Channel; JL = Jeffreys Ledge; SB = Stellwagen Bank; GS = Great South Channel.

More recent sightings data are known to be biased due to the fact that individual sighting efforts are not independent events (Hain, p.c., 1998). In other words, scientists tend to look for whales where they have been able to find them in the past. Notwithstanding this bias, recent personal communications with scientists who study marine mammals suggest that there is no evidence of large whales or harbor porpoise consistently occurring at the proposed project site (Clapham, p.c., 1998; Hain, p.c., 1998; Kenney, p.c., 1998; Mayo, p.c., 1998). Indeed, there is no evidence in the scientific record of *any* sightings of large whales or harbor porpoise specifically at the proposed project site. Figure 8 depicts all sightings of right whales and other endangered whales from a University of Rhode Island (URI) database maintained by Dr. Robert Kenney. Figure 9 depicts sightings from the URI database during 1990-1995.

3.2.4.1. Northern Right Whale (Western North Atlantic Stock)[5]

The northern right whale is the most severely depleted of the large whales that frequent the U.S. east coast. The 1996 stock assessment (Waring *et al.* 1997) references a 1992 estimate of 295 individuals (Knowlton *et al.* 1994) as the current minimum population estimate for the northern right whale. Due to the limited size of the population, the lengthy calving interval, and other factors that may be affecting population growth (Waring *et al.* 1997), it is expected that any individual mortality event will further inhibit recovery of this species. Recent increased cooperation among state and federal agencies in reporting sightings of both dead and living whales has resulted in more information on mortalities. Other than the few calves that have died from natural causes, many of these known deaths are related to human activity, specifically ship strikes and fishery interactions. An increase in right whale sighting rates during 1979-89 suggests that the population may be recovering slowly from extreme depletion (Kenney, Winn and Macaulay 1995).

Right whale distribution patterns have long been studied but are still incompletely understood. Figure 8 depicts marine mammal sightings, including right whales. Right whales require high densities of prey for efficient feeding (Kenney *et al.* 1986). Their preferred prey are *Calanus finmarchius* and *Pseudocalanus spp.*, but they will also feed on euphausiids. Several studies have now shown correlations between dense patches of *Calanus* and the presence of right whales (Beardsley *et al.* 1996; Kenney, Winn and Macaulay 1995; Mayo and Marx 1990; Wishner *et al.* 1988). In the Great South Channel, right whale diving patterns are correlated with the horizontal and vertical distributions and movements of prey zooplankton (Winn *et al.* 1995). Results of the SCOPEX studies support the hypothesis that, in areas like the Great South Channel, large numbers of *Calanus* are advected into the region because of hydrographic processes (Kenney and Wishner 1995). Density of copepod patches may also be increased by swarming behavior (Beardsley *et al.* 1996). SCOPEX also confirmed the co-occurrence of right whales with high density *Calanus* patches (Kenney and Wishner 1995).

There has been very little study of plankton dynamics near the proposed project site in Rhode Island Sound (Davis, p.c., 1998; Sherman, p.c., 1998). The kinds of

[5] This summary borrows language in part from NMFS (1997).

Figure 8: Marine Mammal Sightings

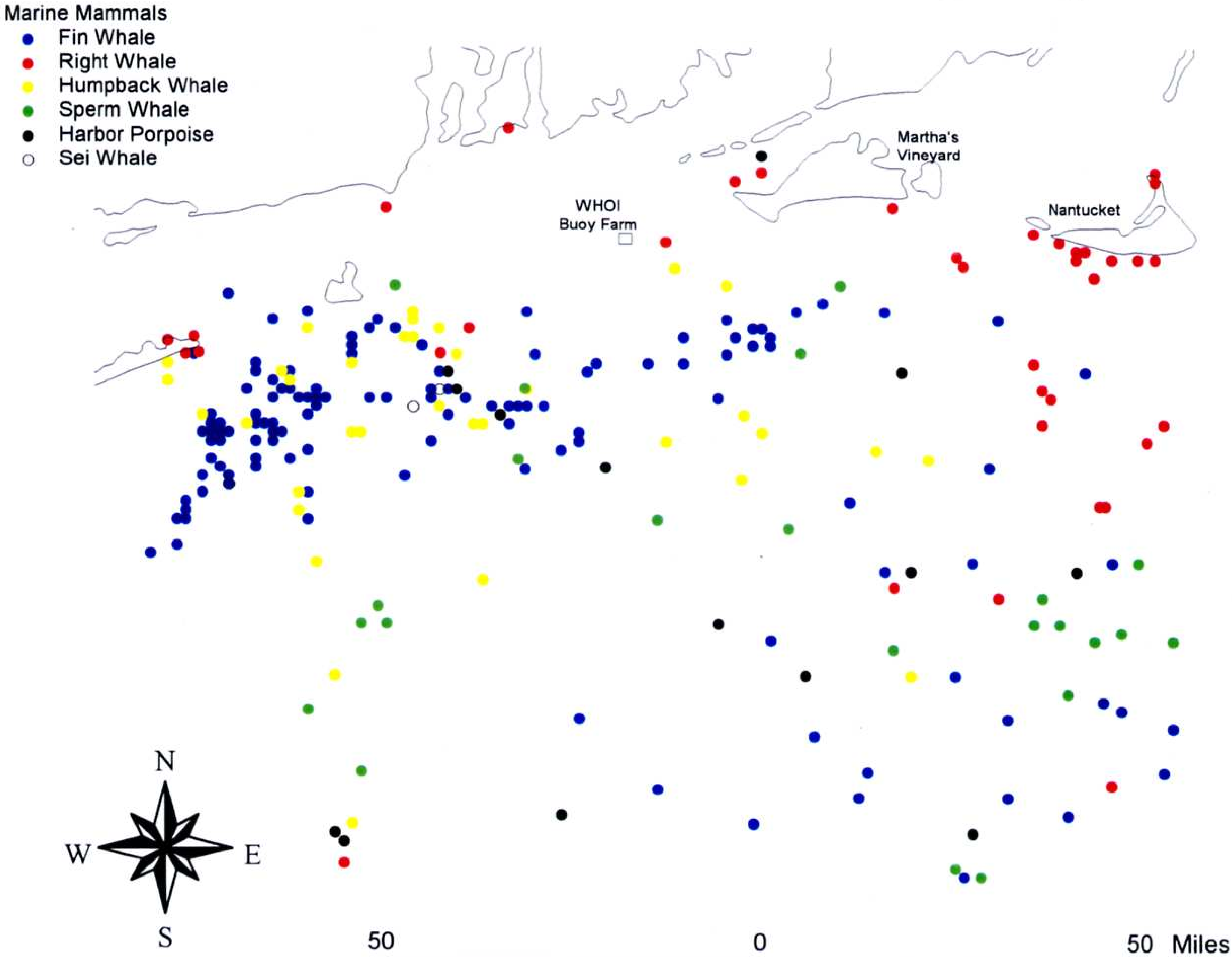
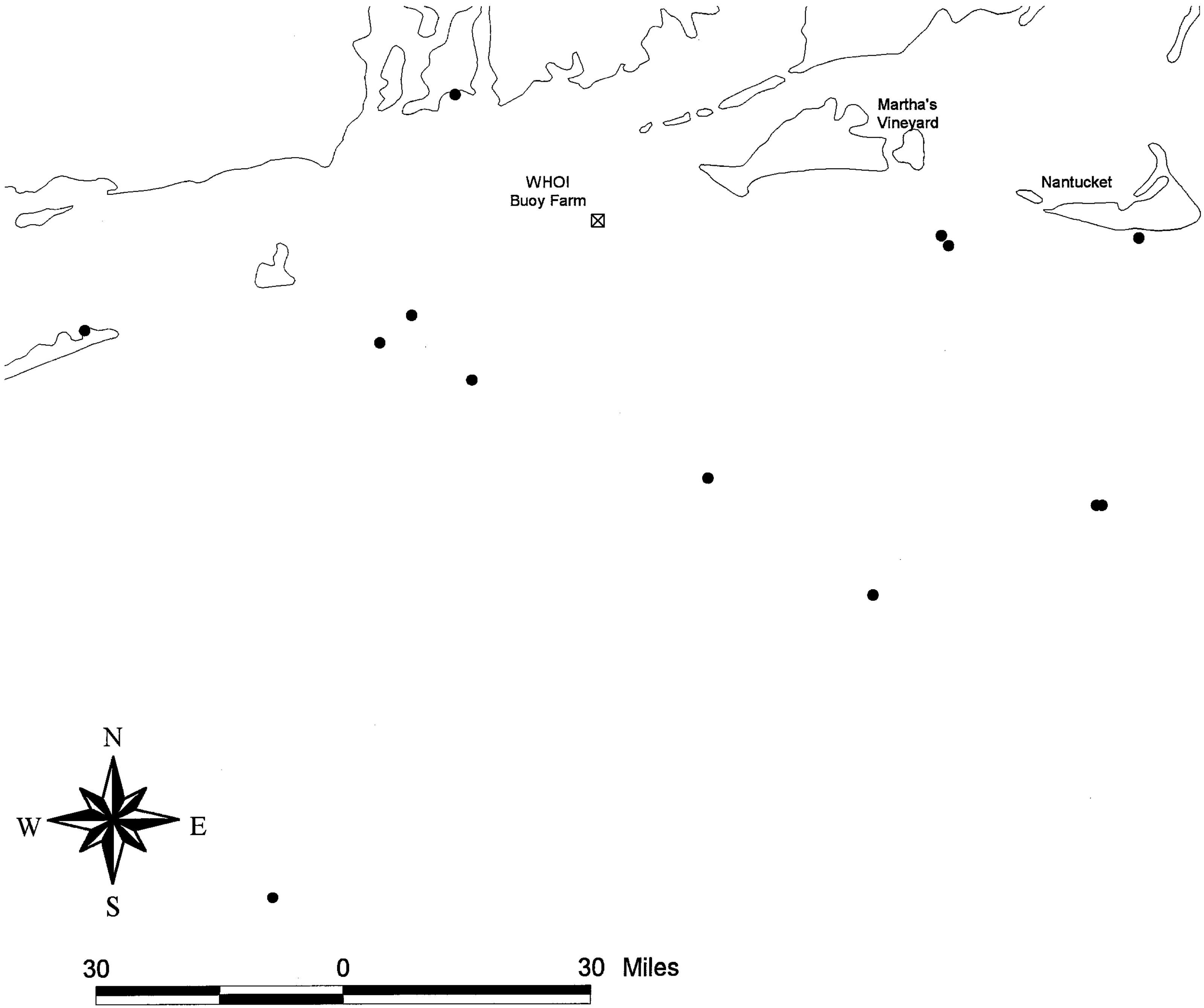


Figure 9: Marine Mammal Sightings, 1990-95



hydrographic processes that concentrate *Calanus* in the Great South Channel and at other right whale feeding grounds do not appear to be operating at the proposed project site. As a result, it seems unlikely that right whales will be found feeding at the proposed project site. Nevertheless, the potential still exists for the occurrence of right whales in Rhode Island Sound. For example on 19 April 1998, a pod of 23 right whales were sighted by a NMFS aerial survey just to the east of Block Island (Figure 10). On 21 April, five right whales were seen in the same region and one more was sighted off of Gay Head, Martha's Vineyard. Whales occurring in Rhode Island Sound are most likely to be either migrating whales or "wandering" juvenile males (Allen, p.c., 1998; Mayo, p.c., 1998), although the 1998 sighting may have included at least one mother and calf pair. During 1986, several right whales were seen entering the Sandwich entrance to the Cape Cod Canal. However, scientists do not know whether these particular whales transited the canal (Mayo, p.c., 1998). Further, except for anecdotes, there is no concrete evidence that right whales use the canal as a migration route.

Cow/calf pairs are often seen migrating north along the east coast as they move toward feeding areas in New England. Right whales begin congregating in Cape Cod Bay in December, and some right whales are generally in the Bay through April. The whales then tend to move offshore to feed in the rich and productive waters of the Great South Channel. They are joined there by significant numbers of humpback and fin whales through June. The whales then move north to the Canadian feeding grounds in the lower Bay of Fundy and the Browns/Baccarro Banks regions.

Right whales leave the northern feeding grounds in October or November. Females about to give birth move south to the Georgia-Florida area, but the migration route has not been mapped with any degree of certainty. More than half of the population is not seen during the winter months. These observations suggest that, even if the proposed project site can be considered to be on the right whale migration route, which has not yet been demonstrated, only a subset of the right whale population (albeit one of the most vulnerable subsets) would pass by the site.

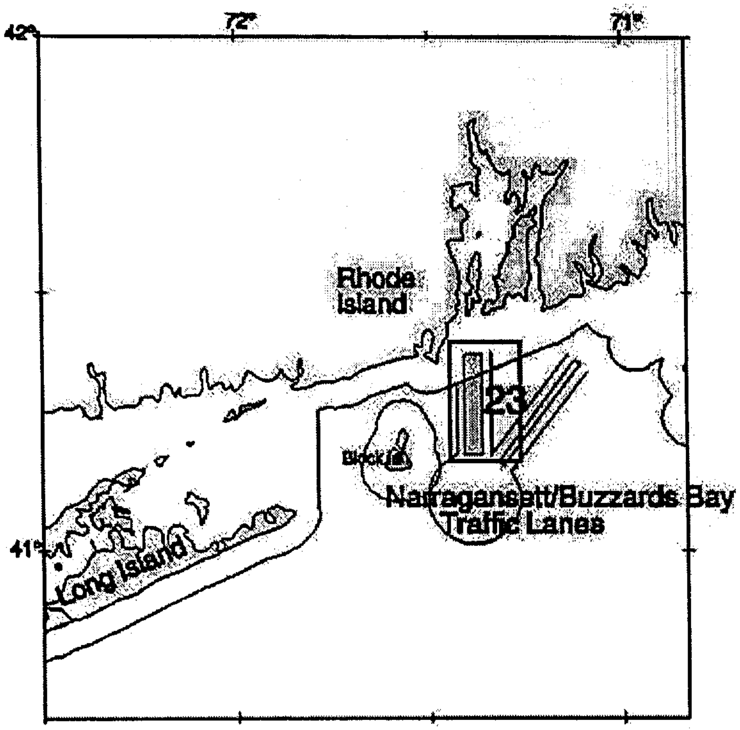
Research that is now ongoing but for which results are not yet available includes the following: aerial surveys sponsored by Massachusetts and NMFS of right whale distribution relative to high use lobstering areas and in the Great South Channel; studies being conducted by the Center for Coastal Studies in Provincetown to measure the correlation between sea surface satellite images of ocean thermal gradients, copepod concentrations, and right whale occurrences (Mayo, p.c., 1998); and the use of passive detection technologies to determine the presence of right whales (MIT Sea Grant).

3.2.4.2. Humpback Whale (Western North Atlantic Stock)[6]

The 1996 stock assessment (Waring *et al.* 1997) lists the minimum population estimate for the Western North Atlantic humpback stock at 4,848 individuals. Recent studies have increased that estimate substantially. Using genetic markers, Palsbøll *et al.* (1997) now estimate the population to be 7,698 whales. Using photographic identification and biopsy

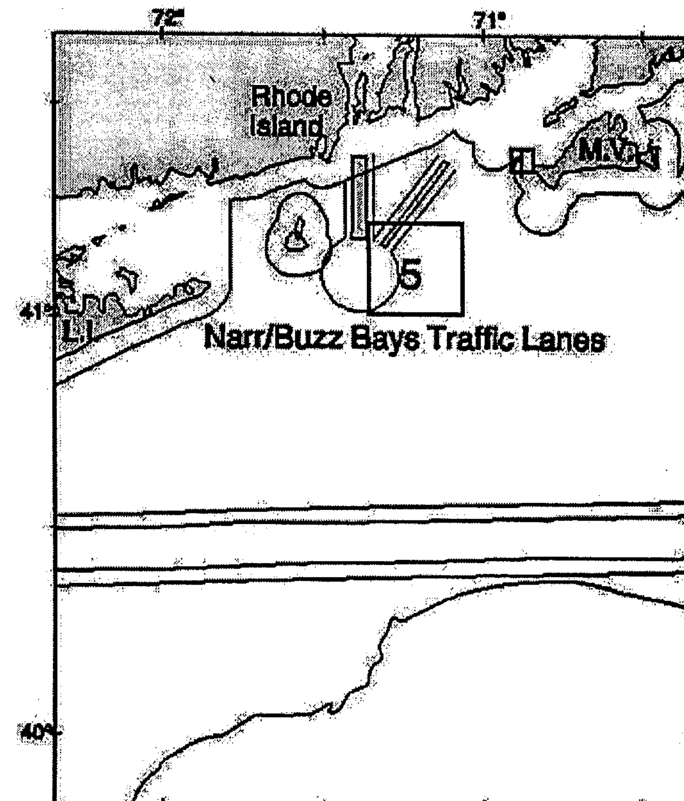
[6] This summary borrows language in part from NMFS (1997).

Figure 10: Recent sightings of right whales in Rhode Island Sound



Right Whale Zones from CCS/MA & NMFS Aerial Surveys, 19 April 1998

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA



Right Whale Zones from NMFS Aerial Survey, 21 April 1998

National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Northeast Fisheries Science Center
Woods Hole, MA

data from feeding and breeding areas, Smith *et al.* (in press) estimate a population of more than10,000 humpbacks.[7] Figure 8 includes humpback whale sightings during the 1990s off Rhode Island Sound.

The mean calving rate for the population has been observed to be about 8% per year. The humpback whale distribution patterns have long been studied, with mating and calving activity concentrated in the Caribbean on the banks off the Dominican Republic in the winter months. Humpback whales from the North Atlantic are now believed to "constitute a single panmictic population" (Palsbøll *et al.* 1997). Feeding aggregations are dispersed and likely determined by "maternally directed site fidelity" (Palsbøll *et al.* 1997). Juvenile humpbacks have been sighted recently in the winter off the Mid-Atlantic coast of Virginia. Humpback whales begin congregating in the rich and productive waters of the Great South Channel in April and May. The whales then move north to the Gulf of Maine feeding grounds at Stellwagen Bank and Jeffreys Ledge as well as in the lower Bay of Fundy. Other feeding areas are known to be off Newfoundland and Labrador, Canada. Humpback whales leave these northern feeding grounds in October or November.

Humpbacks are primarily piscivores (95 percent of their diet), favoring sand lance but also herring and mackerel. Due to the sediment characteristics at the proposed project site (fine grained silt and mud), sand lance are not believed to be present (Hampson, p.c., 1998). Schools of herring or mackerel may move through the site on occasion.[8] Humpbacks are not frequent visitors to Rhode Island Sound, although there was some movement of humpbacks into Block Island Sound, including recorded sightings of humpbacks from Block Island to Nomans Land (off Marthas Vineyard) in 1986 (Kenney, p.c., 1998). In that year, a crash in the Stellwagen Bank sand lance stock is believed to have forced humpbacks and fin whales out of Massachusetts Bay onto alternative feeding grounds (Payne *et al.* 1990).

Humpback whales are occasionally seen entangled in fishing gear in all of their northern feeding grounds. Scarring evidence from photo-identification work also suggest they are susceptible to ship strikes. The potential biological removal (9.7) for this species is close to the numbers of animals known to be killed or injured in fishing gear. However, the continued high calving rate for this species and the increasing population estimates suggest that these mortality factors are not having as significant effect on this population as on the population of right whales.

3.2.4.3. Fin Whale (Western North Atlantic Stock)[9]

The 1996 stock assessment (Waring *et al.* 1997) lists the minimum population estimate for the Western North Atlantic fin stock at 1,704 individuals, although this estimate is derived from surveys that did not cover the complete range of the stock. The distribution

[7] A 95% confidence interval based upon the photographic identification is from 9,300 to 12,100 individuals (Smith *et al.* in press).

[8] Small quantities (580 lbs) of mackerel were landed from the proposed project site during 1990-93. There is no record of herring landings from this site during the same period.

[9] This summary borrows language in part from NMFS (1997).

of fin whale sightings during 1990-95 show fin whales occurring at the edge of the continental shelf and up into the western edge of the Gulf of Maine (Waring *et al.* 1997). Figure 8 shows some fin whale sightings have occurred historically in Rhode Island Sound.

Fin whale distribution is not well known. Seipt *et al.* (1990) suggest that patterns of occurrence and distribution of fin whales are broadly similar to those of humpbacks, including patterns of recurring site fidelity. This suggestion is given greater weight by the fact that both species are predominantly piscivores. Sighting information describes a general distribution of this species all along the continental shelf edge in the summer and fall. They are also sighted along the shelf edge in the winter, but in smaller numbers, suggesting an offshore movement in winter. Fin whales are fast whales capable of feeding on large schooling fishes, which are found all along the continental shelf edge in all seasons.

Although entanglement and ship strikes contribute to the total known mortality rate for fin whales on the U.S. East Coast, there are only a small number of records of fin whales impacted by fishery interactions or entanglements, or by vessel collisions. During 1991-95, there were no reported fishery-related mortalities or serious injuries of fin whales (Waring *et al.* 1997). It is possible that known fin mortality is under-represented relative to humpback and right whale estimates due to the fact that fin carcasses are more likely to sink immediately after death. However, fin whales tend to spend less time in inshore waters, so they are less likely to encounter certain anthropogenic threats.

3.2.4.4. <u>Sei Whale (Western North Atlantic Stock)</u>

Sei whales are planktivorous whales, feeding mainly on euphausiids and copepods. Sei whales are typically found in deep waters near the edge of the continental shelf. During the spring and summer months, sei whales tend to occur along the eastern and southwestern edges of Georges Bank and up into the Northern Gulf of Maine. Sei whales may make trips into the Great South Channel and Massachusetts Bay during periods of reduced predation on copepods by other predators, such as in the summer of 1986 (Waring *et al.* 1997). Sei whales rarely frequent coastal waters and are unlikely to be a concern for the proposed project (Clapham, p.c., 1998). Figure 8 shows two sei whale sightings southeast of Block Island in the sighting record.

There are no current abundance estimates for sei whales, and therefore NMFS has been able to estimate neither a minimum population size nor a potential biological removal (Waring *et al.* 1997). During 1991-95, there were no reported fishery-related mortalities or serious injuries to sei whales. Waring *et al.* (1997) report that data on fishery interactions or human impacts on sei whale stocks are almost nonexistent.

3.2.4.5. <u>Harbor Porpoise (Gulf of Maine/Bay of Fundy Stock)</u>

Harbor porpoise range along the coast from North Carolina to Maine during the late fall, winter, and early spring. No specific migratory pathways have been documented, although higher distributions are known to occur near the coast. In the mid-winter (January to February), only low densities of harbor porpoise occur along the coast from New York north to New Brunswick. During the summer, harbor porpoise tend to be concentrated in the northern Gulf of Maine and up into the Bay of Fundy. Harbor porpoise have been proposed for listing as a threatened species under the Endangered Species Act.

Harbor porpoise are taken in fishing weirs, sink gillnets, coastal gillnets, and pelagic gillnets. In the United States, most of the takes occur in the New England multispecies sink gillnet fishery. During 1990-95, the annual number of takes were estimated to be 1,833 in this fishery. Takes in the Mid-Atlantic coastal gillnet fishery have not been estimated (Waring *et al.* 1997). The use of acoustic alarms on sink gillnets has been demonstrated to be an effective means of reducing the takes of harbor porpoise in that fishery (MMC 1996).

Harbor porpoise are unlikely to be attracted to a longline structure for blue mussel growout located offshore, unless there are aggregations of prey finfish near the structure (Waring, p.c., 1998). The longline structure is likely to be more visible and acoustically reflective than gillnets, thereby posing less of an entanglement threat.

3.2.5. Marine Turtles

Two species of endangered sea turtle, the leatherback (*Dermochelys coriacea*) and the Atlantic or Kemp's ridley (*Lepidochelys kempi*), and one threatened species, the loggerhead (*Caretta caretta*), have been observed seasonally in Massachusetts waters. For the most recent assessment of their status, see NMFS/USFWS (1995).

Loggerhead turtles, although occasionally sighted as far north as Georges Bank and Newfoundland, are a southern species; individuals sighted north of Cape Cod are considered to be stragglers. Leatherback turtles, the largest of the living sea turtles, are wide-ranging pelagic animals. Although the center of their distribution is in tropical and subtropical waters, they are reported frequently in the temperate waters of New England, the Canadian Maritime Provinces, and occasionally as far north as Baffin Island (NRC 1990).

Aggregations of juvenile Kemp's ridleys have been observed feeding in shallow coastal waters of Martha's Vineyard and Buzzards Bay during the summer (Carr 1967).

Although marine turtles are widely known to have been endangered by shrimp trawls in southern U.S. waters, there is no record of a marine turtle taking in trawl nets among the approximately 30,000 NMFS-observed trawls in New England waters (Christensen, p. c., 1998). On the other hand, turtles have been known to become entangled in fixed or stationary fishing gear, such as gillnets and lobster trap buoy lines in Massachusetts Bay (Prescott, p. c., 1998).

3.2.5.1. Loggerhead Turtle

The loggerhead sea turtle (*Caretta caretta*) is listed as threatened under the Endangered Species Act. It is estimated that some 43,000 adult females nest along the U.S. Atlantic and Gulf coasts; and the overall population of loggerhead sea turtles is thought to be decreasing (NMFS 1997b).

Loggerhead turtles are abundant during spring and summer months in coastal waters off New York and the middle Atlantic states. In the fall, they migrate southward to coastal waters off the south Atlantic states, particularly Florida, and the Gulf of Mexico. In the spring, they congregate off southern Florida before migrating northward to their summer feeding ranges (URI 1982; Shoop and Kenney 1992). During the winter, the turtles tend to aggregate in warmer waters along the western boundary of the Gulf Stream off Florida (Thompson 1988).

Along the Atlantic coast, mating and nesting take place in the spring and summer. Nesting beaches along the Atlantic coast of the United States are concentrated between the southern tip of Florida and Cape Canaveral, with occasional nesting as far north as North Carolina on the Atlantic coast and along the coasts of the Gulf of Mexico (Thompson 1988).

Adult loggerheads are primarily bottom feeders, foraging in coastal waters for benthic molluscs and crustaceans (Bjorndal 1985). During feeding, they spend more than 57 minutes of each hour submerged (Thompson 1988). In New York coastal waters, they feed primarily on small benthic crabs, such as rock and green crabs (Burke *et al.* 1990).

The greatest human threats to loggerheads arise from beach activities that interfere with nesting, and from entrapment in trawls (primarily in the shrimp fishery) and gillnets; annual take from shrimp trawling is estimated in the tens of thousands (NMFS 1997b). The treat of entanglement in trap lines is comparatively less significant. Three loggerhead turtles were reported entangled in lobster gear between 1983 and 1991 by the Sea Turtle Stranding and Salvage Network (NMFS 1994).

The recovery plan for the U.S. population of loggerhead turtles (NMFS/USFWS 1991) called for greater efforts to study the take of loggerheads in fisheries other than shrimping, and listed bottom trawling gear, gill nets, driftnets, and longlines as of "particular concern."

3.2.5.2. Leatherback Turtle

The leatherback turtle (*Dermochelys coriacea*) is the largest living turtle, the second most common turtle along the eastern seaboard of the United States, and the most common north of 42°N latitude. Leatherbacks are largely oceanic and pelagic. Nearly all nesting occurs in the tropics; only a small fraction of the North Atlantic population nests on beaches of the continental United States, mostly in Florida (NRC 1990). An estimated 16,000 leatherbacks live in the western North Atlantic Ocean, and an estimated 20,000 to 30,000 females are thought to exist worldwide. The leatherback was listed as endangered throughout its range in 1970; current population trends in U.S. waters are not known (NMFS 1997b).

Leatherback turtles are common during the summer in North Atlantic waters from

Florida to Massachusetts, the Canadian Maritime Provinces, and occasionally as far north as Baffin Island (Goff and Lien 1988). New England waters support the largest populations on the Atlantic coast during the summer and early fall (Lazell 1980). Leatherbacks are sighted only rarely north of Cape Hatteras during the winter. During most of the year, they are pelagic and remain far offshore in oceanic waters. However, during the summer, they may come relatively close to shore pursuing their jellyfish prey (Lee and Palmer 1981). Most leatherbacks that visit New England waters are adult males, usually longer than 150 cm and weighing more than 450 kg (NOAA 1991).

In the spring, following breeding and nesting in the tropical Caribbean, leatherback turtles move northward beyond the shelf break, aided by the northward flow of the Gulf Stream. Therefore, there are few sightings of leatherbacks in coastal and outer continental waters in the spring months (URI 1982). They appear in offshore waters off the middle Atlantic states and in the Gulf of Maine in late May to June, and in shelf waters from June through October (Shoop *et al.* 1981; Shoop and Kenney 1992). In New England waters, they are seen most frequently in the southern Gulf of Maine, including Cape Cod and Massachusetts Bays. In the fall, leatherbacks move offshore and begin their migration south to the winter breading grounds in the tropical Caribbean (Payne *et al.* 1986).

Leatherback turtles are pelagic feeders, though they can dive to considerable depths. They feed throughout the water column to depths of at least 50 m on jellyfish and other gelatinous zooplankton, such as salps, ctenophores, and siphonophores (Limpus 1984). Their seasonal inshore movements in New England waters have been linked to inshore movements of their preferred prey, the jellyfish *Cyanea capillata* (Lazell 1980; Payne and Selzer 1986).

Leatherbacks apparently are not caught frequently in commercial shrimp nets; mortality from entanglement in shrimp nets is estimated to be a few hundreds annually (NMFS 1997b). Entanglement in longlines, drift/gill nets, fish traps, buoy anchorlines, discarded monofilament fishing line, and abandoned netting can lead to injuries or death by drowning (NMFS 1997b). Because they are adapted to a pelagic existence, they have trouble maneuvering in tight places and swimming backwards, and have difficulty avoiding obstructions in shallow waters (Payne and Selzer 1986; NOAA 1991). Leatherbacks have been entangled in lobster gear (O'Hara *et al.* 1986) and longlines (Balazs 1985) in New England waters. Records from the Sea Turtle Stranding and Salvage Network show that 45 leatherback turtles became entangled in lobster gear between 1983 and 1993 in coastal waters of New Jersey, New York, and southern New England (NMFS 1994). Eleven of these turtles died. The large front flippers (often one meter long) of leatherbacks often bear cuts and chafing marks, or are severed altogether, possibly due to entanglement (Frety 1982). In 1987 and 1988, 119 and 63 leatherbacks, respectively, stranded along the U.S. coast (NRC 1990). There was only one stranding in New England. The cause of death of most of these turtles is not known.

The recovery plan for leatherback turtles (NMFS/USFWS 1992) called for greater efforts to study the take of leatherbacks in fisheries other than shrimping, particularly in the U.S. Caribbean and in the Northeast, where leatherbacks have been known to get entangled in lobster trap gear.

3.2.5.3. Kemp's Ridley Turtle

The Kemp's ridley (*Lepidochelys kempii*) was listed as endangered in 1970 and remains the most endangered sea turtle in the world. The U.S. population is estimated at 400 to 600, and the trend is stable. The total world population, mostly in the Gulf of Mexico, was estimated at 3000 adults in 1995; and it may be that the species is poised for an "exponential expansion" in population (NMFS 1997b).

Adult Kemp's ridleys occur mainly in the coastal areas of the Gulf of Mexico. During the summer, juvenile individuals (up to about 30 cm in length) are found in the northwestern Atlantic Ocean from Florida to Long Island Sound, Martha's Vineyard, and occasionally in Cape Cod Bay, Massachusetts Bay, the Gulf of Maine, and as far north as the Canadian Maritime Provinces (Lazell 1980). It is generally thought that hatchlings and young juveniles from the western Gulf of Mexico drift to the east in the Gulf gyres and are caught in the eastern Gulf Loop Current. They are carried by the Florida Current to the Gulf Stream, in which they are carried up the eastern seaboard of the United States (Collard 1987).

It is uncertain whether any of these turtles, particularly those that drift as far north as New England, are able to return to the Gulf of Mexico to breed (nesting takes place only along certain beaches in the Gulf); and it is possible that the ridley turtles that visit New England are lost to the gene pool of the population (Carr 1980).

Following a pelagic feeding stage that lasts for several months after hatching (Carr 1986), the juvenile ridleys move into shallow coastal waters to feed and grow. The young juveniles often forage in water less than one meter deep (Ogren 1989), but they tend to move into deeper water as they grow.

Little is known about the feeding behavior and food preferences of hatchling Kemp's ridley turtles during their pelagic stage (NRC 1990). During the pelagic period, they presumably feed on zooplankton and floating matter, including Sargassum weed and the associated biotic community (Pritchard 1979). Juveniles and adults feed on a variety of mostly demersal or benthic crabs, shrimp, clams, snails, squid, sea urchins, starfish, coelenterates, and even small fish (Dobie *et al.* 1961; Pritchard and Marquez 1973; Bjorndal 1985). Crabs seem to be the favorite food throughout their range. Because of their preference for crabs and other primarily shallow-water demersal prey, juvenile and adult ridley turtles concentrate in coastal waters less than 100 m deep throughout their range (Thompson 1988). In New England waters, they probably feed primarily on benthic crustaceans.

Entanglement in commercial shrimp nets was by far the greatest threat to Kemp's ridleys prior to the implementation of turtle excluder devices. The turtles have also been caught in pound nets, trawls, gillnets, hook and line, crab traps, and longlines. Ingestion of floating debris (plastics, monofilament, discarded netting, etc.) is a threat (NMFS 1997b). Most stranding of Kemp's ridleys in New England waters have been attributed to cold stunning as water temperatures fall between November and January.

3.3. Human Use of the Area

The project principal investigators anticipate few conflicts with existing uses of the water column or the seabed because of the small size of the site and the position of the longline in the water column.

3.3.1. Navigation

The site is located 5 nmi to the southeast of the vessel traffic lane leading into Buzzards Bay. Commercial shipping uses this traffic lane as an entrance to the Cape Cod Canal. The Canal has a design depth of 32 feet; vessels drawing more than this generally do not use the Canal. In 1997, the Canal was used by a total of 16,269 vessels. Of these, 8,241 were over 65 ft in length (primarily tugs and tank barges). Due mainly to its position outside the traffic lane, the project principal investigators expect that there will be no impacts on commercial or recreational navigation.

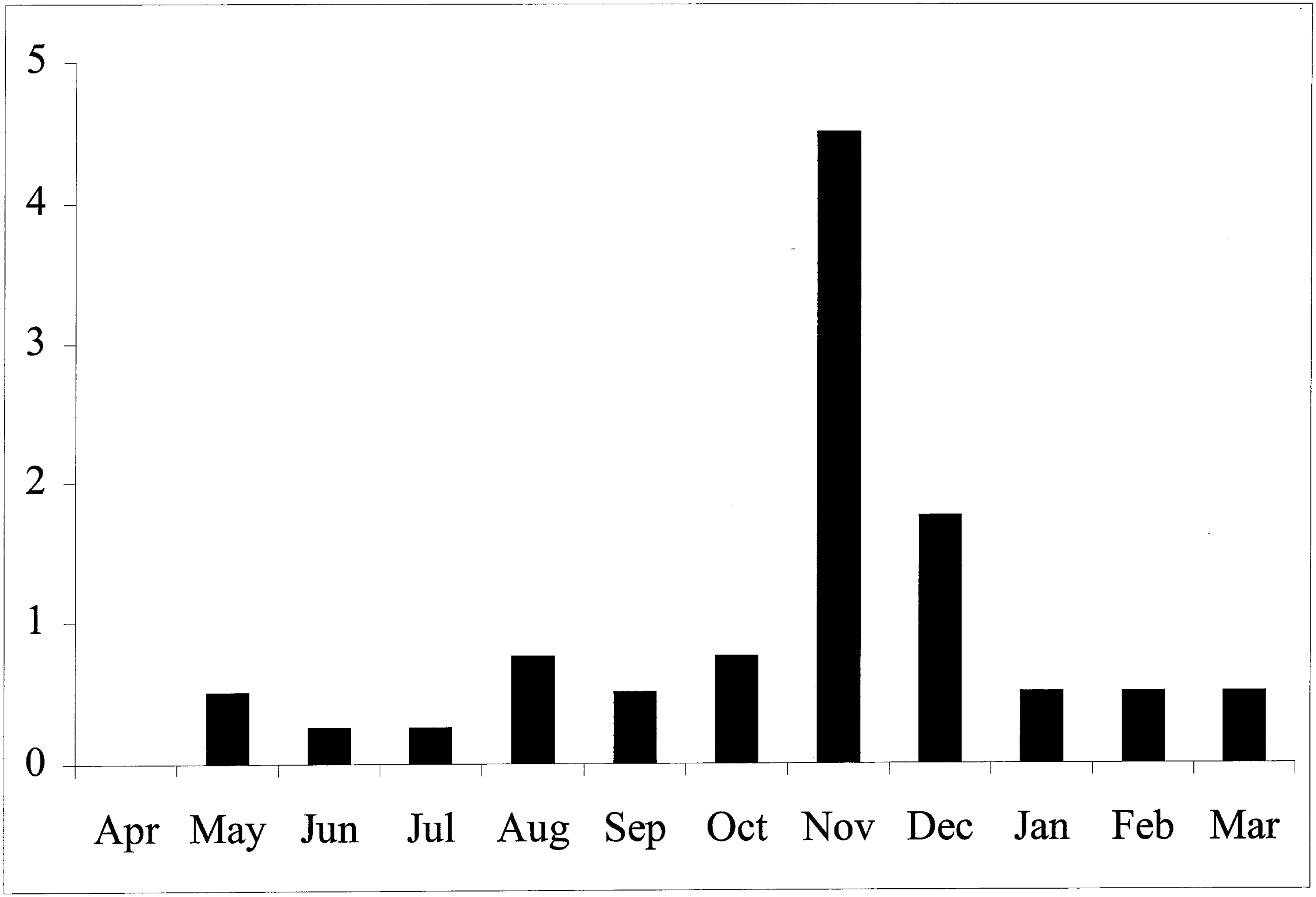
3.3.2. Fishing

Except for trawling over the longline, commercial or recreational fishing, including lobstering and the setting of sink gillnets, will not be displaced. In fact, the project principal investigators expect that some kinds of fishing, especially lobstering, may be enhanced at the site. Because of the site's longstanding use as a scientific testing area, the project principal investigators are unaware of any recent evidence of trawling at the site. As mentioned above, NMFS data from 1990-93 demonstrate some limited fishing activity near the proposed project site. On an annual basis, there are less than five trawls and less than seven gillnet sets during the year. These data suggest a very low level of fishing activity in the area. Table 4 presents some descriptive summary statistics on fishing trips from the "ten minute square" within which the proposed project site is located (the coordinates of the square are 71°00'-10' W longitude, 41°10'-20' N latitude). The average number of trips per month is very low. The 1990-93 data show less than one trip per month except for the months of November and December (Figure 11). The site has been used as a turning point for commercial fishing vessels traveling from Point Judith to Georges Bank, but is not known as a productive groundfish site (Paul, p.c., 1998). The presence of high flyer buoys with radar reflectors will alert any trawlers to the presence of the longline structure in the water column. The buoys will be marked to indicate the presence of a WHOI scientific research project at the site. The project principal investigators plan to notify fishermen in local ports of the location and nature of the project.

Table 4: Statistics on annual fishing activity at 71°05'W latitude, 41°15'N longitude (1990-93)

	Number of Trips	Number of Trawls	Number of Gillnets Set	Number of Days Fished	Average Days Fished per Trip
1990	21	3	18	54.1	2.6
1991	4	3	1	2.4	0.6
1992	18	10	8	15.0	0.8
1993	1	1	0	0.3	0.3
Average	**11**	**4.25**	**6.75**	**17.95**	**1.63**

Figure 11: Average number of fishing trips per month near the proposed project site (1990-93)



3.3.3. Recreation

Recreational activities include recreational fishing and boating. Recreational fishing is not impeded in the vicinity of the proposed project. The presence of high flyer buoys should alert any recreational fishermen to the position of the longline structure. The buoys will be marked to indicate the presence of a WHOI scientific research project at the site. Due to the depth of the longline structure in the water column, there should be no interference whatsoever with recreational boating activity. Most recreational boating is focused much closer to shore in the Elizabeth Islands and Martha's Vineyard.

4. Assessment of Possible Biological Effects on Endangered Marine Mammals and Sea Turtles[10]

The proposed project could affect protected species adversely due to physical contact with project gear. Other types of potential effects include alteration of behavior patterns of whales and turtles, adverse effects on plankton and forage fish distribution or abundance, or disturbance by human presence at the site. In theory, these latter effects could result from the project, but, because of the very low occurrence of protected species at the site, these types of effects are not considered likely.

4.1. Physical Contact with Project Gear

Large whales. Large whales may have difficulty avoiding the longline and growout socks suspended in the water if they attempt to feed at the proposed project site. Right whales are known to have trouble detecting and avoiding lines and nets suspended in the water column. Most humpback whale entanglements involve gear deployed near or on the bottom. Based upon sighting records, fin whales and sei whales are less likely to become entangled in fishing gear, although evidence of entanglements exists. Most of the reported entanglements of fin whales have been in groundfishing traps and lobster gear, suggesting that the whales become entangled while feeding near the bottom.

The project principal investigators have incorporated several features into the design of the longline structure to minimize the possibility of entanglements. These features are described in section 5 below. They include: positioning the longline structure below the surface and off the bottom; maintaining the longline and side mooring lines under high tension; using material for the longline and growout socks that is visible and sinks if it becomes detached; using weak links in lines to surface marker buoys and socking material; careful hydrodynamic modeling supporting the design of the engineered longline system; and ensuring the survivability of the structure to minimize the occurrence of marine debris.

Even with these and other design features, the primary method of minimizing potential impacts on large whales, especially the right whale, is the geographic location of the proposed project in an area where whales are known to occur only rarely.

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[10] Portions of the discussion in this section are borrowed or paraphrased from Smith *et al.* 1995.

Marine Turtles. The three endangered or threatened sea turtles are rare visitors to Rhode Island Sound. Although several individuals of each species are observed in Rhode Island Sound each year, little is known of their distribution or behavior while they are in the bays.

Kemp's ridley and loggerhead turtles are bottom feeders that forage for crabs and mollusks in shallow coastal waters. While feeding, they may spend more than 90 percent of their time submerged. Both species include mussels in their diet and may be attracted to mussels on the growropes. If they feed at the proposed project site, they could come in contact with the longline structure. These turtles readily become entangled in loose nets and other fishing gear. However, because the longline is under tension, it does not represent an entanglement threat. The socks are a potential entanglement threat only for a short time immediately after deployment, but the weak links on the socks have been designed to reduce this threat. Mussels will grow out of the socks at a rapid rate, reaching a diameter of four to six inches. At this point the socks are much less likely to entangle turtles. Lines to surface marker buoys represent possible entanglement threats, and will be kept to a minimum (one or two at most).

The leatherback turtle is quite different from the other two species. It is a massive animal often weighing more than 500 kg. It is a pelagic feeder that wanders into coastal waters, including those of Rhode Island Sound in the summer in search of rafts of jellyfish, upon which it feeds. They frequently become entangled in lobster gear in New England waters. Although leatherback turtles may forage through the area of the proposed project, they are unlikely to come into contact with it. The longline and mooring lines probably would not pose a hazard for leatherback turtles. It is unlikely that leatherbacks would interpret the mussel socks as a food source, and, given the low tensile strength of the socks, they are unlikely to become entangled. The research team plans to keep buoys on the longline structure clear of fouling, which may appear to leatherbacks to resemble jellyfish.

4.2. Alteration of Whale and Turtle Behavior

Each of the four endangered great whales, the harbor porpoise, and three endangered or threatened sea turtles has a unique instinctive behavior. However, the whales, the harbor porpoise, and, to a lesser extent, the sea turtles are able to adapt to natural and noncomplex man-induced habitat alterations. The proposed project represents a minor, very localized alteration to an area of the ocean that is thought to be only a transitory and noncritical habitat for these species.

In the case of the large whales and harbor porpoise, the most likely behavioral alteration is a slight change in normal cruising and foraging territory caused by overt avoidance of the longline. It is uncertain whether the whales would actually avoid the longline. However, if whales can detect the longline, they are likely to alter feeding behavior in order to avoid contact with it. Avoidance would decrease the likelihood of direct encounters and possible entanglement. Whales seem to accommodate readily to the presence of man-made structures (e.g., oil drilling rigs) and human activities in their environment with only a few incidents of entanglement or other adverse effects. The proposed project is likely to present only a very minor presence.

Sea turtles seem to have less of an ability to alter behavior than whales and are less likely to exhibit behavioral accommodation to a change in their habitat. However, the project principal investigators predict that the proposed project probably will not cause significant disturbance or require significant behavioral modification in the small numbers of sea turtles that may occur near the site.

4.3. Effects on Plankton and Forage Fish Distribution or Abundance

Given the scale of the experiment, there are unlikely to be measurable effects on plankton distribution or abundance in Rhode Island Sound. Due to the feeding behavior of mussels, there may be a reduced concentration of plankton in the immediate vicinity of the site. There will be no effect on forage fish distribution or abundance. There is some limited evidence that lobster may be attracted to the benthic environment in the immediate vicinity of mussel aquaculture facilities (Hampson, p.c., 1998).

4.4. Disturbance of Endangered Species by Human Presence at the Site

Construction and operation of the longline structure will entail human activities, including limited boat traffic, at the site. Most mollusk aquaculture operations do not require intensive day to day activities on site, except during deployment, thinning, and harvesting. Normal maintenance will involve one small boat (of the size of an inshore New England lobster boat) within the area on a periodic basis. The project principal investigators plan to monitor the site on a monthly basis. Thus, human activities are not likely to increase substantially above the current level when the facility is in place and operating.

Collisions between vessels and whales can be an important source of whale injury or death. However, most collisions that harm or kill whales involve large vessels. Whales can easily avoid small boats, and boat handlers of small boats can easily avoid whales. With adequate precautions, there is little likelihood of collisions between these boats and whales, particularly right whales, which may be present at the site.

Sea turtles also suffer harm and mortalities from encounters with boats and propellers. The additional boat traffic due to the proposed project is negligible in the context of normal commercial, fishing, and recreational vessel transits of Rhode Island Sound. As with the whales, the likelihood of injury from a small boat of the type that will tend the aquaculture facility is extremely low.

5. Measures Taken to Minimize Adverse Effects

The proposed project site is not generally regarded as either a nursery ground or a feeding area for protected species. There have been no known interactions between protected species and deployed buoy moorings during the twenty-year history of scientific research at the site. Deployment of a similar longline technology in Quebec has been visited frequently by minke whales (*Balaenoptera acutorostrata*) with no adverse impacts (Bonardelli, p.c., 1998). Nevertheless, the potential for interaction with protected species can be determined only through actual experience. The project principal investigators have planned to take the following measures to minimize any possible adverse effects on protected species.

5.1. Geographic Location

The longline is planned for deployment at a scientific testing area in Rhode Island Sound known as the "WHOI Buoy Farm," which is located at 41°16'N latitude, 71°01'W longitude. The Buoy Farm is clearly marked as a "surface and subsurface scientific testing area" on U.S. Coast and Geodetic Survey nautical chart No. 13218 (Figure 3). The Buoy Farm is an exposed site10 nm from the entrance to Vineyard Sound and 5 nm to the southeast of the Buzzards Bay Inbound Traffic Lane. Water depth at the site is approximately 42 m.

The Buoy Farm is located outside of critical habitat for the northern right whale. As shown in Figure 9, there are no recent recorded sightings in the NMFS database of either right whales or humpback whales specifically at the site. The NMFS database has not been corrected for sighting effort, but experts have stated that there is no evidence of large whales or harbor porpoise consistently occurring at the proposed project site (Clapham, p.c., 1998; Hain, p.c., 1998; Kenney, p.c., 1998; Mayo, p.c., 1998). It is possible that large whales may transit through the area during annual migrations (Figure 10). Transiting whales are most likely to be traveling at the sea surface.

5.2. Limited Geographic Scale

The Buoy Farm itself is 0.06 km^2 in area. This area represents approximately 0.02 percent of the area of Rhode Island Sound. The longline is limited in scale, extending only 200m in length between anchoring points. Hydrodynamic modeling of the longline system under current and wave forcing will cover the vertical and lateral excursion of the moored system under these forces.

5.3. Limited Project Duration

The research project will be limited in duration. The principal investigators plan to deploy the longline during the summer of 1998. Mussels will grow on the longline for one to two years.

5.4. Removal of Equipment from the Water Column

The longline, all growout gear, buoys, and anchors will be removed during the fall of 1999 or the spring of 2000. The precise removal date will depend upon observed mussel growth at the site. At the end of the experiment, all gear will be removed from the water.

5.5. Monitoring Program

The project team plans to implement a monitoring program to monitor the presence and behavior of any protected species in the vicinity of the site. The program has several elements including regular aerial and shipboard surveillance, deployment of emergency beacons, and the use of platforms of convenience.

5.5.1. Frequency of Inspections

The site will be visited by research vessel at least once a month during the summer and during peak migration periods for large whales. The project principal investigators plan to hire the services of a local seaplane to conduct overflights on a weekly basis. The seaplane operator, based in New Bedford, shuttles passengers between mainland points and various islands off the New England coast.

5.5.2. Emergency Beacon

The project investigators estimate that there is an extremely small probability of an interaction between the gear and a protected species. The probability of an entanglement event occurring is even smaller.

The project team has included in the design of the longline an emergency position-indicating radio beacon (EPIRB) that will release when the line is disturbed significantly. As shown in Figure 12, one or more EPIRBs will be attached to the longline on "breakaway sections" designed to give way when longline tension exceeds normal environmental loads (e.g. when a whale has become entangled). When the breakaway material parts, the EPIRB's positive buoyancy carries it to the surface, and the keel ballast causes it to invert, thereby activating the radio beacon.

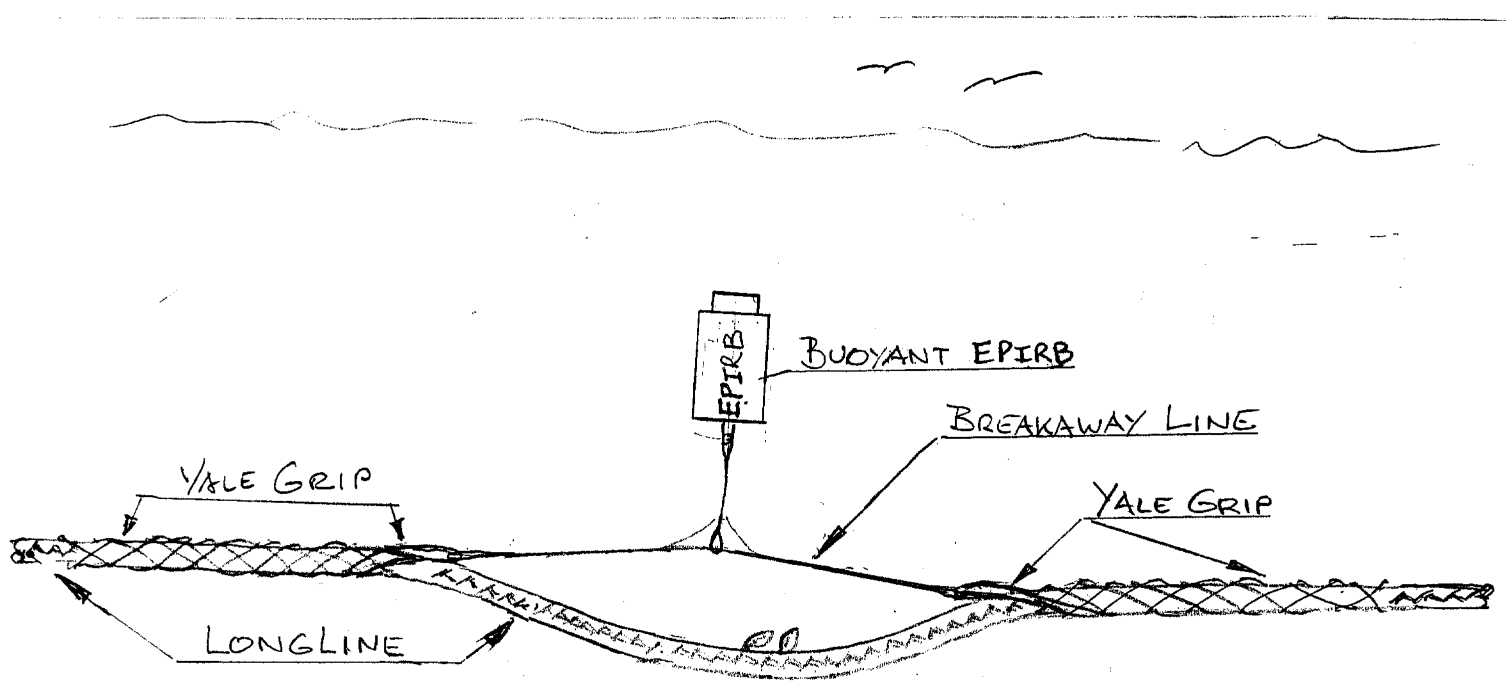
Once it is activated at the surface, the EPIRB will emit a signal that can be picked up by satellite and relayed to WHOI. The project researchers will either dispatch a vessel to the site or arrange for a special surveillance flight immediately. In the event of a protected species entanglement, the Disentanglement Team (see below) will be notified immediately.

There exists the possibility that the EPIRB will release because of the disturbance of the longline during a storm event or due to large surface waves and swells. The project team plans to check the longline immediately after any EPIRB release.

5.5.3. Platforms of Opportunity

The project team will request all oceanographic research vessels operating or transiting through Rhode Island Sound and in the vicinity of the project to report sightings of any large whales. The project team will request fishing vessels transiting the area and operating near the site to report sightings of any protected species in the area. The project team will follow closely the sighting efforts of NMFS, the state of Massachusetts, and other institutions to determine whether right whales or other protected species are in the vicinity of

Figure 12: A schematic showing the deployment of the emergency beacon technology



the proposed project site. The new program through which ships must signal to the Coast Guard for information on the locations of right whales may be useful in this regard (McGrory 1998).

5.6. Engineering Design

5.6.1. Survivability of Structure

One of the biggest concerns in the management of protected species is the potential for fishing gear to be lost, resulting in marine debris. The presence of marine debris heightens the potential for protected species entanglement. The longline will be designed to survive extreme storm events, thereby minimizing the release of any marine debris from the site.

The project team has already initiated computer-modeling efforts to predict the behavior of the longline when it is subject to extreme currents and storm events (Figure 13). The longline itself has been designed to withstand hurricane conditions at the sea surface. The design includes 4000 lb anchors; anchor lines with a tensile strength of 8-10,000 lbs; and the longline itself with a tensile strength of 10-12,000 lbs.

5.6.2. Location of Gear in the Water Column

The longline will be suspended with corner buoys having a buoyancy of 500-2,000 lbs (pending completion of modeling analysis). Given the strength of the longline and anchor lines and the buoyancy of the corner buoys, the entire system will be much like a rigid, tensioned structure. Should any protected species come into contact with the structure, its rigidity makes it highly unlikely that any entanglements will occur.

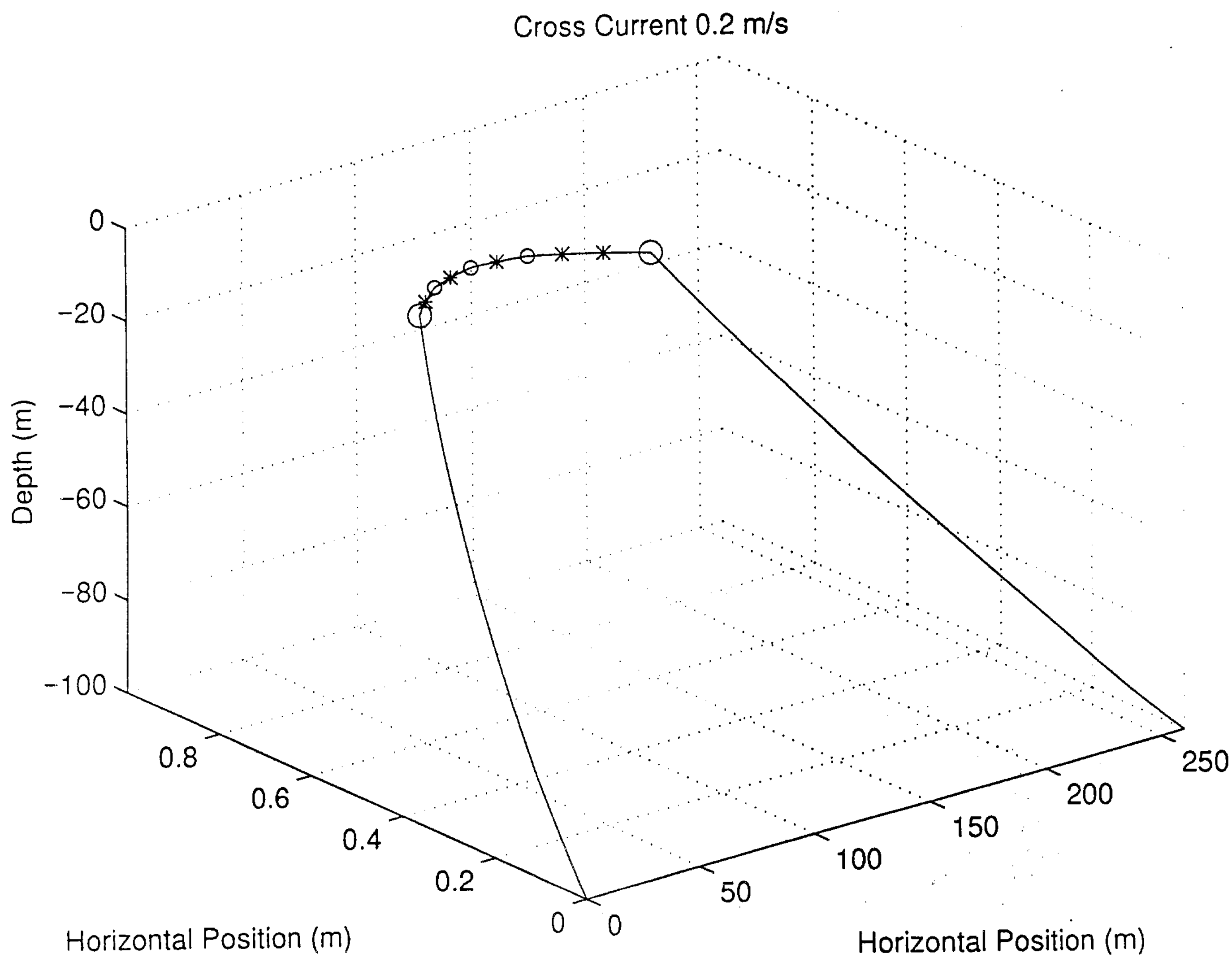
The longline will deployed at a depth of 5 m. No lines or growout socks will be arranged closer than 6 m from the seafloor. These restrictions minimize the possibility that large whales, which may be transiting the proposed project site at the surface or feeding on the bottom, will become entangled.

5.6.3. Growout Technology and Weak Links

Mussel socks hung from the longline will assume the shape of catenaries of various lengths (to be determined). The mussel socking material has a tensile strength of 70 lbs, which is far below the breakaway strength mandated for coastal lobster pots. Even with this low tensile strength, the project investigators will install "weak links" with a breaking strength of about 25 lbs at the bottom of each catenary. In the event that any protected species comes in contact with a catenary, the weak links will break, removing any entanglement potential. The mussel socking material will remain fixed to the longline.

Weak links will also be attached to the high flyer buoys that mark the submerged longline position.

Figure 13: Output from WHOI computer model of the lateral excursion of a longline due to wave and current forcing (Paul, p.c., 1998)



5.6.4. Use of Sinking Lines

The longline and connecting anchor lines will be manufactured of polyester with a specific gravity of 1.38 (33% heavier than seawater), designed to sink to the bottom immediately should anything become detached. The socking material is manufactured from polyethylene (which Floats). Small ballast weights will be attached to the socking material to sink it if it should become detached. Once mussels attach themselves to the socking material, the socking will sink without the ballasting. If the longline or anchor lines break, the emergency beacon will release immediately.

5.6.5. Visibility

All lines, buoys, and socks will be manufactured of a light colored material, such as white or yellow, to increase visibility in the water column. As mussel growth proceeds, the dimensions of mussel growth on all surfaces will be such that large whales and harbor porpoises will easily see the structure. The project principal investigators expect the dimensions of the mussel growth to approach 4 to 6 inches in diameter near the end of the growout period.

5.7. Relationship to Disentanglement Network

The project team will notify the Center for Coastal Studies (CCS) Disentanglement Team if any entanglements are found to occur. The process for notification is to telephone the CCS at 508-487-3622. The CCS Disentanglement Team will immediately notify the Coast Guard and NMFS to send a ship out to the site within one hour. Disentanglement gear will be helicoptered to the site. Disentanglement operations will begin as soon as the gear arrives.

As the principal investigators approach the time at which the longline will be deployed, they plan to meet with the CCS Disentanglement Team to discuss any disentanglement issues that may arise specific to the longline technology employed.

5.8. Gear Marking

We plan to mark all buoys with the WHOI logo and telephone number. Marking or painting the lines, socks, and gear is not practical. We plan to attach small textile "flags" with a distinctive shape and color (to be determined) on all lines, socks and other gear at intervals of 1-6 m.

6. Discussion and Conclusions

Table 5 summarizes the risks posed to protected species by the proposed research project. In general, these risks are extraordinarily small because of the low probability of encounter. The longline structure is a single, relatively small piece of equipment deployed for a limited period of time in a large body of water that is not known to be an area in which any of the species in question congregate or feed at length. At most, the area is part of a migration path for these species.

Table 5: Project components and associated threats and mitigating factors

Project Component	Species	Threat/Risk	Mitigating Factors
Longline Structure	Right Whale	possible entanglement (unlikely)	very low probability of encounter; emergency beacon
	Humpback Whale	possible entanglement	low probability of encounter; emergency beacon
	Fin Whale	possible entanglement (unlikely)	very low probability of encounter; emergency beacon
	Sei Whale	possible entanglement (unlikely)	very low probability of encounter; emergency beacon
	Harbor Porpoise	none	very low probability of encounter
	Loggerhead Turtle	none	n/a
	Leatherback Turtle	none	n/a
	Kemp's Ridley Turtle	none	n/a
Grow Ropes/Socks	Right Whale	possible entanglement (unlikely)	very low probability of encounter; material will break away
	Humpback Whale	possible entanglement	low probability of encounter; material will break away
	Fin Whale	possibly entanglement (unlikely)	very low probability of encounter; material will break away
	Sei Whale	possible entanglement (unlikely)	very low probability of encounter; material will break away
	Harbor Porpoise	possible entanglement	very low probability of encounter, material may break away
	Loggerhead Turtle	possible entanglement	material may break away
	Leatherback Turtle	possible entanglement	material will break away
	Kemp's Ridley Turtle	none	n/a
Surface Buoys and Ropes	Right Whale	possible entanglement (unlikely)	very low probability of encounter; breakaway section in surface marker buoy ropes
	Humpback Whale	possible entanglement	low probability of encounter; breakaway section in buoy ropes
	Fin Whale	possible entanglement (unlikely)	very low probability of encounter; breakaway section in buoy ropes
	Sei Whale	possible entanglement (unlikely)	very low probability of encounter; breakaway section in buoy ropes
	Harbor Porpoise	possible entanglement	breakaway section in buoy ropes
	Loggerhead Turtle	possible entanglement	breakaway section in buoy ropes
	Leatherback Turtle	possible entanglement	buoys kept clear of fouling; breakaway section in buoy ropes
	Kemp's Ridley Turtle	negligible	low probability of encounter
Project Vessels and Site Activity	Right Whale	negligible	vessel operators stay clear of whale
	Humpback Whale	negligible	vessel operators stay clear of

Project Component	Species	Threat/Risk	Mitigating Factors
			whales
	Fin Whale	negligible	vessel operators stay clear of whales
	Sei Whale	negligible	vessel operators stay clear of whales
	Harbor Porpoise	none	n/a
	Loggerhead Turtle	negligible	vessel operators stay clear of turtles
	Leatherback Turtle	negligible	vessel operators stay clear of turtles
	Kemp's Ridley Turtle	negligible	vessel operators stay clear of turtles

The only realistic threat to these species from the project is entanglement in surface buoy lines and grow ropes/socks, particularly for humpbacks and the larger turtles (loggerheads and leatherbacks). This threat is mitigated by breakaway sections in lines and ropes, and by the small number (one or, at most, two) surface buoys. Entanglement in the longline structure itself is extremely unlikely because of its rigidity; and should a whale nonetheless become entangled, the emergency beacon release will ensure a rapid response by the Disentanglement Team. Small turtles are unlikely to be able to get entangled in any of the structures' components due to their size and stiffness. The proposed structure will be observed regularly to ensure that it is performing as expected and that no entanglements have occurred. Vessel operations and human activity around the longline pose virtually no threat to these species.

Thus, in summary, the risk posed by the proposed project to protected species, while not zero, is small and further mitigated by a number of design features and observation programs.

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