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DRAFT RECOVERY PLAN FOR THE FIN WHALE *BALAENOPTERA PHYSALUS* AND SEI WHALE *BALAENOPTERA BOREALIS*

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D R A F T

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[To be added.]

DISCLAIMER

This is the first draft of the Fin and Sei Whale Recovery Plan. The plan was prepared by a contractor in collaboration with scientists from the Office of Protected Resources of the National Marine Fisheries Service (NMFS) in Silver Spring, Maryland. It identifies reasonable actions believed to be required to recover and/or protect the two species. Funds will be expended contingent upon appropriations, priorities, and other budgetary constraints.

Draft recovery plans are not official government documents, and when released for public comment, they will not have been approved by NMFS or by any other agency. Therefore, draft plans do not necessarily represent the positions or policies of the United States Government or any other government. The conclusions and recommendations in this draft recovery plan are solely those developed by the authors. In addition, the views expressed are not necessarily those of all individuals consulted in the formulation of the plan. Draft plans will be subject to revision or modification following review.

This recovery plan will represent the official position of NMFS only after it has been signed by the Assistant Administrator as approved. Approved recovery plans are subject to modification as dictated by new findings, changes in the species' status, and completion of recovery tasks described in the plan.

Although one of the purposes of a recovery plan is to provide a comprehensive list of actions needed to promote the recovery of a listed species, the plan itself does not obligate NMFS to perform all of those actions. Rather, the activities actually undertaken in a given fiscal year will depend on available funding and on agency priorities at the time. The activities that the government is willing to undertake are typically described in an implementation plan, which is developed subsequent to the recovery plan.

PREFACE

Congress passed the Endangered Species Act of 1972 (16 USC 1531 *et seq*) to protect species of plants and animals endangered or threatened with extinction. The National Marine Fisheries Service and the U.S. Fish and Wildlife Service share responsibility for the administration of the Act. NMFS is responsible for most marine mammals including fin and sei whales. This Plan was written at the request of the Assistant Administrator for Fisheries to promote the conservation of fin and sei whales.

The goals and objectives of the Plan can be achieved only if a long-term commitment is made to support the actions recommended here. Achievement of these goals and objectives will require the continued cooperation of the governments of the United States and other nations. Within the United States, the shared resources and cooperative involvement of federal, state, and local governments, industry, academia, non-governmental organizations, and individuals will be required throughout the recovery period.

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EXECUTIVE SUMMARY

Fin whales, *Balaenoptera physalus*, are widely distributed in the world's oceans. Most stocks were depleted by modern whaling, but there are still tens of thousands of fin whales worldwide. Commercial whaling for this species ended in the North Pacific in 1976 and the North Atlantic in 1987. Fin whales are still hunted, however, in Greenland, subject to catch limits under the International Whaling Commission's "aboriginal subsistence whaling" scheme. Although reliable and recent estimates of fin whale abundance are available for large portions of the North Atlantic Ocean, this is not the case for most of the North Pacific Ocean. Moreover, the status of stocks in both of these ocean basins, stated in terms of present population size relative to "initial" (pre-whaling, or carrying capacity) level, is uncertain.

Sei whales, *Balaenoptera borealis*, were hunted by modern whalers primarily after the preferred larger (or more easily taken) baleen whale species had been seriously depleted, including the right (*Eubalaena* spp.), humpback (*Megaptera novaeangliae*), gray (*Eschrichtius robustus*), blue (*Balaenoptera musculus*), and fin whales. Most stocks of sei whales were reduced, some of them drastically, by whaling in the 1950's through the early 1970's. International protection only began in the 1970's for this species, and the sei whale continued to be exploited in the North Atlantic, by Iceland, through 1986. Of the commercially-exploited "great whales," the sei whale is one of the least well studied, and the current status of most sei whale stocks is poorly known.

The main potential direct threat to fin and sei whales today is the possibility of illegal whaling or a resumption of legal whaling. Collisions with vessels, entanglement in fishing gear, reduced prey abundance due to overfishing and habitat degradation, and disturbance from low-frequency noise are the most obvious potential indirect threats. The possible effects of pollution on fin and sei whales remain poorly understood. However, published evidence indicates that their body burdens of most contaminants (e.g., organochlorines and heavy metals) are lower than those of many toothed-whale species. Schooling fish constitute a large proportion of the fin whale's diet in many areas of the North Atlantic. Thus, trends in fish populations, whether driven by fishery operations, human-caused environmental deterioration, or natural processes, may strongly affect the size and distribution of fin whale populations. As a more deepwater species that generally occurs on the continental slope and rarely enters inshore waters, the sei whale appears to be less prone to collisions with fishing gear and strikes by vessels than are most of the other Northern Hemisphere baleen whales. Sei whales in the North Atlantic feed low on the food chain and are unlikely to be negatively affected by competition with fisheries. Those in the North Pacific seem to have a more varied diet, and this should make them resilient to any effects of resource competition.

This Plan identifies measures that need to be taken to protect, and promote and monitor the recovery of, fin and sei whale populations in the North Atlantic and North Pacific oceans. The most important element is continued protection from commercial whaling. Other key features of the proposed recovery program for these species are: (1) coordinate state, federal, and international efforts to implement recovery efforts, (2) establish classification criteria for the

recovery status of fin and sei whale populations, (3) determine population discreteness and stock structure, (4) estimate population sizes and monitor trends in abundance, (5) identify and protect critical habitats, (6) identify causes and minimize frequency of human-caused injury and mortality, (7) determine and minimize any detrimental effects of directed vessel and aircraft interactions, and (8) maximize efforts to acquire scientific information from dead, stranded, and entangled animals. Criteria for delisting or downlisting recovering fin and sei whale populations do not exist and developing them is one of the recommended actions of this plan.

I. BACKGROUND: FIN WHALE

A. Species Description and Taxonomy

The fin whale, *Balaenoptera physalus* (Linnaeus 1758), is a well-defined, cosmopolitan species of baleen whale (Gambell 1985b). It is the second-largest whale species, by length. Adults in the Antarctic can be more than 23 m long and weigh more than 70,000 kg. In general, fin whales in the Northern Hemisphere attain a smaller maximum body length (by up to 3 m), and those in the North Atlantic at least are leaner, than their Antarctic counterparts (Lockyer and Waters 1986). However, the largest fin whales reported in the catch off California were a 24.7 m (81 ft) female and a 22.9 m (75 ft) male (Clapham et al. 1997). As with other baleen whales, female fin whales grow to a larger size than males (Aguilar and Lockyer 1987).

Fin whales are long-bodied and slender, with a prominent dorsal fin set about two-thirds of the way back on the body. The streamlined appearance can change during a feeding run, when the pleated throat and chest area becomes distended by the influx of prey and sea-water, giving the animal a tadpole-like appearance. The basic body color of the fin whale is dark gray dorsally and white ventrally, but the pigmentation pattern is complex. Individually distinctive features of pigmentation, along with dorsal fin shapes and body scars, have been used in photo-identification studies (Agler et al. 1990).

The general similarity in appearance of fin whales to sei whales (*B. borealis*) and Bryde's whales (*B. edeni*) has resulted in confusion about distributional limits and frequency of occurrence, particularly in low latitudes where "fin" whales described in the whaling literature have often proved to be Bryde's whales. The diagnostic features for distinguishing the three species were outlined by Mead (1977). Fin whales and blue whales (*B. musculus*) are known to interbreed occasionally in the North Atlantic (Bérubé and Aguilar 1998) and apparently also in the North Pacific (Doroshenko 1970).

B. Zoogeography

Fin whale populations exhibit differing degrees of mobility, presumably depending on the stability of access to sufficient prey resources through the year. Most groups are thought to migrate seasonally, in some cases over distances of thousands of kilometers. They feed at high

latitudes in summer and fast at low latitudes in winter. Some groups apparently move over shorter distances and can be considered resident to areas with a year round supply of adequate prey.

The fin whale is a cosmopolitan species with a generally anti-tropical distribution centered in the temperate zones. Two subspecies - a large Southern Hemisphere form and a smaller Northern Hemisphere form - have been recognized by some authorities (Tomilin 1946, 1967; Sokolov and Arsen'ev 1994; Rice in press). On a global scale, populations in the North Atlantic, North Pacific, and Southern Ocean probably mix rarely (if at all), and there are geographical stocks within these ocean basins. Clark (1995), for example, reported that there was "preliminary evidence" of differences in fin whale vocalizations between the North Atlantic and North Pacific, as well as regional differences within the North Atlantic. This plan treats the two populations of concern here separately - North Atlantic and North Pacific.

C. Protective Legislation

Fin whales were hunted occasionally by the sailing-vessel whalers of the 19th century (e.g., see Scammon 1874; Mitchell and Reeves 1983). The introduction of steam power in the second half of that century made it possible for boats to overtake the large, fast-swimming rorquals, including fin whales, and the use of harpoon-gun technology resulted in a high loss rate (Schmitt et al. 1980; Reeves and Barto 1985). The eventual introduction of deck-mounted harpoon cannons made it possible to kill and secure blue, fin, and sei whales on an industrial scale (T□nnessen and Johnsen 1982). Fin whales were hunted, often intensively, in all the world's oceans for the first three-quarters of the twentieth century. The total reported catch of fin whales in the Southern Hemisphere from 1904 through 1979 was close to three-quarters of a million, making them numerically dominant, by far, among the commercially exploited baleen whales (see IWC 1995:129-130).

Under the 1946 International Convention for the Regulation of Whaling, a minimum size limit of 55 ft (16.8 m) was in effect for fin whales taken by commercial whaling in the North Pacific, and two fin whales were rated as equivalent to one "blue whale unit" under the initial production quota scheme (Allen 1980). The International Whaling Commission (IWC) did not begin managing commercial whaling for fin whales on a species basis until 1969 in the North Pacific (Allen 1980) and 1976 in the North Atlantic (Sigurjónsson 1988). The fin whale was given full protection from commercial whaling in the Antarctic beginning in the 1976/77 season, the North Pacific in the 1976 season, and the North Atlantic in the 1987 season. Since 1987, the only area in the Northern Hemisphere where fin whales have been hunted legally is Greenland. There, a small take of about ten fin whales per year has been authorized under the IWC's "aboriginal subsistence whaling" scheme (Gambell 1993; Caulfield 1993).

The fin whale is protected under both the Endangered Species Act (ESA) (as endangered) and the Marine Mammal Protection Act (MMPA). It is listed as "endangered" by the IUCN (Baillie and Groombridge 1996) and is listed in Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES). The CITES

classification is intended to ensure that no commercial trade in the products of fin whales occurs across international borders.

An estimated 414 fin whales were taken in the eastern North Atlantic between 1977 and 1979 by "pirate" whalers, i.e., whalers whose operations were not subject to IWC regulation (Best 1992). There is evidence of large-scale misreporting of whaling data from Soviet factory ships in the Southern Hemisphere (Yablokov 1994; Zemsky et al. 1995). Soviet authorities originally over-reported fin whale catches to camouflage illegal takes of protected species (right, blue, and humpback whales). Catch data from the North Pacific have yet to be revised and validated, but judging from the Southern Hemisphere example, it seems certain that the officially reported data for the North Pacific will prove to be equally unreliable.

II. BACKGROUND: SEI WHALE

A. Species Description and Taxonomy

The sei whale, *Balaenoptera borealis* Lesson 1828, is a cosmopolitan species of the world's temperate to subpolar marine waters (Gambell 1985a; Horwood 1987). It is generally considered monomorphic, although little effort has been applied to intraspecies comparisons. The difficulty of distinguishing sei whales at sea from their close relatives, Bryde's whales, and also under some circumstances from fin whales, has created confusion about distributional limits and frequency of occurrence, especially in warmer waters where Bryde's whales are most common.

Mead (1977) cited the very fine bristles of the sei whale's baleen (about 0.1 mm in diameter at the base) as the most reliable feature for distinguishing it from all other *Balaenoptera* species. He also noted that the sei whale could be distinguished from all the other species, except the smaller minke whale (*Balaenoptera acutorostrata*), by the relative shortness of its ventral grooves, which extend back only to a point about midway between the flippers and the umbilicus. The best way to separate sei and Bryde's whales, apart from the differences in their baleen, is by the presence of lateral ridges on the dorsal surface of the Bryde's whale's head. Large sei whales can be mistaken for fin whales unless the latter's asymmetrical head coloration is clearly seen - the right lower jaw being white and the left gray.

Sei whales are essentially gray. Their skin is often marked by pits or wounds, which after healing become ovoid white scars. These are probably caused mainly by ectoparasitic copepods (*Penella* spp.) (Andrews 1916; Ivashin and Golubovsky 1978), lampreys (Pike 1951; Rice 1977), and possibly also "cookie-cutter" sharks (*Isistius brasiliensis*)(Shevchenko 1977).

Sei whales in the Southern Ocean can be longer than 17 m and weigh up to 28,000 kg (Lockyer 1977b). Those in the Northern Hemisphere are smaller than those in the Southern Ocean. The largest specimens taken off Iceland were slightly longer than 16 m (Martin 1983). Females are considerably larger than males.

The dorsal fin is usually prominent and back-curved, set about two-thirds of the way back from the tip of the snout. Viewed from the side, the sei whale's head has a slight arch that differs from the comparatively flat profile of the fin whale's. Sei whales, unlike fin whales, tend not to roll high out of the water as they dive. In sei whales, the blowholes and dorsal fin are often exposed above the water surface simultaneously, while in fin whales, this is rarely the case. Sei whales almost never extend their flukes above the surface, and they rarely breach. Dorsal fin shape, pigmentation pattern, and scarring have been used to a limited extent in photo-identification studies of sei whales (Schilling et al. 1992).

B. Zoogeography

Sei whales are highly mobile, and there is no indication that any population remains in the same area year round, i.e., is resident. Pole-ward summer feeding migrations occur, and sei whales generally winter in warm temperate or subtropical waters. The species is cosmopolitan, but with a generally anti-tropical distribution centered in the temperate zones. The larger Southern Hemisphere animals have been regarded by some authorities as differing from the smaller Northern Hemisphere sei whales at the subspecies level (see Rice in press). On a global scale, the populations in the North Atlantic, North Pacific, and Southern Ocean are almost certainly separate, and they may be further subdivided into geographical stocks.

C. Protective Legislation

Sei whales did not have meaningful protection at the international level until 1970, when catch quotas for the North Pacific began to be set on a species basis (rather than on the basis of total production, with six sei whales considered equivalent to one "blue whale unit"). Prior to that time, the kill was limited only to the extent that whalers hunted selectively for the larger species with greater return on effort (Allen 1980). The sei whale was given complete protection from commercial whaling in the North Pacific in 1976, and quotas on sei whales were introduced in the North Atlantic in 1977. With the moratorium on commercial whaling taking effect in the Northern Hemisphere in 1986, all legal whaling for sei whales stopped.

Like the fin whale, the sei whale is protected by both the ESA (as an endangered species) and the MMPA. It is also classified as "endangered" by the IUCN (Baillie and Groombridge 1996) and is listed in CITES Appendix I.

In the late 1970's, some "pirate" whaling for sei whales took place in the eastern North Atlantic (Best 1992). There is no direct evidence of illegal whaling for this species in the North Pacific although the acknowledged misreporting of whaling data by Soviet authorities (Yablokov 1994) means that catch data are not wholly reliable.

III. NATURAL HISTORY

A. North Atlantic Fin Whale Population

1. Stocks

The stock concept has been the subject of much discussion among biologists and natural resource managers. Under the ESA, the NMFS can manage whales at the level of "distinct population segments." In practice, both the IWC and NMFS have needed to define stocks as management units that fall short of this ideal. A recent working definition of "stock" under the MMPA is a "demographically isolated biological population" (Wade and Angliss 1997:55). The IWC continues to waver somewhere between two types of stock: biological stocks based on genetic separation, and management stocks referring to population units defined in functional terms of some kind (Donovan 1991).

Management of the exploitation of fin whales in the North Atlantic has presupposed the existence of six or seven management units, although the scientific basis for defining these as biological stocks was initially weak (Donovan 1991). The management units are: Nova Scotia, Newfoundland-Labrador, West Greenland, East Greenland-Iceland, North Norway, West Norway-Faroe Islands, and British Isles-Spain-Portugal. Results of mark-recapture experiments indicate that some movement occurs across the boundaries of these management units (Mitchell 1974; Gunnlaugsson and Sigurjónsson 1989; IWC 1992).

After evaluating all available evidence through 1991, the IWC Scientific Committee was unable to decide whether the population of fin whales in the North Atlantic consisted of several discrete breeding groups or, instead, comprised a single stock existing in a "patchy continuum" (Sergeant 1977) across the entire ocean basin (IWC 1992). It was, however, agreed that the balance of evidence from various types of analyses (including biochemical, genetic, tag-recapture, morphologic, and biometric; Lockyer 1982; Gunnlaugsson and Sigurjónsson 1989; 'Arnason et al. 1992; Jover 1992) indicated that the fin whales hunted off Spain belonged to a different stock from those hunted off Iceland (IWC 1992). Based on a comparison of biological parameters and analyses of catch and effort at Canadian shore whaling stations, Breiwick (1993) supported Mitchell's (1974) hypothesis that there are at least two stocks in the western North Atlantic, one centered in Nova Scotia and New England waters and the other in Newfoundland waters.

Recent genetic analyses confirm that there is structuring within the North Atlantic population along the lines suggested by Ingebrigtsen (1929) and Kellogg (1929). Significant heterogeneity in mtDNA was found between the Mediterranean Sea, the eastern North Atlantic (Spain), and the western North Atlantic (Gulf of Maine and Gulf of St. Lawrence) (Bérubé et al. in press). Mixing between the eastern and western North Atlantic populations apparently occurs regularly in the waters around Iceland and Greenland. As noted earlier, it has also been suggested that the vocalizations of fin whales recorded off Bermuda and the West Indies sound different from those recorded in the Norwegian Sea (Clark 1995).

The NMFS position is that there is a single stock of fin whales in U.S. waters of the

western North Atlantic (Waring et al. 1997), presumably equivalent to the Nova Scotia stock as recognized by the IWC (Mitchell 1974; IWC 1992). It is considered likely that fin whales in the U.S. EEZ migrate into Canadian waters, open-ocean areas, and possibly more equatorial regions (Waring et al. 1997).

Of particular importance in the current management context is the IWC's continued recognition of a West Greenland stock of fin whales (IWC 1992) even though the evidence for genetic isolation of this population remains inconclusive (IWC 1996:77; IWC 1998a; Bérubé et al. in press).

2. Distribution and Habitat Use

The fin whale has a very extensive distribution in the North Atlantic, occurring from the Gulf of Mexico (Jefferson and Schiro 1997) and Mediterranean Sea northward to the edges of the arctic pack ice (Jonsgård 1966a, 1966b; Sergeant 1977; IWC 1992). In general, fin whales are more common north of about 30°N latitude, and considerable confusion arises about their occurrence south of there because of the difficulty of distinguishing fin from Bryde's whales (see Mead 1977). Extensive ship surveys led Mitchell (1974) to conclude that the summer feeding range of fin whales in the western North Atlantic was mainly between 41°20'N and 51°00'N, from shore seaward to the 1,000 fathom contour.

Although fin whales are certainly migratory in the sense that they move seasonally into and out of high-latitude feeding areas, where they have often been subjected to whaling, the pattern overall is confusing and seems to be complex (see Christensen et al. 1992a for a recent review). Regular mass movements along well-defined migratory corridors, with specific end-points, have not been documented by sightings, but acoustic recordings from passive-listening hydrophone arrays indicate a southward "flow pattern" in the fall from the Labrador-Newfoundland region, south past Bermuda, and into the West Indies (Clark 1995). Fin whales occur year round in a wide range of latitudes and longitudes, while the density of individuals in any one area changes seasonally. Thus, their aggregate movements are patterned and consistent, but movements of individuals in a given year may vary according to their energetic and reproductive condition, climatic factors, etc. In some parts of their range, such as the Gulf of St. Lawrence and the Newfoundland shelf, ice formation in winter forces fin whales offshore, and its disintegration in spring allows them to move back inshore (Jonsgård 1966a; Sergeant 1977). One or more "populations" of fin whales were thought by Norwegian whalers to remain year round in high latitudes, actually moving offshore, but not southward, in late autumn (Hjort and Ruud 1929; Jonsgård 1966a). These impressions were recently reinforced by acoustic evidence that fin whales occur throughout the winter in the Norwegian and Barents seas, apparently in considerable numbers (Clark 1995).

The local distribution of fin whales during much of the year is probably governed largely by prey availability (e.g., Ingebrigtsen 1929; Jonsgård 1966a, 1966b). For example, the positions off southwestern Iceland where fin whales were caught correlated well with the known

distribution of spawning krill (*Meganyctiphanes norvegica*), their preferred prey in that area (Rørvik et al. 1976). In general, fin whales in the central and eastern North Atlantic tend to occur most abundantly over the continental slope and on the shelf seaward of the 200 m isobath (Rørvik et al. 1976). In contrast, off the eastern United States they are centered along the 100 m isobath but with sightings well spread out over shallower and deeper water, including submarine canyons along the shelf break (Kenney and Winn 1987; Hain et al. 1992).

Segregation seems to occur at least in summer, with the larger (mature) whales arriving at feeding areas earlier, and departing later, than the smaller individuals (Rørvik et al. 1976). Within the Gulf of Maine at least, lactating females may occupy only, or primarily, southern portions of the summer feeding range (Agler et al. 1993).

Tagging and photo-identification studies suggest considerable "site fidelity" on feeding grounds (Mitchell 1974; Edds and Macfarlane 1987; Gunnlaugsson and Sigurjónsson 1989; Seipt et al. 1990; Agler et al. 1990; Clapham and Seipt 1991), but the documented long-distance movements of some individuals (Mitchell 1974; Watkins et al. 1984; Agler et al. 1990) show that fin whales are capable of using large resource areas.

Fin whales are locally common in the River and Gulf of St. Lawrence during the summer and fall, especially on the north shore shelf (Edds and Macfarlane 1987; Borobia et al. 1995; Kingsley and Reeves in press). Sergeant (1977) suggested that they associate with steep contours of the Laurentian Channel, either because tidal and current mixing along such gradients drives high biological production or because changes in depth aid their navigation.

3. Feeding and prey selection

Fin whales in the North Atlantic eat pelagic crustaceans (mainly euphausiids or krill, including *Meganyctiphanes norvegica* and *Thysanoessa inermis*) and schooling fish such as capelin *(Mallotus villosus)*, herring (*Clupea harengus*), and sand lance (*Ammodytes* spp.) (Hjort and Ruud 1929; Ingebrigtsen 1929; Jonsgård 1966a; Mitchell 1974; Sergeant 1977; Overholtz and Nicolas 1979; Christensen et al. 1992b; Borobia et al. 1995). The availability of sand lance, in particular, is thought to have a strong influence on the distribution and movements of fin whales along the east coast of the United States (Kenney and Winn 1986; Payne et al. 1990; Hain et al. 1992).

Although there may be some degree of specialization, most individuals probably prey on both invertebrates and fish, depending on availability (cf., Watkins et al. 1984; Edds and Macfarlane 1987; Borobia et al. 1995). Sergeant (1977) suggested that euphausiids were the "basic food" of fin whales and that they took advantage of fish when sufficiently concentrated, "particularly in the pre-spawning, spawning and post-spawning adult stages on the Continental Shelf and in coastal waters."

4. Competition

There has been considerable discussion of interspecific competition among mysticete whales, but no conclusive evidence has been adduced to demonstrate that it occurs (Clapham and Brownell 1996). The substantial dietary overlap among the balaenopterids (Nemoto 1970; Kawamura 1980) establishes the potential for interference competition. As a species, the fin whale clearly feeds on a fairly broad spectrum of prey, but regional groups of fin whales seem to specialize on particular types of prey. American sand lance (*Ammodytes americanus*) are a major prey of fin whales in the Gulf of Maine, and fin whales are, therefore, potential competitors with several other cetacean species that also depend heavily on these fish as prey, particularly humpback whales (Watkins and Schevill 1979; Kenney and Winn 1986). From an analysis of annual sighting frequencies in the Gulf of Maine, Payne et al. (1990) concluded that fin whales were able to exploit more widely separated patches of prey, and were thus more independent of local fluctuations in prey availability, than humpbacks. The responses of fin whales to shifts in prey abundance were less pronounced than those of humpback, right, and sei whales in this region. As pointed out by Clapham and Brownell (1996), this is not necessarily evidence of competition, *per se*, but rather could indicate simply that the four species have different adaptive traits.

5. Reproduction

The gestation period is probably somewhat less than a year, and fin whale calves are nursed for 6-7 months (Haug 1981; Gambell 1985b). Most reproductive activity, including births and mating, takes place in the winter season (November to March; peak December-January; Haug 1981; also see Mitchell 1974) although "out-of-season" births do occur off the eastern United States (Hain et al. 1992).

The average calving interval has been estimated at about two years based on whaling data (Christensen et al. 1992b). In unexploited populations, the interval may be somewhat longer. Agler et al. (1993) used photo-identification data to estimate an average interval of 2.7 years for fin whales in the Gulf of Maine, although they acknowledged that this value was probably biased upward by incomplete sighting histories. If certain females calved in "missed" years (i.e., years in which they were not photo-identified in the study area), the mean interval could have been as low as 2.24 years (Agler et al. 1993). Breiwick (1993) found that the annual pregnancy rate (defined as the percentage of mature females that are pregnant in a given year) was significantly lower in the population hunted from Blandford, Nova Scotia, than in the population hunted from Williamsport and South Dildo, Newfoundland. Among the hypotheses that could explain this difference is that fin whales show a density-dependent response by shortening the birth interval (and/or the time to sexual maturity) and that the Nova Scotia population was less depleted than the Newfoundland population at the time of sampling.

Fin whales in populations near carrying capacity may not attain sexual maturity until ten years of age or older, whereas those in exploited populations can mature as early as six or seven years of age (Gambell 1985b). It should be noted, however, that the question of whether whaling data from the Southern Hemisphere do or do not demonstrate density-dependent responses in the

reproductive cycle of fin whales is controversial (cf. Mizroch and York 1984; Sampson 1989).

Physical maturity is reached at 20-30 years of age (Aguilar and Lockyer 1987).

The gross annual reproductive rate of fin whales in the Gulf of Maine (calves as a percentage of the total population) was about 8% during the 1980s (Agler et al. 1993). Sigurjónsson (1995) gave the range of pregnancy rates for the species (proportion of adult females pregnant in a given year) as 0.36-0.47.

6. Natural mortality

Little is known about the natural causes of mortality of fin whales in the North Atlantic. Ice entrapment is known to injure and kill some, particularly in the northeastern Gulf of St. Lawrence (Sergeant et al. 1970). There is evidence, most of it anecdotal, that killer whales attack fin whales fairly often in the western North Atlantic (Mitchell and Reeves 1988). Disease presumably plays a major role in natural mortality as well, and shark attacks on weak or young individuals are probably common, but have not been documented. Lambertsen (1986) contended that crassicaudiosis was the primary cause of natural mortality in North Atlantic fin whales. Rates of natural mortality in fin whales generally are thought to range between 0.04 and 0.06 (Aguilar and Lockyer 1987).

7. Abundance and trends

No good estimate of pre-exploitation population size is available, and it seems unlikely that a robust estimate will ever be possible, considering the long history of exploitation and the many uncertainties about current abundance and stock boundaries (see Breiwick 1993). Sigurjónsson (1995) estimated a total pre-exploitation population size in the North Atlantic in the range 50,000 to 100,000 but provided no supporting data and no explanation of his reasoning. Sergeant's (1977) summary of population estimates, derived using various techniques and always assuming catch levels to be sustainable, led him to suggest a "primeval" aggregate total of 30,000 to 50,000 fin whales throughout the North Atlantic. Of the 30,000, about 8,000 to 9,000 would have belonged to the Newfoundland and Nova Scotia "stocks" (see Allen 1970; Mitchell 1974), with whales summering in U.S. waters south of Nova Scotia presumably not having been taken fully into account. With no explanation, Chapman (1976) gave the "original" population sizes as only 1,200 off Nova Scotia and 2,400 off Newfoundland. According to Chapman's calculations, the Nova Scotia stock of about 400 whales was 41% below its maximum-sustainable-yield (MSY) level (700 whales longer than 50 ft) in 1975, while the Newfoundland stock (1,600 whales) was still above its MSY level of 1,400.

Breiwick (1993) concluded, based on population modeling, that the Newfoundland stock likely declined during the most recent episode of whaling (1966-72). A decline in abundance of the Nova Scotia stock (whaled from 1965-72) was evident from both catch-per-unit-effort analyses and population modeling. Breiwick (1993) estimated the "exploitable" component of the

Nova Scotia stock (i.e., animals above the legal size limit of 50 ft) as about 1,500-1,600 animals in 1964, reduced to only about 325 in 1973.

Based on survey data, about 5,000 fin whales were estimated to inhabit northeastern United States continental shelf waters in the spring and summer of 1978-82 (Hain et al. 1992). Ship-board surveys of the northern Gulf of Maine and lower Bay of Fundy in the summers of 1991 and 1992 (designed for harbor porpoise, *Phocoena phocoena*, abundance estimation) resulted in a very imprecise estimate of 2,700 (CV=0.59) fin whales (Waring et al. 1997).

The International Whaling Commission has continued to use Mitchell's (1974) mark-recapture data from 1965-72 for estimating abundance of fin whales in the Nova Scotia/Newfoundland/Labrador area, with no attempt at updating the estimates to take account of possible changes in abundance since 1972 when whaling ended in this area (see IWC 1992: their Table 1). The central estimate was about 11,000, interpreted to refer only to animals longer than 50 ft (the legal minimum length for whaling). This presumably included at least some whales that moved seasonally into U.S. waters. Mitchell (1974) reported shipboard strip survey estimates of 340 fin whales (of all sizes) for the Gulf of St. Lawrence and 2,800 for "the remainder of the Nova Scotian area." Two line-transect aerial survey programs have been conducted in Canadian waters since the early 1970s, giving negatively biased estimates of 79-926 fin whales on the eastern Newfoundland-Labrador shelf, August 1980 (Hay 1982) and a few hundred in the northern and central Gulf of St. Lawrence, August 1995-96 (Kingsley and Reeves, in press).

Estimates of the number of fin whales in West Greenland waters in summer range between about 500 and 2,000 (see Larsen [1995] and IWC [1995] for reviews).

Jonsgård (1974) considered the fin whales off western Norway and the Faroe Islands to "have been considerably depleted in postwar years, probably by overexploitation." The evidence of depletion around Iceland, however, was much less conclusive, and it was suggested that the stock had undergone only a moderate decline since the early 1960s (Rørvik et al. 1976; Rørvik and Sigurjónsson 1981). Large-scale shipboard sighting surveys in the summers of 1987 and 1989 produced estimates in the order of 10,000 to 11,000 fin whales in the northeastern Atlantic between East Greenland and Norway (Buckland et al. 1992b). This compares with an estimate of 6,900 "fully recruited" whales in the East Greenland-Iceland stock in 1976 (including only animals longer than 50 ft) made using CPUE data from the Icelandic whaling industry (Rørvik et al. 1976). The CPUE data were interpreted as indicating a "slight" decrease in the stock size since 1948 (Rørvik et al. 1976).

Recent estimates for the British Isles-Spain-Portugal stock area in summer have ranged from about 7,500 (Goujon et al. 1995) to more than 17,000 (Buckland et al. 1992a). An estimated total of about 56,000 fin whales throughout the North Atlantic in the early 1990's has been cited (Bérubé and Aguilar 1998), based on IWC (1992) and Buckland et al. (1992a, 1992b).

B. North Pacific Fin Whale Population

1. Stocks

The IWC has considered there to be only one stock of fin whales in the main body of the North Pacific even though early work by Fujino (1960), based on blood typing, marking, and morphological data, suggested there were separate stocks (Donovan 1991). A small separate stock in the East China Sea has been generally recognized, and Ohsumi et al. (1971) referred to "Asian" and "American" stocks as management units of some kind. Tag recoveries have established a connection between southern California and the Gulf of Alaska (Rice 1974) and shown considerable movement by fin whales along the Aleutian Islands from near Kamchatka to the Alaskan Peninsula (Nasu 1974).

Mizroch et al. (1984a) discussed five possible stocks, which they called "feeding aggregations": the eastern and western groups that move along the Aleutians (also see Berzin and Rovnin 1966; Nasu 1974), the East China Sea group, a group that moves north and south along the west coast of North America between California and the Gulf of Alaska (cf. Rice 1974), and a group centered in the Sea of Cortez (Gulf of California). The last of these, long thought to be "resident" (Leatherwood et al. 1982), is seasonally augmented by influxes of fin whales from one or more oceanic populations (Tershy et al. 1990; Bérubé et al. in press).

Based on a "conservative management approach," NMFS recognizes three stocks in U.S. Pacific waters: Alaska, California/Washington/Oregon, and Hawaii (Barlow et al. 1997; Hill et al. 1997).

2. Distribution and Habitat Use

Rice (1974) reported that the summer distribution of whales included "immediate offshore waters" throughout the North Pacific from central Baja California to Japan and to as far north as the Chukchi Sea. They occurred in high densities in the northern Gulf of Alaska and southeastern Bering Sea from May to October, with some movement through the Aleutian passes into and out of the Bering Sea (Reeves et al. 1985). Fin whales were observed and taken by Japanese and Soviet whalers off eastern Kamchatka and Cape Navarin, both north and south of the eastern Aleutians, and in the northern Bering and southern Chukchi seas (Berzin and Rovnin 1966; Nasu 1974). They were also taken by whalers off central California during all months of the year (Clapham et al. 1997). In general, however, the numbers reached a peak in late May or early June, then fell off until another influx later in the summer (Rice 1974).

In recent years, fin whales have been observed year round off central and southern California, with peak numbers in summer and fall (Dohl et al. 1983; Barlow 1995; Forney et al. 1995), in summer off Oregon (Green et al. 1992), and in summer and fall in the Gulf of Alaska (including Shelikof Strait) and southeastern Bering Sea (Leatherwood et al. 1986; Brueggeman et al. 1990). Their regular summer occurrence has also been noted in recent years around the Pribilof

Islands in the northern Bering Sea (Baretta and Hunt 1994).

Fin whales have been observed feeding in Hawaiian waters during mid-May (Balcomb 1987; also see Shallenberger 1981), and their sounds have been recorded there during the autumn and winter (Thompson and Friedl 1982; and see Northrop et al. 1968; Shallenberger 1981). Rice (1974) reported that several fin whales tagged in winter (November to January) off southern California were killed in summer (May to July) off central California, Oregon, and British Columbia and in the Gulf of Alaska. A radio-tagged fin whale remained in Prince William Sound for almost the entire month of June and showed a strong preference for a small area within the Sound (Watkins et al. 1981).

Data suggest that, as in the North Atlantic, the migratory behavior of fin whales in the eastern North Pacific is complex: whales can occur in any one season at many different latitudes, perhaps depending on their age or reproductive state as well as their "stock" affinity. Movements can be either inshore-offshore or north-south. Some individuals remain at high latitudes through the winter (Berzin and Rovnin 1966). Japanese marking data suggest some differences in the movements of immature and mature whales, the latter tending to be more strongly migratory in the Aleutians area (Nasu 1974). Fin whale concentrations in the northern North Pacific and Bering Sea generally form along frontal boundaries, or mixing zones between coastal and oceanic waters, which themselves correspond roughly to the 200-m isobath (shelf edge)(Nasu 1974).

Although some fin whales apparently are present in the Gulf of California year round, there is a marked increase in their numbers in the winter and spring (Tershy et al. 1990). Relatively large fin whale concentrations have been observed in the northern Gulf of California (Silber et al. 1994). Their migration into the mid- and lower-Gulf is thought to be related to the high seasonal abundance of krill (Tershy 1992).

3. Feeding and prey selection

In the North Pacific overall, fin whales apparently prefer euphausiids (mainly *Euphausia pacifica*, *Thysanoessa longipes*, *T. spinifera*, and *T. inermis*) and large copepods (mainly *Calanus cristatus*), followed by schooling fish such as herring, walleye pollock (*Theragra chalcogramma*), and capelin (Nemoto 1970; Kawamura 1982).

Fin whales killed off central California in the early twentieth century were described as having either "plankton" (assumed to have been mainly or entirely euphausiids) or "sardines" (assumed to have been anchovies, *Engraulis mordax*) in their stomachs (Clapham et al. 1997). A larger sample of fin whales taken off California in the 1950s and 1960s were feeding mainly on krill (*Euphausia pacifica*), with only about 10% of the individuals having anchovies in their stomachs (Rice 1963).

Fin whales in the Gulf of California prey mainly on zooplankton such as *Nyctiphanes simplex* (Tershy 1992).

4. Competition

The prey species taken by fin whales are also taken by other baleen whales, so competitive interactions are possible and some kind of partitioning must occur. However, as discussed in Section III.A.4, above, there is no evidence of interference competition among the baleen whales.

In the Gulf of California where fin and Bryde's whales are sympatric, the two species apparently specialize on different prey types. Bryde's whales feed mainly on small pelagic fishes while fin whales feed on krill (Tershy 1992).

5. Reproduction

The reproductive biology of fin whales in the North Pacific is assumed to be broadly similar to that of fin whales in the North Atlantic (see Section III.A.5, above). However, Ohsumi's (1986) analysis of age at sexual maturity for a large sample of fin whales killed in the eastern North Pacific from the mid-1950s to 1975 showed a marked decline with time. According to Ohsumi, the average age at attainment of sexual maturity declined from 12 to 6 years in females and from 11 to 4 years in males. This change was interpreted by Ohsumi as a density-dependent response to heavy exploitation of the stock.

6. Natural Mortality

Injury or suffocation from ice entrapment is not known to be a factor in the natural mortality of fin whales in the North Pacific, as it is in the western North Atlantic (see Section III.A.6, above). Although killer whales presumably attack fin whales at least occasionally, there is little evidence of such predation from the North Pacific (e.g., see Tomilin 1967). Shark attack presumably occur on young or sick fin whales, although such events have not been documented.

7. Abundance and trends

The total North Pacific fin whale population before whaling began has been estimated at 42,000-45,000, based on catch data and a population model (Ohsumi and Wada 1974; Omura and Ohsumi 1974). Of this, the "American population" (i.e., the component centered in waters east of 180° longitude) was estimated to be 25,000-27,000. Based on sighting and CPUE data and a population model, the same authors estimated that there were 8,000-11,000 fin whales in the eastern North Pacific in 1973 (Ohsumi and Wada 1974). From a crude analysis of catch statistics and whaling effort, Rice (1974) concluded that the population of fin whales in the eastern North Pacific declined by more than half between 1958 and 1970, from about 20,000 to 9,000 "recruited animals" (i.e., individuals longer than the minimum length limit of 50 ft). Chapman (1976) concluded that the "American stock" had declined to about 38% and the "Asian stock" to 36% below their MSY levels (16,000 and 11,000, respectively) by 1975. As pointed out by Barlow (1994), citing IWC (1989b), CPUE techniques for estimating abundance are not reliable, so the absolute values of the cited abundance estimates should not be taken too seriously.

Ship-board sighting surveys in the summer and autumn of 1991 and 1993 produced an estimate of 933 (CV=0.27) fin whales off California (Barlow and Gerrodette 1996). The minimum estimate for California/Oregon/Washington "stock" is about 750 (Barlow et al. 1997). An increasing trend between 1979/80 and 1993 is suggested by the available survey data, but it is not statistically significant (Barlow et al. 1997).

An aerial survey of the former Akutan whaling grounds around the eastern Aleutians in 1984 produced no sightings of fin whales (Stewart et al. 1987). The absence of sightings in this area of former high abundance (at least 2,500 fin whales were taken on these grounds in 23 years of whaling between 1912 and 1939 (whaling was not conducted for five years during this period); Reeves et al. 1985) was interpreted to mean that the local density of fin whales remained far below those earlier in this century (Stewart et al. 1987). A ship cruise south of the Aleutians in August 1994 also failed to find appreciable numbers of fin whales (Forney and Brownell 1996). It therefore appears that fin whales remain seriously depleted in these northern waters where they were subject to intense whaling, although the paucity of sightings may also be linked to shifts in distribution or incomplete survey coverage. For example, standardized surveys for seabirds near the Pribilof Islands in the Bering Sea indicated a substantial increase in the local abundance of fin whales from 1975-78 to 1987-89 (Baretta and Hunt 1994).

C. North Atlantic Sei Whale Population

1. Stocks

Stock divisions traditionally used by the IWC are based on little evidence (Donovan 1991). The fact that sei whales seem to occur in two main centers of abundance off eastern Canada was used as the primary basis for recognizing two stocks in the northwest Atlantic, one from the southeast coast of Newfoundland northward (Labrador Sea stock) and the other south from Newfoundland (Nova Scotia stock)(Mitchell and Chapman 1977). The very limited evidence from tag-recapture studies was not inconsistent with this two-stock hypothesis (Mitchell and Chapman 1977). A third stock, the Iceland-Denmark Strait stock, was designated in the central North Atlantic essentially to reflect Iceland's shore-based whaling grounds (Donovan 1991). Results of Icelandic sighting surveys, however, have been interpreted as suggesting that the sei whales in Denmark Strait (Irgminger Sea) arrive late in the season from the southwest and thus might belong to the "Labrador Sea stock" (Sigurjónsson et al. 1989, 1991). A preliminary study of genetic variation in sei whales from Icelandic waters indicated that they were more homogeneous than fin whales around Iceland (Daníelsdóttir et al. 1991).

Some evidence supports the idea that the distribution of the "Nova Scotia stock" extends along the U.S. coast to at least North Carolina. Photographic matches showed a connection between sei whales in the southern Gulf of Maine and those on the Scotian Shelf (Schilling et al. 1992). Also, a sei whale stranded alive on Cape Cod and was towed offshore and released in July 1974; this same whale washed ashore dead on the Outer Banks of North Carolina the following April (Mead 1977).

The unpredictability, or irregularity, of the sei whale's appearance in particular feeding areas has frequently been noted (e.g., Ingebrigtsen 1929; Jonsgård and Darling 1977; Martin 1983; Horwood 1987; Schilling et al. 1992). Influxes of sei whales on the whaling grounds in the eastern North Atlantic were sometimes referred to as "invasions" (Andrews 1916). Kapel (1985) reported a correlation between the occasional appearance of sei whales and the incursions of relatively warm waters of the Irminger Current off West Greenland. He provisionally concluded that the sei whales off West Greenland more likely belong to the Iceland-Denmark Strait stock than to the Labrador Sea stock. Some evidence from tag returns indicates that individual sei whales return to the Icelandic whaling grounds in successive (and later) years (Sigurjónsson 1983; Anon. 1984, 1985, 1986, 1987).

2. Distribution and Habitat Use

The total range of sei whales in the North Atlantic extends from southern Europe or northwestern Africa to Norway in the east, and from the southeastern United States to West Greenland in the west (Gambell 1977, 1985a; Horwood 1987). They undertake seasonal north-south movements, wintering at lower latitudes and summering at higher latitudes. Sei whales do not tend to move to high latitudes as do the other balaenopterids, and they also tend not to enter semi-enclosed water bodies such as the Gulf of Mexico, the Gulf of St. Lawrence, Hudson Bay, the North Sea, and the Mediterranean Sea. Throughout their range, sei whales occur predominantly in deep water; typically they are most common over the continental slope (e.g., Mitchell 1975a; CETAP 1982; Martin 1983) or in basins situated between banks (e.g., Sutcliffe and Brodie 1977). An affinity for submarine canyon areas is suggested by a sighting of more than 40 sei whales in a multi-species assemblage over and near Hydrographer Canyon, off Long Island, New York, in April 1980 (Kenney and Winn 1987).

Sei whales are not known to be common anywhere in U.S. Atlantic waters. Sightings are sporadic and usually involve lone individuals (Edds et al. 1984) or small groups of up to six individuals (Schilling et al. 1992). Small numbers have been seen during spring in offshore waters near Georges Bank (mainly the southwestern and eastern portions; Kenney and Winn 1986) and south to perhaps North Carolina (CETAP 1982). The southernmost confirmed records are strandings along the northern Gulf of Mexico and in the Greater Antilles (Mead 1977). Sightings and catch records suggest that sei whales move north along the shelf edge to arrive in the areas of Georges Bank, Northeast Channel, and Browns Bank by mid to late June (Mitchell and Chapman 1977). They are present off the south coast of Newfoundland in August and September, and a southbound "run" moves west and south along the Scotian Shelf from mid-September to mid-November (Mitchell and Chapman 1977). Sei whales in the Labrador Sea as early as the first week of June may move farther northward to waters southwest of Greenland later in the summer (Mitchell and Chapman 1977; also see Anon. 1995).

On Icelandic whaling grounds in Denmark Strait, sei whales were usually not present until mid-July and then remained available through mid-September (Martin 1983). Their migratory routes are poorly known; no tag recoveries in the northeastern Atlantic have been reported.

However, Martin (1983) inferred from the literature that the whales wintered as far south as West Africa and followed the continental slope northward in spring. Judging by catch composition and timing, large females lead the northward migration and reach Denmark Strait earlier and more reliably than other age/sex classes. In some years, males and younger females apparently remain at lower latitudes through the summer months.

Major changes in sei whale distribution and movements in the North Atlantic have been noted. Sei whales were said to have been scarce in the 1960's and early 1970's off northern Norway, where large numbers were taken at the end of the nineteenth century (Jonsgård 1974). They were "plentiful" off western Norway during and after the Second World War but then were rarely observed there during the 1960's. Jonsgård (1974) stated that "[a]lthough this species is known for its irregular appearance, it cannot be denied that its disappearance [off Norway] may be due to overexploitation". A possible alternative explanation is that a "drastic reduction" of copepod stocks in the northeastern Atlantic during the late 1960's caused a change in sei whale distribution (Cattanach et al. 1993).

3. Feeding and Prey Selection

Sei whales in the North Atlantic have been characterized as feeding primarily on calanoid copepods, with a secondary preference for euphausiids (Hjort and Ruud 1929; Mitchell 1975b; Mitchell et al. 1986; Christensen et al. 1992b). Their preference for zooplankton has been shown not only by stomach content analyses, but also by direct observations of feeding behavior (Watkins and Schevill 1979) and examination of feces collected near sei whales in the southern Gulf of Maine (Weinrich et al. 1986; Schilling et al. 1992).

4. Competition

Because it feeds at several different trophic levels (Mitchell 1975b; Nemoto and Kawamura 1977), the sei whale may compete for food resources with a variety of other species, including humans. Its evident preference for copepods means that it could play an important interactive role with other major copepod consumers such as clupeid fishes, basking sharks (*Cetorhinus maximus*), and right whales (*Eubalaena* spp.). It has been suggested that the decline of right whales caused by whaling allowed sei whale populations to increase, in turn impeding the recovery of right whales (Mitchell 1975b). Mitchell et al. (1986) found that sei and right whales were closely sympatric on the Scotian Shelf, especially in Roseway Basin between Browns and Baccaro banks.

After evaluating all available evidence, Clapham and Brownell (1996) concluded that there was no convincing evidence that interspecific competition among baleen whales is affecting population recovery rates. They argued that "... the probable resource partitioning mediated by food preferences or by the biomechanics of body size, the lack of territoriality, and the absence of observations of agonistic interactions, all suggest that such competition is unlikely."

5. Reproduction

The gestation period has been estimated as 10 3/4 months (Lockyer and Martin 1983), 11 1/4 months (Lockyer 1977b), or one year (Risting 1928), depending on which model of fetal growth is selected. In the North Atlantic, most births take place in November/December and conceptions in December/January (Lockyer and Martin 1983). Sei whale calves are probably nursed for six to nine months (Lockyer and Martin 1983), so weaning occurs on the feeding grounds in summer or autumn. The average calving interval is probably at least two years (Jonsgård and Darling 1977; Lockyer and Martin 1983). The mean age at attainment of sexual maturity is thought to be 8-10 years in both sexes (Lockyer and Martin 1983).

6. Natural Mortality

Estimates of natural mortality rate are unavoidably biased by the complete reliance on whaling data. Two independent approaches applied to data from the Southern Ocean gave values in the order of 0.06-0.065 for the natural mortality rates of mature animals of both sexes (Lockyer 1977a). A value of about 0.075 has also been cited (Mizroch et al. 1984b). No estimates of natural mortality rates are available, and little is known about causes of natural mortality, for sei whales in the North Atlantic. Predation by killer whales and sharks, particularly of young or sick individuals, may occur, but such events have not been reported.

7. Abundance and Trends

No estimates of pre-exploitation population size are available for the North Atlantic.

A ship-board sighting survey in 1989 produced an estimate of about 10,200 sei whales in Icelandic and Faroese waters (Cattanach et al. 1993).

Mitchell and Chapman (1977) estimated that during the late 1960s there were about 1,400-2,200 (tag-recapture) or at least 870 (ship-board strip survey) sei whales in the putative Nova Scotia stock and at least 965 (strip survey) in the putative Labrador Sea stock. A very imprecise estimate of about 250 sei whales in spring in continental shelf and shelf-edge waters between North Carolina and Nova Scotia was made in the late 1970s/early 1980s (CETAP 1982; the above-mentioned sighting of 40+ sei whales at Hydrographer Canyon in 1980 was outside the CETAP study area and thus did not contribute to the estimate, *fide* Kenney and Winn 1987). The whales included in this estimate presumably belonged to the putative Nova Scotia stock.

No whaling on sei whales is known to have occurred in the western North Atlantic since 1972, when the Canadian east-coast whaling stations closed, or in the central North Atlantic since 1986, the last year of operation by the whaling station at Iceland. "Aboriginal subsistence" whaling in Greenland for fin whales, which continues under an IWC quota, could result very occasionally in the killing of a sei whale (cf. Kapel 1985).

D. North Pacific Sei Whale Population

1. Stocks

Masaki's (1977) evaluation of tag recoveries, catch distributions, sightings, and baleen morphology led him to propose three North Pacific stocks, divided by longitudes 175° W and 155° W. Tag recoveries in the eastern North Pacific demonstrate movement between waters off central California and Vancouver Island (Rice 1977). Also, sei whales taken off California carried a different species of *Penella* than those taken off Japan (Rice 1977).

2. Distribution and Habitat Use

In the North Pacific as a whole, the sei whale has been said to occur mainly south of the Aleutian Islands (Nasu 1974; Leatherwood et al. 1982) although Japanese sighting records presented by Masaki (1977) indicate concentrations in the northern and western Bering Sea from July through September. These data have never been confirmed and must be considered doubtful, as no other authority has ever reported them in the areas indicated. Horwood's (1987) synoptic evaluation of the Japanese sighting data led him to conclude that sei whales "rarely penetrate deep into the Bering Sea." They are, however, present all across the temperate North Pacific north of 40°N latitude. In the east, they range as far south as Baja California, Mexico, and in the west, to Japan and Korea (Andrews 1916; Horwood 1987).

Sei whales were present during the 1960s off central California mainly in late summer and early fall (Rice 1974). They were also described as abundant off the west coast of Vancouver Island, British Columbia, from June through August (Pike and MacAskie 1969). Their offshore distribution along the continental slope probably explains, at least in part, the infrequency of observations in shelf waters between northern California and Washington. Clapham et al. (1997) suggested that a catch of 25 sei whales in 1926 at Trinidad, California, could have represented a "sudden influx" that year, similar to those described for the North Atlantic (see above). An alternative explanation would be that the whalers switched to sei whales as humpback whales became more scarce in the local whaling areas (Clapham et al. 1997).

The sei whale's tendency not to enter semi-enclosed marginal seas or gulfs, noted above for the North Atlantic, also applies in the North Pacific. They are much rarer than fin and Bryde's whales in the Gulf of California, Mexico (Tershy et al. 1990), although they do occur there occasionally, usually in association with other rorqual species (Gendron and Chávez Rosales 1996). Few enter the Sea of Japan in spite of the very high primary production in portions of this sea (Nemoto and Kawamura 1977).

3. Feeding and Prey Selection

Sei whales are considered to feed at somewhat higher trophic levels in the North Pacific than in the Southern Ocean (Nemoto and Kawamura 1977). In addition to calanoid copepods and

euphausiids, sei whales in the North Pacific are said to prey on "almost every gregarious organism occurring with large biomass," including pelagic squid and fish the size of adult mackerel (Nemoto and Kawamura 1977:84-85; also see Kawamura 1982). Some fish species in their diet are commercially important. Off central California, sei whales fed during the 1960s mainly on anchovies from June through August and on krill (*Euphausia pacifica*) during September and October (Rice 1977; also see Clapham et al. 1997).

4. Competition

In the North Pacific, the trophic interactions of sei whales with other large marine vertebrates are complicated because of the diversity of prey taken by sei whales in this ocean basin (e.g., see Kawamura 1980, 1982). Rice (1977) suggested that the euryphagous character of sei whales in the eastern North Pacific should allow them to take advantage of declines in populations of other mysticete whales by increasing and occupying vacated niches. It could also mean that they are more likely than their North Atlantic counterparts to be affected, and to affect, commercial fisheries for finfish.

5. Reproduction

Rice's (1977) sample of sei whales killed off central California yielded estimates of reproductive parameters that differ somewhat from those reported in Section III.C.5, above, for North Atlantic sei whales. He estimated the gestation period as 12.7 months and the average calving interval as three years. The calving season was judged to last from September to March, and lactation to continue for at least nine months. Rice also found the mean age at sexual maturity to be 10 years.

6. Natural Mortality

Rice (1977) estimated the total annual mortality rate for adult females at 0.088 and adult males at 0.103.

Rice (1977) reported that 7% of the 284 sei whales killed off central California from 1959 to 1970 were afflicted with a disease causing their baleen to be shed and replaced by "an abnormal papilloma-like growth." Although these whales were not emaciated and had fish in their stomachs, Rice speculated that the disease could have caused "significant mortality" in the population.

Rice (1977) also found sei whales taken off California to be heavily infected with endo-parasitic helminths, some of which are pathogenic.

From examinations of whales taken off Japan, Andrews (1916) concluded that sei whales were attacked by killer whales less often than were fin and blue whales on the same grounds.

7. Abundance and Trends

Application of various models to whaling catch and effort data suggests that the total population of adult sei whales in the North Pacific declined from about 42,000 to 8,600 between 1963 and 1974 (Tillman 1977). Since 500-600 sei whales per year were killed off Japan from 1910 to the late 1950s, the stock size presumably was already, by 1963, below its carrying capacity level (Tillman 1977). The catch per unit effort for sei whales in California shore whaling declined by 75% between 1960 and 1970 (Rice 1977), which is consistent with the idea that the overall population was substantially reduced.

Ship surveys of coastal waters off California and Baja California in 1979-80 and 1991 provided no meaningful estimates of sei whale abundance, in part because of the failure to consistently distinguish sei from Bryde's whales (Barlow 1994). Even if it were assumed, however, that all whales logged as "unidentified sei or Bryde's whale" were sei whales, the estimated abundance from these surveys would be very low (several tens to several hundreds).

IV. HUMAN IMPACTS

1. Vessel interactions

a. Collisions with ships

Fin whales are occasionally injured or killed by ship strikes off the U.S. east coast (Waring et al. 1997). The decomposing carcass of a sei whale was found on the bow of a container ship in Boston harbor, suggesting sei whales, too, are killed occasionally by ship strikes (Waring et al. 1997). At least one, and probably more, fin whales were killed by collisions with ships off California in the early 1990s (Barlow et al. 1997). The difficulty of documenting mortalities at sea is discussed under item 2, below.

b. Disturbance from vessels

Fin whales are among the main attractions of whale-watching enterprises in eastern Canada and the northeastern United States (Hoyt 1984; Beach and Weinrich 1989). As a result, they are regularly subjected to close and persistent following by vessels. Sei whales, in contrast, are observed from whale-watching vessels in eastern North America only occasionally (Edds et al. 1984) or in years when exceptional foraging conditions arise (Weinrich et al. 1986; Schilling et al. 1992).

According to Schevill et al. (1964), the fin whale "seems somewhat to avoid ships." In Cape Cod waters, fin whales were notably wary of vessels before the mid-1970s, but since then they have become much less responsive to vessels (Watkins 1986). Edds and Macfarlane (1987) documented that a fin whale observed from an elevated site on the north shore of the St. Lawrence River significantly reduced its mean dive time while it was being pursued by a ferry

carrying whale-watchers. Also in the St. Lawrence, Michaud and Giard (1998) documented short-term changes in dive behavior of fin whales approached by vessels. Fin whales observed from a lighthouse in Maine responded to the presence of vessels by decreasing dive times, surface times, and number of blows per surfacing (Stone et al. 1992). No comparable evidence is available for evaluating the possibility that sei whales experience significant disturbance from vessel traffic.

Fin whales are much less often subject to whale-watching in the eastern North Pacific than in the western North Atlantic. Thus, disturbance in the Pacific, of both fin and sei whales, is more likely to come from the abundant industrial, military, and fishing vessel traffic off the Mexican, U.S., and Canadian coasts than from the deliberate approaches of whale-watching vessels. The low-frequency sounds used by fin whales for communication and (possibly) in courtship displays (Watkins 1981) could be masked or interrupted by loud noise from ships, seismic testing, explosives, and other sources. In a study off Oregon, however, fin whales continued to produce their normal sounds despite the presence of seismic airgun pulses (McDonald et al. 1993).

2. Entrapment and entanglement in fishing gear

Fin whales are killed and injured by inshore fishing gear (e.g., gillnets and lobster lines) off eastern Canada and the United States, but the frequency is probably much lower in proportion to their abundance than it is for humpback, right, and minke whales (Read 1994; Lien 1994; Waring et al. 1997). Fin whales apparently are entangled in inshore fishing gear in the North Pacific only very rarely (Barlow et al. 1994, 1997). Sei whales, because of their offshore distribution and relative scarcity in U.S. Atlantic and Pacific waters, probably have a lower incidence of entrapment and entanglement than fin whales.

Heyning and Lewis (1990) made a crude estimate of about 73 rorquals killed/year in the southern California offshore drift gillnet fishery during the 1980's. Some of these may have been fin whales and some of them sei whales. Some balaenopterids, particularly fin whales, may also be taken in the drift gillnet fisheries for sharks and swordfish along the Pacific coast of Baja California, Mexico (Barlow et al. 1997). Heyning and Lewis (1990) suggested that most whales killed by offshore fishing gear do not drift far enough to strand on beaches or to be detected floating in the nearshore corridor where most whale-watching and other types of boat traffic occur. Thus, the small amount of documentation should not be interpreted to mean that entanglement in fishing gear are insignificant causes of mortality. Observer coverage in the Pacific offshore fisheries has been too low for any confident assessment of species-specific entanglement rates (Barlow et al. 1997). Fin and sei whales may break through or carry away fishing gear. Whales carrying gear may die later, become debilitated or seriously injured, or have normal functions impaired, but with no evidence recorded.

3. Habitat degradation

No major habitat concerns have been identified for fin and sei whales in either the North Atlantic or the North Pacific. However, fishery-caused reductions in prey resources (e.g., herring

and mackerel in the North Atlantic) could have influenced fin whale abundance (Waring et al. 1997).

The sei whale's strong preference for copepods and euphausiids (i.e., low trophic level organisms), at least in the North Atlantic, may make it less susceptible to the bioaccumulation of organochlorine and metal contaminants than, for example, fin, humpback, and minke whales, all of which seem to feed more regularly on fish and euphausiids (see O'Shea and Brownell 1995). Since sei whales off California often feed on pelagic fish as well as invertebrates (Rice 1977), they might accumulate contaminants to a greater degree than do sei whales in the North Atlantic. There is no evidence that levels of organochlorines, organotins, or heavy metals in baleen whales generally (including fin and sei whales) are high enough to cause toxic or other damaging effects (O'Shea and Brownell 1995). It should be emphasized, however, that very little is known about the possible long-term and trans-generational effects of exposure to pollutants.

High-energy, low-frequency underwater sound transmissions, such as those produced during Acoustic Thermometry of Ocean Climate (ATOC) experiments in the North Pacific, have the potential to disturb large whale species. Studies of the responses of several whale species to the ATOC signal at Pioneer Seamount off Half Moon Bay are being concluded. Preliminary analysis shows that whales observed during trials were distributed slightly farther from the source when it was activated compared to when it was not. No other changes in behavior or distribution were observed.

4. Military operations

No evidence is available to indicate that military activities in the North Atlantic have had an impact on fin or sei whales. However, concern about the potential for injury or disturbance to cetaceans influenced the siting and timing of ship-shock trials on the Scotian Shelf in November 1994 (see Reeves and Brown 1994). A monitoring program was undertaken by the Canadian Department of Defence to ensure that whales were clear of the area during the blasting, and no direct effects on fin or sei whales were documented (R. Sears, pers. comm., August 1995). Recent military activities are not known to have had impacts on fin or sei whales in the North Pacific. However, the large scale and diverse nature of such activities in this ocean basin mean that there is always potential for disturbing, injuring, or killing these and other whales.

A study to assess the impact of loud low-frequency active sonar signals by the U.S. Navy is underway. The Navy has completed a three-phase research program as the basis for an Environmental Impact Statement (EIS) on their Low-Frequency Active (LFA) sonar system. Phase I focused on the effects of the LFA signal on foraging blue whales in California, phase II focused on the effects on migrating gray whales off California, and phase III focused on its effects on breeding humpback whales off Hawaii. The EIS planning and writing are underway, and the draft EIS is expected to be completed in late 1998 or early 1999.

5. Hunting

a. Fin Whale: North Atlantic

Some whaling for fin whales occurred in New England waters during the 1880s (Reeves and Barto 1985). Large numbers of fin whales were killed in the western North Atlantic beginning in the late 1890s when whaling stations were established on the coast of Newfoundland (Mitchell 1974). More than 12,500 whales were reported in the Newfoundland-Labrador catch statistics from 1903 to 1972, and this does not include the nearly 1,800 whales listed as taken but not identified to species (Mitchell 1974: his Table 5-5; supplemented by data from Committee for Whaling Statistics 1973). Nearly 400 whales (blue and fin, combined) were taken at whaling stations in the Gulf of St. Lawrence between 1911 and 1915 (Mitchell 1974: his Table 5-7), and an additional 1,564 fin whales were taken off Nova Scotia between 1964 and 1972 (Mitchell 1974: his Table 5-8; supplemented by data from the Committee for Whaling Statistics 1973). Thus, the total number of fin whales taken by modern whaling in eastern Canada is probably close to 15,000.

Fin whales were hunted in Davis Strait by Norwegian and Danish pelagic whalers, beginning in 1919 (or earlier; see Hjort and Ruud 1929) and 1924, respectively (Jonsgard 1977; Kapel 1979). Although this whaling had ended by the late 1950s, fin whales have continued to be taken from Greenlandic fishing vessels equipped with mounted harpoon cannons operating in coastal waters off Greenland (Kapel 1979).

Shore-based commercial whaling for fin whales began in Iceland in 1883 and continued with some interruption through the 1986 season (Hjort and Ruud 1929; Rørvik et al. 1976; Sigurjónnson 1988). Effort was especially intensive during the period 1889-1915, when an estimated 8,100 fin whales were taken at stations on the east and west coasts. From 1916 to 1948 fin whale catches around Iceland were more modest. From 1948 through 1985 the average annual take was 234, with IWC quotas having been introduced in 1977. The total catch of fin whales near Iceland from 1948 through 1986 was 8,963 (Sigurjónnson 1988; IWC 1988). In 1987-89 Iceland took an additional 216 fin whales under a national scientific research permit (IWC 1989a, 1990, 1991). Sigurjónsson (1988) noted that fin whales have long been the preferred target species in Icelandic whaling because of their large yield of high-quality meat.

Fin whales were hunted intensively off northern and western Norway from the earliest days of modern whaling. Between 1868 and 1904, about 10,500 were taken off Finnmark (Christensen et al. 1992a), and they continued to be hunted in this area through 1971 (Jonsgård 1977). Norwegian whalers took more than 8,700 fin whales off the west coast of Norway between 1913 and 1969, and close to 6,000 off the Faroe Islands between 1910 and 1969 (Jonsgård 1977). Large numbers of fin whales were taken off Spain and Portugal during the 1920s and 1930s, and some whaling continued in this region until the mid-1980s (Sanpera and Aguilar 1992).

Fin whales are presently hunted legally in the Northern Hemisphere only in Greenland, where about 20 per year are authorized to be taken under the IWC's procedure for aboriginal

subsistence whaling (Gambell 1993; Caulfield 1993). Meat and other products from whales killed in this hunt are widely marketed within the Greenland economy, but export is illegal. The IWC Scientific Committee has repeatedly expressed concern about the small central estimate and approximate lower confidence interval (1,096, 95% CI, 520-2,106) for this stock (IWC 1998a). In the absence of scientific management advice, the IWC has continued to set a quota of 19 fin whales per year for Greenland (IWC 1998b).

b. Fin Whale: North Pacific

Fin whales were hunted at shore stations in western North America from the early twentieth century. Minimum recorded catches were: 3,000 at Akutan, Alaska, 1912-39, and 464 at Port Hobron, Alaska, 1926-37 (Reeves et al. 1985); well over 6,000 in British Columbia, early 1900s to 1967 (Pike and MacAskie 1969); 602 in Washington, 1911-25 (Scheffer and Slipp 1948); 177 and 1,060 in California, 1919-26 (Clapham et al. 1997) and 1956-70 (Rice 1974), respectively.

Japanese pelagic whaling for fin whales in the Bering Sea and around the Aleutian Islands began in 1954 and continued through 1975 (Ohsumi 1986). A reported total of approximately 46,000 fin whales were killed by commercial whalers in the North Pacific between 1947 and 1987, including the shore-based catches mentioned above as well as Japanese and Russian pelagic catches (Barlow et al. 1997).

Yablokov's (1994) acknowledgment that the Soviet Union engaged in the illegal killing of protected whale species in the North Pacific, both from land stations and in pelagic operations, implies that reported catch data are incomplete.

c. Sei Whale: North Atlantic

Initially because of their apparent elusiveness (cf. Ingebrigtsen 1929; Sigurjónsson 1988), and later because of their comparatively small yield of oil and meat, sei whales were generally not hunted while sufficient stocks of right, blue, fin, and humpback whales were available. They were, however, taken in large numbers off Norway and Scotland from the very beginning of modern whaling in the late nineteenth and early twentieth centuries (Thompson 1928; Brown 1976; Jonsgard 1977). In a single year (1885), more than 700 sei whales were killed off Finnmark, Norway (Andrews 1916). According to Ingebrigtsen (1929), sei whale meat was a popular food in Norway, and it was the value of the meat that made the hunting of this species remunerative in the early part of the twentieth century.

Small numbers of sei whales were taken off Spain, Portugal, and in the Strait of Gibraltar beginning in the 1920's (at least sometimes misidentified as fin whales in the catch statistics; Aguilar and Lens 1981; Aguilar and Sanpera 1982; Sanpera and Aguilar 1992) and by Norwegian and Danish whalers off West Greenland from the 1920s to 1950s (Kapel 1985). In Iceland, a total of 2,574 sei whales were taken from the Hvalfjördur whaling station between 1948 and 1985

(Sigurjónsson 1988). Since the late 1960's or early 1970's, the sei whale has been second only to the fin whale as a preferred target of Icelandic whalers. The demand for high-quality meat has taken precedence over that for sperm whale oil.

A total of 825 sei whales were taken on the Scotian Shelf by whalers operating out of Blandford, Nova Scotia, between 1966 and 1972, and an additional 16 were taken during the same period at Newfoundland shore stations, where the species had also been taken occasionally in earlier whaling episodes (Mitchell 1974; Mitchell and Chapman 1977).

d. Sei Whale: North Pacific

Several hundred sei whales were taken each year by whalers based at shore stations in Japan and Korea between 1910 and the start of World War II (Committee for Whaling Statistics 1942). The species was taken less regularly and in much smaller numbers by pelagic whalers elsewhere in the North Pacific during this period (Committee for Whaling Statistics 1942). Small numbers were taken sporadically at shore stations in British Columbia from the early 1900s until the 1950s, when their importance began to increase (Pike and MacAskie 1969). More than 2,000 were killed in British Columbia waters between 1962 and 1967, when the last whaling station in western Canada closed (Pike and MacAskie 1969). Small numbers were taken by shore whalers in Washington (Scheffer and Slipp 1948) and California (Clapham et al. 1997) in the early twentieth century, and California shore whalers took 386 from 1957 to 1971 (Rice 1977). Heavy exploitation by pelagic whalers began in the early 1960s, with total catches throughout the North Pacific averaging 3,643 per year from 1963 to 1974 (total 43,719; annual range 1,280-6,053; Tillman 1977). The total reported kill of sei whales in the North Pacific by commercial whalers was 61,500 between 1947 and 1987 (Barlow et al. 1997).

V. RECOVERY ACTIONS

Given the essentially similar management and research needs involved, the fin whale and sei whale populations in both the North Atlantic and North Pacific are treated together here, with explicit distinctions made only where appropriate. Unless otherwise indicated, the following summary of conservation efforts and recommended actions applies to both species in both oceans.

The existing moratorium on the commercial hunting of fin and sei whales in most of their range has been in force for more than a decade, and it has almost certainly had a positive effect on the species' recovery. There is currently no legal whaling for fin and sei whales in the Northern Hemisphere, apart from the annual take of about 20 fin whales in Greenland, which is sanctioned and managed under an IWC quota scheme. It must be noted, however, that Iceland has consistently expressed a strong interest in resuming its whaling industry targeting fin, sei, and minke whales (Sigurjónsson 1989). Well-documented "pirate" whaling in the northeastern Atlantic occurred as recently as 1979 (Sanpera and Aguilar 1992; Best 1992), and the illegal shipment and sale of whale meat (including that from baleen whales) have been documented

during the early and mid-1990s in Japan, South Korea, and Taiwan (Chan et al. 1995; Dizon et al. 1995; Baker et al. 1996; Mills et al. 1997). Since the mid-1970s, there has been a strong demand in world markets (most of it presumably centered in Japan) for baleen whale meat (cf. Aguilar and Sanpera 1982). Therefore, it cannot be assumed that Northern Hemisphere fin and sei whales have been fully protected from commercial whaling since 1986, or that their current legal protection from commercial whaling will continue into the future.

A. Goals and Objectives

The overall long-range goal of this Plan is to promote recovery of all fin and sei whale populations to levels at which it becomes appropriate to downlist them from endangered to threatened status, and ultimately to remove them from the list of Endangered and Threatened Wildlife and Plants, under the provisions of the ESA. The Act defines an "endangered species" as "any species which is in danger of extinction throughout all or a significant portion of its range." A "threatened species" is defined as "any species which is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range."

The primary purpose of the Plan is to propose a set of actions that will minimize or eliminate effects from human activities that are detrimental to the recovery of fin and sei whale populations. Immediate objectives are to identify factors that may be limiting population growth, and actions necessary to allow the populations to increase. Although not an explicit goal, one result of the Plan's implementation would be to bring fin and sei whale populations closer to levels that meet the requirements of the MMPA.

Since fin and sei whales move freely across international borders, it is not reasonable to confine recovery efforts to U.S. waters, and this Plan stresses the importance of a multi-national approach to management. The Plan recognizes the limits imposed by the national nature of protective legislation; however, as demonstrated by recent work on humpback whales involving a number of countries (Palsbøll et al. 1997), considerably more information becomes available for management of whale populations when actions are taken based on biological rather than political divisions and through multi-lateral cooperation, which leads to research and conservation at oceanic rather than national levels.

Tasks required to carry out the objectives of this Plan are listed in the step-down outline below.

B. Stepdown Outline

Items in this outline are not in order of priority. Priorities are identified in Appendix A.

1.0 Coordinate State, Federal, and International Efforts to Implement Recovery Actions for Fin and Sei Whales

1.1 Support a continued international ban on commercial hunting and other directed lethal take, and encourage international efforts to detect and prevent illegal whaling.

1.2 Identify, at an appropriate time, representatives of the scientific community, private, state, and federal agencies (and international agencies where applicable) to periodically review and update this Recovery Plan.

1.3 Develop methods for defining "the population level below which aboriginal harvests should not be allowed," as required in Para. 13 in the IWC Schedule of Whaling Regulations.

2.0 Establish Classification Criteria for the Recovery Status of Fin and Sei Whales

3.0 Determine Population Discreteness and Stock Structure of Fin and Sei Whales that Occur in U.S. Waters and Assess their Relationship to Others in the North Atlantic Ocean Basin

3.1 Support existing studies and initiate new studies to investigate population discreteness and stock structure of fin and sei whales using genetic analyses.

3.2 Assess daily and seasonal movements and inter-area exchange using telemetry.

4.0 Estimate Population Size and Monitor Trends in Abundance

4.1 Develop an intensive and geographically broad-scale program to obtain biopsies of fin and sei whales for mark-recapture abundance estimation.

4.2 Conduct surveys to estimate abundance and monitor trends in fin and sei whale populations.

4.3 Maintain existing fin whale photo-identification catalogs, and establish and maintain catalogs for sei whale sightings on an opportunistic, long-term basis.

5.0 Identify and Protect Habitats Essential to the Survival and Recovery of Fin and Sei Whale Populations in U.S. Waters and Elsewhere

5.1 Promote action to protect known areas of importance in U.S. waters.

5.2 Promote action to protect known areas of importance in foreign waters.

5.3 Improve knowledge of fin and sei whale feeding ecology.

5.4 Improve knowledge about the characteristics of important fin and sei whale habitats,

and how fin and sei whales use such areas.

5.5 Identify and protect, as necessary, other habitats essential to the survival and recovery of fin and sei whales.

6.0 Reduce or Eliminate Human-caused Injury and Mortality of Fin and Sei Whales

6.1 Identify areas where concentrations of fin and sei whales coincide with significant levels of maritime traffic, fishing, or pollution.

6.2 Identify and implement measures to reduce ship collisions and gear entanglements with fin and sei whales.

6.3 Conduct studies of environmental pollution that may affect fin and sei whale populations and their prey.

7.0 Maximize Efforts to Acquire Scientific Information from Dead, Stranded, and Entangled or Entrapped Fin and Sei Whales

7.1 Maintain the system for reporting dead, entangled, or entrapped fin and sei whales.

7.2 Improve the existing program to maximize data collected from dead fin and sei whales.

8.0 Determine and Minimize any Detrimental Effects of Directed Vessel Interactions with Fin and Sei Whales

8.1 Investigate the potential effects of whale-watching on fin and sei whales.

8.2 Implement appropriate protective measures on any such activities which may be detrimental to fin or sei whales.

C. Narrative

Data collected through any research outlined in this Plan should be analyzed and reported in a timely manner. Reports should be thoroughly referenced and follow standards of organization to facilitate comparison with other reports. As much as possible, data should be presented in peer-reviewed journals and other open publications to ensure that research programs benefit from regular peer scrutiny.

To the maximum extent possible, data should be collected in such a way that comparisons with historical data are possible. It may be necessary to develop methods of calibrating the results using new or recent techniques with those obtained using more traditional methods. Data analyses

should examine trends over time, and attempts should be made to correlate observed changes with physical, biological, or human-induced changes in the environment.

1.0 Coordinate State, Federal, and International Efforts to Implement Recovery Actions for Fin and Sei Whales

A coordinated approach to the tasks described in this Plan would greatly facilitate their completion. The establishment of a team charged with coordinating state and federal implementation efforts, and with pursuing international cooperative efforts, is highly desirable. Liaison efforts between the team and the lead agency would be the responsibility of a designated individual from the latter body.

1.1 Support a continued international ban on hunting and other directed lethal take and encourage international efforts to detect and prevent illegal whaling.

The international ban on the commercial hunting of the great whales is vital to population recovery. With the possible exception of the central and eastern North Atlantic, there is no area in the Northern Hemisphere where enough is known about the recent and current status of fin and sei whale stocks to justify the resumption of carefully managed exploitation. Even in the case of the central and eastern North Atlantic, great uncertainty remains about stock structure, particularly vis-à-vis the whales occurring seasonally off eastern North America, Greenland, and Iceland. The possibility that fin and sei whales found around Greenland, Iceland, and the Faeroe Islands belong to the same populations as those found off the eastern United States and Canada cannot be ruled out. Thus, any whaling in the central or eastern North Atlantic could directly affect recovery of the stocks in the western North Atlantic.

1.2 Identify, at an appropriate time, representatives of the scientific community, private, state, and federal agencies (and international agencies where applicable) to periodically review and update this Recovery Plan.

As the Plan is implemented, new information will be obtained and the priorities of the Plan will accordingly require periodic review and revision. Representatives of the relevant agencies and the scientific community should be appointed to review and revise the Plan every five years for the first 15 years of implementation, and every ten years thereafter. This schedule would, of course, be subject to change in the event of resumed whaling for fin and sei whales or the occurrence of an environmental catastrophe causing significant fin or blue whale mortality.

1.3 Develop methods for defining "the population level below which aboriginal harvests should not be allowed," as required in Para. 13 in the IWC Schedule of Whaling Regulations.

For a number of years, the IWC and its Scientific Committee have been attempting to develop an appropriate procedure for managing aboriginal subsistence whaling. This work is of

immediate relevance to management of the West Greenland "stock" of fin whales, which is exploited by aboriginal Greenlanders for "subsistence" (i.e., for sale only within the Greenland economy; see Kapel and Petersen 1982; Caulfield 1993). The concern about authorized take levels, repeatedly expressed by the IWC Scientific Committee, can be properly addressed only after the long-awaited revised management procedure for aboriginal subsistence whaling (see Gambell 1993) is in place.

2.0 Establish Classification Criteria for the Recovery Status of Fin and Sei Whales

Generally accepted classification criteria do not exist for these species or other listed large whale species. Development of scientifically defensible classification criteria for any endangered species is an essential part of recovery plan implementation. The ESA requires "objective, measurable criteria, which when met, would result in a determination ... that the species be removed from the List." Even though the biology and behavior of balaenopterine whales (i.e., those in the genus *Balaenoptera*) may be similar in some respects, their feeding habits, geographical distribution, and stock structure are sufficiently different as to require separate algorithms for each species. It is likely that populations of fin and sei whales have differing vulnerabilities and recovery rates. A recent attempt to develop classification criteria for humpback whales (Gerber and DeMaster 1997) demonstrated the importance of knowing a great deal about stock structure and abundance before meaningful application of such criteria is possible. The base of information on fin whales in the North Atlantic comes much nearer to meeting the standard requirements (cf. Gerber and DeMaster 1997) than does the current state of knowledge about North Pacific fin whales or about either North Atlantic or North Pacific sei whales. One or more workshops should be convened to develop criteria for these two species and to assess the adequacy of data for applying any such criteria. Participants should include representatives of relevant agencies, acknowledged experts on fin and sei whales, and individuals with expertise in relevant scientific and statistical fields.

3.0 Determine Population Discreteness and Stock Structure of Fin and Sei Whales that Occur in U.S. Waters and Assess their Relationship to Others in the North Atlantic Ocean Basin

Existing knowledge of the stock structure of fin and sei whales is insufficient, and a more nearly comprehensive understanding is essential for developing strategies to promote recovery and for classifying the stocks according to their recovery status.

3.1 Support existing studies and initiate new studies to investigate population discreteness and stock structure of fin and sei whales throughout the North Atlantic using genetic analyses.

Although fin whales are regularly observed on the continental shelf in U.S. waters, important questions concerning population discreteness and stock structure can only be addressed by reference to materials that include samples obtained in areas outside U.S. coastal waters. In the

case of sei whales, this requirement is even more compelling since they are so infrequently observed in U.S. continental shelf waters. Researchers equipped to sample other whale species (e.g., right and humpback whales) within U.S. waters, but particularly in more remote areas where samples have not previously been obtained (e.g., Oregon, Washington, and Alaska in the Pacific), should be encouraged to take advantage of opportunities to obtain samples from fin and sei whales on an opportunistic basis. Collaborative efforts with foreign (particularly Canadian, Mexican, Greenlandic, and Icelandic) agencies and researchers will probably be necessary to obtain sufficient samples over wide enough areas for conclusive analyses. Standard sampling protocols and analytical procedures should be used. All biopsy samples should be preserved in such a way that the accompanying blubber can be used for contaminant analyses (item 6.3, below). The genetics work should be complemented by a thorough review of existing data from whaling and other sources. This might include investigation of geographical variation in morphology and meristics of fin and sei whales.

3.2 Assess daily and seasonal movements and inter-area exchange using telemetry.

Telemetry studies using satellite-linked and VHF radio tags are needed to investigate patterns and ranges of daily, seasonal, and longer-term movements of individual fin and sei whales. Exchange rates between stocks might also be addressed to some degree by telemetry studies.

4.0 Estimate Population Size and Monitor Trends in Abundance

Recovery of fin and sei whale populations can only be assessed if reliable estimates of abundance are available, and if trends in abundance can be determined. Although abundance estimates are available for both species in portions of their range along both the Atlantic and Pacific coasts, these estimates are generally imprecise and refer to geographic areas rather than to well-founded population units (i.e., populations or stocks). Considering the high mobility and far-ranging habits of sei whales, a multi-national effort at population assessment is clearly necessary if a solid understanding of their status is to be achieved.

4.1 Develop an intensive and geographically broad-scale program to obtain biopsies of fin and sei whales for mark-recapture abundance estimation.

The feasibility of using a genotype-based mark-recapture study to estimate abundance was demonstrated for North Atlantic humpbacks by Palsbøll et al. (1997). This approach uses microsatellite DNA to identify individuals unequivocally - without any of the problems associated with photo-identification. Microsatellite primers have already been developed for fin whales (Bérubé et al. in press), and they could probably easily be optimized for sei whales. Given the likely large sizes of the fin and sei whale populations involved, a great amount of effort will be required to sample on a sufficient scale to generate reasonably precise abundance estimates. Costly, large-scale programs are unavoidable, however, if abundance estimates with acceptable levels of precision are to be obtained.

4.2 Conduct surveys to estimate abundance and monitor trends in fin and sei whale populations.

Systematic surveys should be conducted to assess abundance in areas known, primarily from historic whaling data and large-scale sighting surveys, to have been inhabited regularly by fin and sei whales in the past. The timing of such surveys would be critically important in view of these whales' migratory behavior. For example, surveys of sei whales in the shelf-edge region off the mid-Atlantic states and New England should take place in spring, those off the U.S. west coast probably in late summer and early autumn. For meaningful estimates of entire populations off either coast, it will be necessary for U.S. scientists to promote and participate in cooperative surveys with scientists in Mexican, Canadian, Greenlandic, and Icelandic waters. Findings from stock structure studies identified in item 3.0, above, will be useful in interpreting survey results. Because of the relatively long generation times of fin and sei whales, and the time scales on which environmental factors affecting their distribution may operate, programs to monitor trends in their populations must involve long-term commitments.

4.3 Maintain existing fin whale photo-identification catalogs and establish and maintain catalogs for sei whale sightings on an opportunistic, long-term basis.

The existing photo-identification catalogs for fin whales at the College of the Atlantic (Agler 1992; Agler et al. 1990) and elsewhere should be maintained. The scientific importance of such catalogs has been demonstrated with numerous species, and the possibilities for obtaining insights relevant to management increase with time.

The sei whale is one of the few baleen whale species for which a substantial effort at photo-identification has yet to be made. Useful information was gained by the *ad hoc* efforts of scientists, working in close collaboration with whale-watching vessel operators, to photo-identify individual sei whales during an unusual influx in the Gulf of Maine in summer 1986 (Weinrich et al. 1986; Schilling et al. 1992). High-quality photographs should be taken of all sei whales encountered opportunistically during research and whale-watch cruises in U.S. waters.

It should be noted, however, that mark-recapture models for abundance estimation, using photo-identification as the marking and recapture method, will be more difficult to apply to fin and sei whales than to humpback whales. There are two main reasons: (a) variation in natural markings in fin (and presumably sei) whales is not nearly as great (or as obvious) as in some other species (e.g., humpback, right, and blue whales), and matching is therefore difficult and sometimes equivocal; and (b) many researchers who have worked with fin whales believe that the population contains significant numbers of unmarked animals, i.e., whales which have so few markings that they are effectively unrecognizable from one encounter to the next (P.J. Clapham, pers. comm.). From the standpoint of mark-recapture statistics, this creates the problem of potential false positives (two individuals wrongly identified as one animal), which is a much more serious source of bias than false negatives (an individual observed repeatedly but not matched) (see Gunnlaugsson and Sigurjónsson 1990).

5.0 Identify and Protect Habitats Essential to the Survival and Recovery of Fin and Sei Whale Populations in U.S. Waters and Elsewhere

Some areas are known to represent important habitats for fin and sei whales; others may be discovered during survey work discussed in items 3.0 and 4.0, above. Protection of such areas is essential to the full recovery of fin and sei whale populations.

5.1 Promote action to protect known areas of importance in U.S. waters.

These areas are well defined on both the Atlantic and Pacific coasts from past survey work. There is considerable overlap in the distributions of fin and sei whales with those of other cetacean species listed as "endangered" - blue, fin, sperm, and right whales. Such overlap should enhance the feasibility of using carefully-planned management measures to provide meaningful protection to several species at once.

5.2 Promote action to protect known areas of importance in foreign waters.

Efforts should be made to encourage the governments of Canada, Mexico, Greenland, Iceland, and perhaps other countries to protect fin and sei whale habitat within their national borders, and to join multi-national efforts on behalf of marine habitat protection.

5.3 Improve knowledge of fin and sei whale feeding ecology.

Studies designed to improve knowledge of fin and sei whale prey preferences, dietary requirements, and energetics will be important to understanding both habitat use and recovery potential. Sei whale heavy reliance on copepods in the North Atlantic means that its movements are often correlated with those of right whales. The sei whale's trophic position is complex and may differ in important ways between the North Atlantic and North Pacific basins or between regions or on smaller scales. Consumption of fin-fish by sei whales in Californian waters and by fin whales in many areas means that they could interact in important ways with commercial fisheries, in addition to being affected by shifts in prey abundance and distribution caused by climatic fluctuations.

5.4 Improve knowledge about the characteristics of important fin and sei whale habitats, and how these whales use such areas.

Characterization of habitats that are intensively used by fin and sei whales, or alternatively are used infrequently or for short periods but for purposes linked to population fitness, is essential. Only with information on the ecological needs of the species will managers be able to provide necessary protection. Such characterization would include prey types, densities, and abundances along with the associated oceanographic and hydrographic features. Studies to determine inter-annual variability in habitat characteristics, and in fin and sei whale habitat use, are

an important component of such work. Ultimately, the goal should be to develop a predictive framework for identifying potentially important fin and sei whale habitats.

5.5 Identify and protect, as necessary, other habitats essential to the survival and recovery of fin and sei whales.

The identification of other habitats would be accomplished using information gained from studies conducted under item 3.4 (above).

6.0 Reduce or Eliminate Human-caused Injury and Mortality of Fin and Sei Whales

Known or suspected types of anthropogenic mortality in fin and sei whales include vessel strikes and entanglement or entrapment in fishing gear. Studies of the circumstances leading to collisions with ships and fishing gear are required before measures can be developed and implemented to reduce the frequency of these harmful interactions.

6.1 Identify areas where concentrations of fin and sei whales coincide with significant levels of maritime traffic, fishing, or pollution.

Research on the frequency with which shipping-related and fishery-related mortality or injury occurs is desirable, although it must be acknowledged that present evidence does not indicate that such mortality and injury are affecting recovery of fin and sei whale populations. Given the offshore distribution of sei whales (and some fin whales), geographical expansion of existing observational effort would probably be required to achieve a comprehensive understanding of the frequency of ship strikes and entanglements. Studies to quantify the volume and type of ship traffic, fisheries, and pollution sources in areas known to be important to fin and sei whales might provide a useful perspective on the potential seriousness of the problem.

6.2 Identify and implement methods to reduce ship collisions and gear entanglements with fin and sei whales.

If research suggests that ship-strike mortalities and (or) entanglements and entrapments in fishing gear represent a serious threat to the recovery of fin and sei whales, actions should be taken to reduce the incidence of such events. This will require an evaluation of the practicality and effectiveness of various options.

6.3 Conduct studies of environmental pollution that may affect fin and sei whale populations and their habitats.

In general, baleen whales (including fin and sei whales) have lower contaminant levels in their tissues than toothed whales. However, nothing is known about the effects of pollutants on baleen whales, notably regarding long-term impacts, trans-generational effects, and impacts on prey resources. Studies should be conducted to improve knowledge of these topics, and to

examine related issues such as metabolic pathways and the effects of sex, age, reproductive condition, and geographic origin on contaminant burdens. Biopsy samples collected under item 3.1, above, will be usable for much of this work. Studies should also be conducted on the impact on fin and sei whales, or on their habitats, of point-source and other types of pollution, including low-frequency noise.

7.0 Maximize Efforts to Acquire Scientific Information from Dead, Stranded, and Entangled or Entrapped Fin and Sei Whales

Assessment of the causes and frequency of mortality (either natural or human-caused) is important to understanding fin and sei whale population dynamics and the threats that may impede the recovery of their populations. However, discovery of a carcass under circumstances allowing it to be examined in a timely and rigorous manner is a relatively rare event. Accordingly, the efficiency of efforts to detect and investigate fin and sei whale mortalities should be maximized. Strandings or entanglements of live individuals are even more rare, but improved reporting might provide opportunities for rescue attempts.

7.1 Maintain the system for reporting dead, entangled, or entrapped fin and sei whales.

The detection and reporting of dead fin and sei whales, whether stranded or floating at sea, need to be encouraged in every way possible. The Large Whale Recovery Program coordinator and the National Marine Mammal Stranding Network coordinator should continue working with representatives of local, state, and federal agencies, private organizations, academic institutions, and regional and national stranding networks to ensure efficiency in detecting, reporting, and investigating strandings and to facilitate information exchange.

7.2 Improve the existing program to maximize data collected from dead fin and sei whales.

Each fin or sei whale carcass represents an opportunity for scientific investigation of the cause of death, as well as addressing other questions related to the biology of the species. Delays in attempts to secure or examine a carcass can result in the loss of valuable data, or even of the carcass itself. The Stranding Network coordinator should work with appropriate agencies, organizations, and individuals to ensure that, when a fin or sei whale carcass is reported and secured: (i) a necropsy is performed as rapidly and as thoroughly as possible by qualified individuals selected to gather information regarding the cause of death; (ii) samples are taken and properly preserved for studies of genetics, toxicology, and pathology; and (iii) funding is available to notify and transport appropriate experts to the site rapidly and to distribute tissue samples to appropriate locations for analysis or storage. In addition, the coordinator should work with stranding networks and the scientific community to develop and maintain lists of tissue samples requested by qualified individuals and agencies, and ensure that these samples are collected routinely from each carcass and stored in appropriate locations or distributed to appropriate researchers.

8.0 Determine and Minimize Any Detrimental Effects of Directed Vessel Interactions with Fin and Sei Whales

There is a potential for interactions of fin and sei whales with whale-watching or research vessels. Fin whales are regularly encountered by whale-watching vessels along the east coast of North America, while sei whales are rarely encountered along either coast.

8.1 Investigate the potential effects of whale-watching on fin and sei whales.

For conclusive results, any study to determine the responses of fin and sei whales to approaches by boats or aircraft must be carefully designed and include controls. It seems unlikely, at present, that whale-watching activities are limiting the recovery of either species, although in several local areas (e.g., the Gulf of Maine, the St. Lawrence River) there is evidence for at least short-term behavioral responses by fin whales to whale-watching vessels.

8.2 Implement appropriate protective measures on any such activities which may be detrimental to fin or sei whales.

If studies of the kind mentioned in item 8.1, above, were to suggest that certain types or frequencies of vessel or aircraft approach had adverse effects on fin or sei whales, appropriate regulations should be developed and implemented to minimize or eliminate such conflicts.

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APPENDIX A

Fin and Sei Whale Recovery Plan Implementation Schedule and Cost Estimates

An implementation schedule is used to direct and monitor implementation and completion of recovery tasks. Priorities in column 3 of the following implementation schedule are assigned as follows:

Priority 1 - An action that must be taken to prevent extinction or to identify those actions necessary to prevent extinction.

Priority 2 - An action that must be taken to prevent a significant decline in population numbers or habitat quality, or to prevent other significant negative impacts short of extinction.

Priority 3 - All other actions necessary to provide for full recovery of the species.

This implementation schedule prioritizes individual tasks to emphasize their importance in the recovery effort. The priority system and the criteria for each priority is based on the established NMFS policy (55 FR 24296). It should be noted that even the highest priority tasks within a plan are not given a Priority 1 ranking unless they are actions necessary to prevent extinction. Therefore, some plans will have no Priority 1 tasks. In general, Priority 1 tasks only apply to a species facing a high magnitude of threat. This allows NMFS to set priorities for allocation of available resources among different recovery plans.

Funding is estimated according to the number of years necessary to complete the task once implementation has begun. The provision of cost estimates is not meant to imply that appropriate levels of funding will necessarily be available for all blue whale recovery tasks. Also, identification of cost estimates does not assign responsibility for providing support to NMFS or any other agency or group. The costs associated with the various recovery tasks listed below are for those to be implemented in U.S. waters only. Costs associated with promotion of international action have not been estimated.

Appendix A. Fin and Sei Whale Recovery Plan Implementation Schedule.

PLAN TASK	Priority	Task Duration	Fiscal Year Costs (thousands of $)				
			FY 1	FY 2	FY 3	FY 4	FY 5
1.0 COORDINATE STATE, FEDERAL, AND INTERNATIONAL EFFORTS TO IMPLEMENT RECOVERY ACTIONS FOR FIN AND SEI WHALES							
1.1 Support a continued international ban on commercial hunting and other directed lethal take, and encourage international efforts to detect and prevent illegal whaling	1	ongoing	*				
1.2 Identify representatives of the scientific community, private, state, and federal agencies (and international agencies where applicable) to periodically review and update this Recovery Plan	3	2 years	*		15		15
1.3 Develop methods for defining "the population level below which aboriginal harvests should not be allowed" as required in Para. 13 in the IWC Schedule of Whaling Regulations	2	2 years				15	10
2.0. ESTABLISH CLASSIFICATION CRITERIA FOR THE RECOVERY STATUS OF FIN AND SEI WHALES	2	2 years			25	25	
3.0 DETERMINE POPULATION DISCRETENESS AND STOCK STRUCTURE OF FIN AND SEI WHALES THAT OCCUR IN U.S. WATERS AND ASSESS THEIR RELATIONSHIP TO OTHERS IN THE NORTH ATLANTIC OCEAN BASIN							
PLAN TASK			Fiscal Year Costs				

Appendix A. Fin and Sei Whale Recovery Plan Implementation Schedule.

	Priority	Task Duration	(thousands of $)				
			FY 1	FY 2	FY 3	FY 4	FY 5
3.1 Support existing studies and initiate new studies to investigate population discreteness and stock structure of fin and sei whales using genetic analyses	2	5 years	15	15	10	10	5
3.2 Assess daily and seasonal movements and inter-area exchange using telemetry	2	3 years	50	50	50		
4.0 ESTIMATE POPULATION SIZE AND MONITOR TRENDS IN ABUNDANCE							
4.1 Develop an intensive and geographically broad-scale program to obtain biopsies of fin and sei whales for mark-recapture abundance estimation	2	5 years	15	15	15	10	10
4.3 Maintain existing fin whale photo-identification catalogs, and establish and maintain catalogs for sei whale sightings on an opportunistic, long-term basis	3	ongoing	40	40	30	30	30
4.2 Conduct surveys to estimate abundance and monitor trends in fin and sei whale populations	2	5 years	80	80			80

Appendix A. Fin and Sei Whale Recovery Plan Implementation Schedule.

PLAN TASK	Priority	Task Duration	Fiscal Year Costs (thousands of $)				
			FY 1	FY 2	FY 3	FY 4	FY 5
5.0. IDENTIFY AND PROTECT HABITATS ESSENTIAL TO THE SURVIVAL AND RECOVERY OF FIN AND SEI WHALE POPULATIONS IN U.S. WATERS AND ELSEWHERE							
5.1 Promote action to protect known areas of importance in U.S. waters	2	ongoing	*				
5.2 Promote action to protect known areas of importance in foreign waters	3	ongoing	*				
5.3 Improve knowledge of fin and sei whale feeding ecology	3	2 years	65	65			
5.4 Improve knowledge about the characteristics of important fin and sei whale habitats, and how fin and sei whales use such areas	3	1 year	60				
5.5 Identify and protect, as necessary, other habitats essential to the survival and recovery of fin and sei whales	3	ongoing	*				

Appendix A. Fin and Sei Whale Recovery Plan Implementation Schedule.

PLAN TASK	Priority	Task Duration	Fiscal Year Costs (thousands of $)				
			FY 1	FY 2	FY 3	FY 4	FY 5
6.0. REDUCE OR ELIMINATE HUMAN-CAUSED INJURY AND MORTALITY OF FIN AND SEI WHALES							
6.1 Identify areas where concentrations of fin and sei whales coincide with significant levels of maritime traffic, fishing, or pollution	2	2 years		30	30		
6.2 Identify and implement measures to reduce ship collisions and gear entanglements with fin and sei whales	2	ongoing	*				
6.3. Conduct studies of environmental pollution that may affect fin and sei whale populations and their prey	2	2 years	*	20	20		
7.0. MAXIMIZE EFFORTS TO ACQUIRE SCIENTIFIC INFORMATION FROM DEAD, STRANDED, AND ENTANGLED OR ENTRAPPED FIN AND SEI WHALES							
7.2 Improve the existing program to maximize data collected from dead fin and sei whales	2	2 years	*				
7.1 Maintain the system for reporting dead, entangled, or entrapped fin and sei whales	2	2 years	10	10			
8.0. DETERMINE AND MINIMIZE ANY DETRIMENTAL EFFECTS OF DIRECTED VESSEL INTERACTIONS WITH FIN AND SEI WHALES							

Appendix A. Fin and Sei Whale Recovery Plan Implementation Schedule.

8.1 Investigate the potential effects of whale-watching on fin and sei whales	3	1 year	20				
8.2 Implement appropriate protective measures on any such activities which may be detrimental to fin or sei whales	3	ongoing	*				

* No direct costs associated with this task.