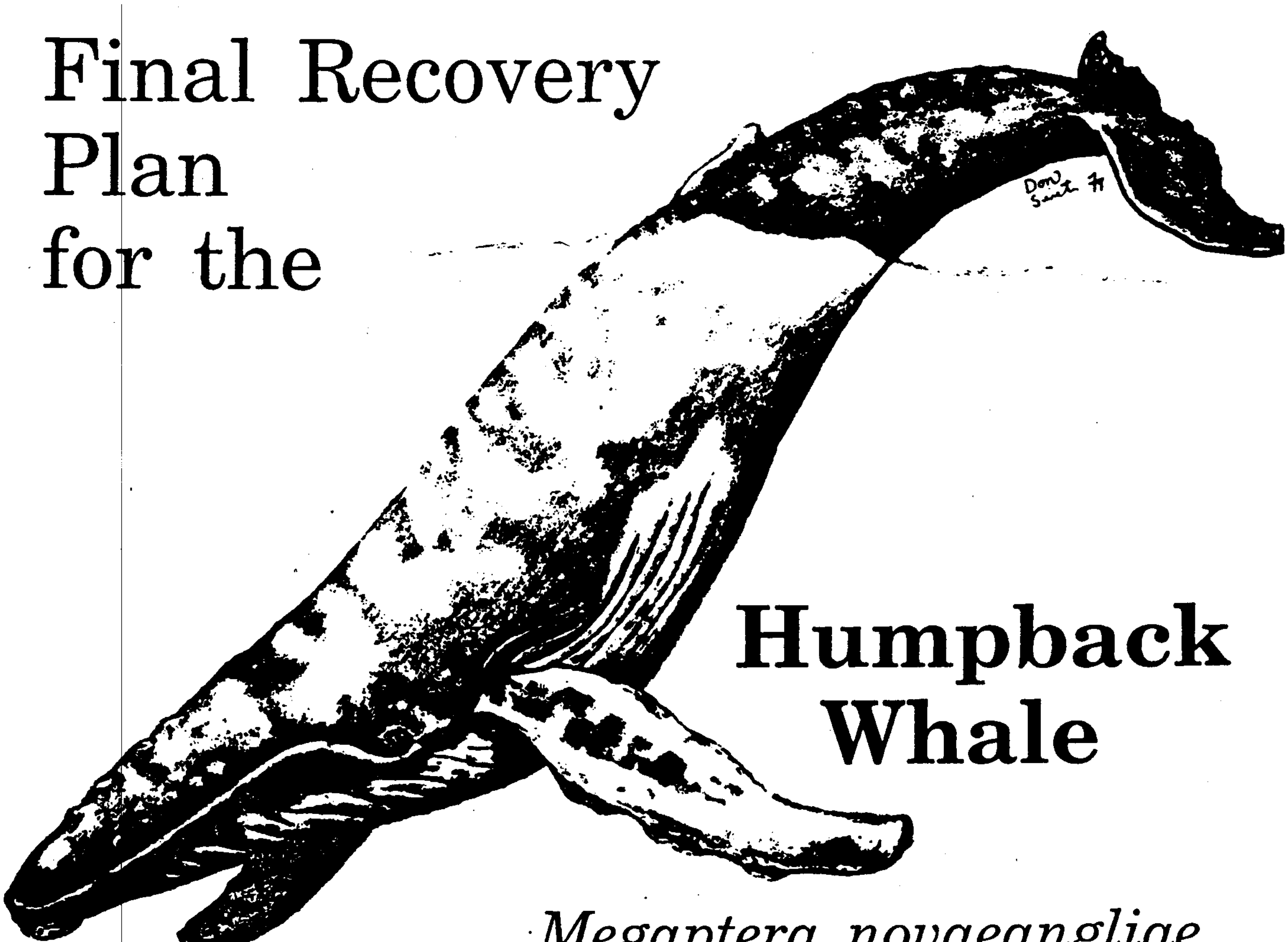
Final Recovery Plan for the



Humpback Whale

Megaptera novaeangliae

November 1991

U.S. Department of Commerce

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Office of Protected Resources

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FINAL RECOVERY PLAN FOR THE

HUMPBACK WHALE

(MEGAPTERA NOVAEANGLIAE)

NOVEMBER 1991

PREPARED BY THE

HUMPBACK WHALE RECOVERY TEAM

APPROVED: ______________________________

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Disclaimer

This Recovery Plan for the Humpback Whale has been approved by the National Marine Fisheries Service. It does not necessarily represent official positions or approvals of cooperating agencies. It does not necessarily represent the views of all individuals involved in the plan formulation. The plan has been prepared by the Humpback Whale Recovery Team to delineate reasonable actions believed required to lead to the recovery of the humpback whale. This plan is subject to modification as dictated by new findings, changes in species status and completion of tasks described in the plan. Goals and objectives will be attained and funds expended contingent upon appropriations, priorities and other constraints.

Literature Citations should read as follows:

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Preface

Congress passed the Endangered Species Act (ESA) of 1973, (16 USC 1531 *et seq.*, amended 1978, 1982, 1986, 1988) to protect species of plants and animals threatened with extinction. The National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (FWS) share responsibility for administration of the ESA. NMFS is responsible for most marine mammal species. The ESA requires Federal agencies to use all reasonable methods available to conserve endangered and threatened species, including planning and actions to prevent further decline of the species, to facilitate an increase in its population and to improve the quality of its habitat.

Section 4(f) of the ESA directs the responsible agency to develop and implement a Recovery Plan, if it is determined that such a plan will promote conservation of the species. NMFS has determined that a National Recovery Plan (Plan) would promote conservation of the humpback whale, *Megaptera novaeangliae*.

This Plan was written by the Humpback Whale Recovery Team at the request of the Assistant Administrator for Fisheries of the National Oceanic and Atmospheric Administration (NOAA) to promote the conservation of humpback whales as provided in the 1978 amendments to the ESA. The recovery team includes experts on marine mammals from the private sector, academia, and government (Appendix A). This Plan concentrates primarily on populations of humpback whales believed to occur seasonally or permanently in the U.S. territorial waters of the North Atlantic and North Pacific Oceans. It summarizes current information on humpback whales, identifies problems that may interfere with recovery, and recommends research or management actions to restore and maintain the humpback whale as a viable member of the ecosystem.

The Plan is organized into five major sections. Following a review of **Natural History,** it provides details on populations in the **North Atlantic Ocean** and the **North Pacific Ocean**. A discussion of **Known and Potential Impacts** to the species and its habitat(s) is followed by **Recommended Recovery Actions.** Six **Appendices** (A-F) highlight valuable information that might otherwise clutter the text.

The processes and actions described in this Plan are dynamic. Habitats, population sizes and other factors will change over time, so this Plan will require updating as new information becomes available. Recovery efforts may be modified, reduced or ended at any point during the planning process as new information becomes available or if there is sufficient evidence to indicate that protection under the ESA is no longer necessary.

Executive Summary

The humpback whale, *Megaptera novaeangliae*, is classified as an endangered species and the Assistant Administrator for Fisheries has determined that a Recovery Plan (Plan) would help this species to increase in abundance. This Plan first reviews the natural history of the humpback whale, concentrating particularly on those reproductive stocks or feeding aggregations which regularly spend portions of the year in waters under the jurisdiction of the United States. Following a summary of existing and potential threats to this species, the Plan sets out a series of recommended goals and actions for (1) maintaining and enhancing the habitats of humpback whales; (2) identifying and reducing death, injury or disturbance to the whales caused by humans; (3) performing research to evaluate progress toward recovery goals; and (4) implementing the Plan through improved administration and coordination.

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**"Despite a century of propaganda,
conservation still proceeds at a snail's pace;
progress still consists largely of
letterhead pieties and convention oratory."**

Aldo Leopold (1949)

I. INTRODUCTION

The humpback whale, *Megaptera novaeangliae* (Borowski 1781), occurs in all oceans of the world, although less commonly in Arctic regions. Throughout its range, it was heavily exploited by commercial whalers until the middle of this century. The species first received protection in the North Atlantic in 1955 when the International Whaling Commission (IWC) placed a prohibition on non-subsistence hunting by member nations. Protection was extended to the North Pacific and Southern Hemisphere populations after the 1965 hunting season. The humpback was classified as an endangered species when the U.S. Endangered Species Act was passed in 1973, and it remains so today.

The status of humpback whales was recently evaluated by Whitehead (1987) for the Canadian government's Committee on Status of Endangered Wildlife in Canada (COSEWIC). The COSEWIC Review Committee is equivalent to the U.S. Recovery Team and that document is the Canadian equivalent to this Plan.

As a species, humpback whales are probably the fourth most numerically depleted large cetacean worldwide, trailing the northern right whale, *Eubalaena glacialis*; blue whale, *Balaenoptera musculus*; and bowhead whale, *Balaena mysticetus*. Prior to commercial whaling, the worldwide population is thought to have been in excess of 125,000. American whalers alone killed 14,164-18,212 humpbacks between 1805-1909 (Best 1987) and the total North Pacific kill was estimated to be about 28,000 (Rice 1978). Today perhaps no more than about 10,000 to 12,000 exist (Braham 1984), about 10% of the estimated initial numbers.

GOALS AND OBJECTIVES

The creation of goals for a Recovery Plan must be balanced by the development of criteria for measuring their achievement. Simply put, it is necessary to establish ways to judge whether a population is recovering or has recovered. The intent of this Plan is to assist humpback whale populations to grow and to reoccupy areas where they were historically found. Verification of growth rate will require new research described in Section VI of this Plan.

While some of us might like to encourage humpback whale populations to reach the equilibrium carrying capacities that prevailed before commercial hunting, such a goal may not be feasible. For better or worse, humans have claimed an increasing share of the habitat and resources once available to humpbacks and other species. Humpback whales have no alternative but to share the oceans with humans and exist in lower numbers. In contrast, it is only through force of law that humans must share the oceans with humpback whales. The actions recommended in this Plan attempt to guarantee that we share enough resources that humpback whale populations increase to levels specified below.

The Recovery Team has found it useful to describe three types of goals for this Plan. Of fundamental importance is the "biological goal" of building and maintaining populations large enough to be resilient to chance events such as episodic changes in oceanographic conditions, epizootics, anthropogenic environmental catastrophes or inbreeding. The "numerical goal" is an attempt to choose desirable population sizes consonant both with the biological goal and with continuing human use of the oceans. Our long-term numerical goal is to achieve population sizes equal to at least 60% of the historical environmental carrying capacity for those populations in each of the North Atlantic and North Pacific Oceans that contain whales which enter waters under U.S. jurisdiction. That percentage was chosen because populations of large mammals are thought to be maximally productive at between 60% and 80% of their environmental carrying capacity (Fowler and Smith 1981; Fowler 1984). That target is also consistent with management goals of the Marine Mammal Protection Act of 1972 (MMPA), as amended. Finally, there is the "political goal" of being able to change the classification of particular stocks of humpback whales from "endangered" to "threatened" (called "down-listing"), or of removing them from the list of protected species ("delisting") (see Section VI, Task 4.9).

Unfortunately, these goals are difficult to fulfill. The biological goal is vexing, because future changes in resource abundance or environmental conditions cannot be predicted accurately, so one can never be absolutely certain that populations are large enough to rebound. The numerical goal is difficult to evaluate, because estimates of present and past abundance and historical carrying capacity are uncertain, and in some instances unknown. We do not yet know exactly which numbers should be multiplied by 60% to produce a long-term population goal. Tasks recommended in this Plan will attempt to rectify this deficiency. Finally, the political goal is problematic, because different constituencies are likely to disagree about costs, benefits and desirability of different levels of protection. This Plan recommends timely development and agreement on criteria for making such decisions.

In the meantime, this Plan recommends adoption of an interim goal that populations double in size during the next 20 years. It will be important to reach early agreement on the indices used to track population status over the long term. The Atlantic and Pacific Oceans each contain several relatively distinct populations of humpback whales. Each differs somewhat in past and present histories of hunting and in ecological or environmental factors. Each population will therefore have somewhat different management requirements. Different populations may require different periods of time to double in size, but reaching that milestone within two decades will be evidence of meaningful progress. Tasks recommended in this Plan provide for periodic assessment of populations. Data showing (1) statistically significant trends of population increase as determined by accepted analytical methods and (2) statistically significant trends of population increase in portions of the range known to have been occupied in historical times will be evidence of continuing satisfactory progress.

This Plan summarizes our understanding of the status of those humpback whale populations wholly or partly under U.S. jurisdiction. It recommends management activities to assist those and other populations to increase in numbers; and research activities to measure rates of population change. It emphasizes two major ways to achieve population growth: (1) protection of habitats and (2) reduction of human activities that interfere with annual life cycle processes. Activities to educate the public about aspects of this Plan are included. The Plan recognizes that many years of protection may be necessary before some humpback whale populations achieve the "60%" population milestone.

In summary, the long-term numerical goal of the Plan is to increase humpback whale populations to at least 60% of the number existing before commercial exploitation or of current environmental carrying capacity. Those levels remain to be determined. In the meantime, the interim goal is a doubling of extant populations within the next 20 years. Acceptable evidence of ongoing population recovery will be data showing (1) statistically significant trends of population increase as determined by accepted analytical methods, and (2) statistically significant trends of population increase in portions of the range known to have been occupied in historical times.

The Major Objectives by which this Plan seeks to accomplish that Goal are to: (1) Maintain and enhance habitat; (2) Reduce human-related mortality, injury and disturbance; (3) Measure and monitor key population parameters; and (4) Promote coordinated administration and implementation of this Plan. Specific recommended tasks are organized in Section VI and Appendix A.

Construction of the Plan has entailed review of hundreds of published and unpublished documents concerning humpback whales. Whenever possible, citations were drawn from recent, peer-reviewed scientific publications, but the Recovery Team is aware that many of the citations included in this Plan were drawn from literature that has not been formally published. Such references include reports to Federal or state agencies, abstracts or work presented at scientific meetings, personal communications (cited as pers. comm.; see also Appendix C) and manuscripts in preparation. Since such information has not been subjected to peer review, it should be interpreted with some degree of caution. Nevertheless, those references form a sufficiently rich source of information to require their inclusion in this Plan. An annotated bibliography of 390 publications on humpback whales from 1864-1980 is available (Bird 1983).

II. NATURAL HISTORY

A. Species Description and Taxonomy

Humpback whales are distinguished from other whales in the same Family (Balaenopteridae) by extraordinarily long flippers (up to 5 m or about 1/3 total body length), a more robust body, fewer throat grooves (14-35), more variable dorsal fin, and utilization of very long (up to 30 min.), complex, repetitive vocalizations (songs) (Payne and McVay 1971) during courtship. Their grayish-black baleen plates, approximately 270 to 440 on each side of the jaw, are intermediate in length (65-70 cm) to those of other baleen whales. Humpbacks in different geographical areas vary somewhat in body length, but maximum recorded size is 18 m (Winn and Reichley 1985). Mean length at physical maturity for humpbacks killed off California was 14.5 m (females) and 13.5 m (males) (National Marine Mammal Laboratory, unpublished data). A 14 m female weighing 43.9 metric tons was the heaviest humpback measured by Nishiwaki (1959) in the North Pacific.

The whales are generally dark on the back, but the flippers, sides and ventral surface of the body and flukes may have substantial areas of natural white pigmentation plus acquired scars (white or black). White coloration on the flippers may be used to startle and herd schools of fish (Brodie 1977). Researchers distinguish individual humpbacks by the apparently unique black and white patterns on the underside of the flukes as well as other individually variable features (Katona and Whitehead 1981; Glockner and Venus 1983; Kaufman *et al.* 1987).

B. Zoogeography

The humpback whale is distributed worldwide (Fig. 1) in all ocean basins, though it is less common in Arctic waters. In winter, most humpbacks occur in temperate and tropical waters of both hemispheres (10°-23° latitude). In summer, most are in waters of high biological productivity, usually in the higher latitudes (35°-65° latitude). The timing of key biological functions, such as migrations and reproduction, is tied to seasonal progression; these functions are therefore about 6 months out of phase between whales in the Northern and Southern Hemispheres (Winn and Reichley 1985).

Even though our knowledge is still fragmentary and geographically uneven concerning the identity, movements and habitat use of apparently reproductively isolated sub-populations ("stocks"), a general picture of humpback zoogeography is emerging. Some aspects of seasonal movements and distributions can be expected to change as the numbers of whales change.

Humpback whales are generally considered to inhabit waters over continental shelves, along their edges and around some oceanic islands (Balcomb and Nichols 1978; Whitehead 1987). They winter in warm waters at a small number of relatively specific locations. They probably mate and give birth while on the wintering areas, but reproductive events may also take place during migration. It is thought that little feeding occurs on the wintering grounds.

Most humpbacks migrate considerable distances to high latitude summering areas, where they feed intensively. Summer ranges are often relatively close to shore, including major coastal embayments and channels. However, humpbacks may also summer offshore, as in the Gulf of Alaska (Brueggeman *et al.* 1987, 1988) or, in the southern ocean, along the margin of the seasonal pack ice and in waters of the Antarctic Convergence. More detailed information about seasonal movement and distribution of the North Atlantic and North Pacific populations is discussed in subsequent sections.

This overview of humpback whale migration and distribution indicates that a Recovery Plan must include consideration of the whales in all parts of their seasonal ranges, although they may be more vulnerable in one area than in another.

C. Populations and population sub-units

Inconsistency in the terminology used to demarcate populations and population sub-units of humpbacks and other whales has been a source of confusion. Hereafter in this Plan, we use the term "stocks" to refer to groups of whales using geographically distinct winter ranges for reproduction; and "feeding aggregations" for groups using geographically distinct summer ranges for feeding. Some stocks are comprised of whales from several feeding aggregations. These terms are defined to facilitate management of such population units. The geographical discreteness of these units reflects different behavioral characteristics of the whales comprising them, but not enough information is yet available to fully describe their genetic relationships.

Because humpbacks utilize traditional coastal areas and oceanic islands for reproduction, it is believed that many relatively separate geographic breeding stocks may exist. Worldwide there are thought to be approximately 13 stocks that winter in the lower latitudes of tropical and sub-tropical waters. Designation of those stocks is based on historical commercial whaling records (Townsend 1935; Winn and Scott 1981; Mitchell and Reeves 1983; Fig. 2 in Reeves and Mitchell 1986), early research activities associated with whaling practices (Kellogg 1929) and recent studies (in *lit.*). Winn and Reichley (1985) suggested that such a model might be oversimplified and that the whales probably form a series of stocks around the world with isolation decreasing as one goes to smaller units. As one example, instead of the two stocks designated here as Western and Central South Pacific, Gaskin (1982, p. 385) names 6 stocks.

Disagreement over the exact number and definition of existing stocks does not affect this Plan, which concentrates on those stocks which spend at least part of the year in waters under jurisdiction of the United States. Those stocks are Western North Atlantic; central North Pacific; and eastern North Pacific. In addition, U.S. Territories at Guam (Commonwealth of the Mariana Islands) and at American Samoa lie within the winter range of the Western North Pacific and Central South Pacific stocks, respectively. Those stocks are not described in detail within this Plan, since U.S. territorial waters form only a small part of the habitat used by those stocks. However, this Plan includes Tasks that encourage other nations to form and implement recovery plans for stocks under their jurisdiction.

We have presumed that stocks of humpback whales return to traditional sites for reproduction and that there is little interchange between most of the stocks listed above. Nevertheless, reoccupation of historical (or new) habitats is possible in time, because some movement between stocks or feeding aggregations is likely to occur, even if on a slow time scale. Possible interchange between the Western and Eastern North Pacific stocks or between the Eastern North Pacific and the Eastern South Pacific stocks is discussed in Section IV. Analysis of existing photo-identification catalogues and databases (see Hammond *et al.* 1990), coupled with new field research, including long-term radio tagging and genetic characterization of population subdivisions may help clarify our understanding of relationships between stocks.

D. Habitat Use and Behavior

1. Summering Areas: Feeding

All humpback whales feed while on the summer range, which is usually located over a continental shelf at latitudes between about 40° to 75°. Many summer habitats are apparently traditional feeding grounds, as evidenced by the long historic record of occupation and by recent records of returns of identified individuals for many years (e.g. Baker *et al.* 1988).

Sea surface temperatures in lower latitude summering habitats, for example in Massachusetts Bay (about 42°N), may rise to at least 21°C (Mayo *et al.* 1988). However, surface temperatures in higher latitude summering areas may be very low, e.g. 2°C near the edge of pack ice in western Greenland at 64°N

(Whitehead *et al.* 1982). Depending on prey type and abundance, the whales must often dive below the thermocline as they pursue prey; therefore, even in warmer areas they frequently swim in cool to cold water, e.g. 5°C to 10°C in Massachusetts Bay (Mayo *et al.* 1988).

Marine productivity in humpback summering habitats is, on average, very high. Perhaps of more importance than high average productivity is the opportunity for whales to encounter patches of prey in very dense concentrations (Brodie *et al.* 1978). The productivity and local distribution of prey are directly linked to physical oceanographic factors, including upwelling, converging currents and other factors often characteristic of fjords, channels, continental shelves, offshore banks, and the edges of continental shelves. Other factors, including biological competition, may also be important. The search for concentrated sources of food (e.g Brodie *et al.* 1978; Dolphin 1987a,b; Mayo *et al.* 1988), which may vary year-to-year, seasonally, diurnally, and even on shorter time scales, probably determines the whales' fine-scale distribution within the broader summering areas. Shifts in summer distributions of humpbacks along the Newfoundland coast (Whitehead and Carscadden 1985), in southeastern Alaska (Bryant *et al.* 1981; von Ziegaser and Matkin 1986; Baker *et al.* 1988) and in the Gulf of Maine (Payne *et al.* 1986) have occurred in apparent response to changes in prey abundance.

Sonar observations have shown humpback whales to dive as deep as 200 m (Whitehead 1981) while pursuing prey, but Dolphin (1987a) stated that such efforts may put them into oxygen debt. According to his calculations, the aerobic limit is reached after a dive lasting 4 to 6 minutes, during which the whale could descend to approximately 41-60 m. Dolphin (1987b) observed average ascent and descent velocities of 1.8 m s^{-1}. Dolphin (1987b) also demonstrated the importance of food concentration and depth distribution on humpback feeding. A whale feeding on krill patches (10^4 m^{-3}) located at 81-100 m would require 12.7 hr to consume its daily ration, compared to only 4.5 hr if the patches were at 21-40 m.

Humpback whales carry out the most diverse repertory of feeding behaviors known for any baleen whale. Among the unique feeding methods reported (Ingebritsen 1929; Jurasz and Jurasz 1979; Watkins and Schevill 1979; Hain *et al.* 1982; Weinrich 1983; Baker and Herman 1985; Baker 1985; Hays *et al.* 1985; Winn and Reichley 1985; D'Vincent *et al.* 1985) are: (1) use of columns, clouds or nets of expelled bubbles to concentrate krill or fish; (2) herding, and possibly disabling, prey by maneuvering, flicking or pounding with the flukes and flippers; (3) using the water surface as a barrier to prevent the escape of prey; (4) feeding in formation ("echelon feeding"); (5) apparent use of acoustic cues to synchronize feeding lunges; and (6) apparent short- and long-term (multi-year) cooperation between individuals, frequently mature females without calves. There are also some reports of humpbacks approaching fishing boats in the process of hauling gear to take fish concentrated by the net (W.A. Watkins, J. Sigurjonsson, pers. comm.) or portions of the catch that escaped through the trawl mesh (D.E. Sergeant, pers. comm.). During 1981, humpback whales in Prince William Sound, Alaska, appeared to be feeding on prey stirred up as the heavy, steel-plated doors of a shrimp trawl scraped along the bottom (von Ziegesar 1984).

The prey species used by humpback whales have not been studied in detail for most populations, but available literature consistently shows major foods to be small schooling fishes and large zooplankton, mainly krill (Nemoto 1957, 1959, 1970; Klumov 1963; Tomilin 1967; Krieger and Wing 1984, 1986). Humpback whales probably feed whenever and wherever sufficient concentrations of suitably-sized prey are encountered. Useful descriptions of the mechanisms by which the whales engulf and filter prey are given by Nemoto (1970), Pivorunas (1979), Lambertson (1983) and Orton and Brodie (1987). Species reported to have been eaten by humpbacks in different regions are mentioned below.

Important prey of humpbacks in the North Atlantic Ocean included herring (*Clupea harengus*), sand lance (*Ammodytes americanus*), and capelin (*Mallotus villosus*). Other fishes taken at times are mackerel (*Scomber scombrus*), small pollock (*Pollachius virens*), and haddock (*Melanogrammus aeglefinus*). Krill, primarily *Meganyctiphanes norvegica*, is also an important food (Tomilin 1967; Meyer *et al.* 1979; Overholtz and Nicolas 1979; Whitehead 1987).

J. Lecky (pers. comm.) observed two humpbacks feeding on schools of anchovy (*Engraulis mordax*) in waters of the Southern California Bight. Rice (1963) found that 64% of food-containing stomachs of humpbacks hunted off the Central California coast contained anchovies (*E. mordax*) and 36% contained krill (*Euphausia pacifica*).

In Southeastern Alaska and Prince William Sound, Alaska, herring (*Clupea harengus pallasi*) and krill (*Euphausia pacifica, Thysanoessa spinifera, T. raschii* and perhaps occasionally *T. longipes*) are important prey (Bryant *et al.* 1981; Krieger and Wing 1984, 1986; Baker *et al.* 1985; Perry *et al.* 1985; Dolphin 1987b).

In the North Pacific, Nemoto (1957) reported euphausiids as the only food present in 201 of 261 food-containing stomachs of humpbacks killed there. Fifty-six (56) stomachs contained only fish or fish plus krill. Frost and Lowry's (1981) review named at least 10 species of fishes eaten by humpbacks (capelin, *Mallotus villosus*; walleye pollock, *Theragra chalcogramma*; Atka mackerel, *Pleurogrammus monopterygius*; eulechon, *Thaleichthys pacificus*; sand lance, *Ammodytes hexapterus*; pollack, *Pollachius virens*; Pacific cod, *Gadus macrocephalus*; saffron cod, *Eleginus gracilis*; arctic cod, *Boreogadus saida*; salmon, *Oncorhynchus* spp. and rockfish, *Sebastes* spp.); plus several invertebrates (euphausiids, *Thysanoessa raschii*; mysids, *Mysis oculata*; pelagic amphipods, *Parathemisto libellula*; shrimps, *Eualus gaimardii* and *Pandalus goniurus*; and copepods, *Calanus* spp.). Tomilin (1967) listed mysids as the main prey of humpbacks in the Bering Strait and southern Chuckchi Sea.

Around Australia and New Zealand, krill (*Euphausia spinifera, E. hemigibba* and *Nyctiphanes australis*); decapod larvae (*Munidia gregaria*) and herring like fishes (perhaps *Clupea fimbriata*) were reported as prey (Kawamura 1980). In Antarctic regions, krill, *E. superba*, is the species most frequently reported as prey, but Nemoto (1959) also listed several other euphausiids, a copepod (*Calanus propinquus*) and an amphipod (*Parathemisto gaudichaudi*).

2. Migrations

Two types of migrations may be distinguished: (1) within-season movement through a portion of the summer range, presumably in order to find or follow concentrations of prey; and (2) long-distance migrations between summering and wintering areas.

As an example of within-season movement, Whitehead *et al.* (1982) showed that individual humpbacks moved along the Northeastern Newfoundland and Labrador coast at a minimum speed of approximately 1° latitude per month (0.154 km/hr), perhaps in association with capelin spawning, which occurs progressively later further north along the coast.

The first detailed descriptions of long-distance migrations between summering and wintering areas were for Southern Hemisphere populations (Matthews 1938; Dawbin 1966), because data were available from shore whaling stations and the pelagic fishery. As summarized by Dawbin (1966), individual whales could swim at 4-6 kt for some hours, at least. Estimates for mean rate of migration were between 180-220 nautical miles/week or 15° latitude/month, but one whale swam 500 n. mi. in 6 days.

Estimated migration speeds of photographically-identified Northern Hemisphere whales were; 78 dy (2.38 km/hr) for a 4,500 km distance between Hawaii and Alaska (Baker *et al.* (1985); and 3.29 km/hr (21° latitude/month) and 2.28 km/hr (14.8° latitude/month) for two individuals migrating between the Greater Antilles and Massachusetts Bay (Clapham and Mattila 1988).

Marking efforts that used Discovery tags (Nishiwaki 1967) and resightings of photographically-identified humpbacks (Martin *et al.* 1984; Darling and McSweeney 1985; Katona 1986; Baker *et al.* 1986; Katona and Beard, in press) show the beginning and end points of numerous migrations, but the exact routes travelled are not known. As yet, there are no reported features that characterize the migration routes of all populations of humpbacks. Some whales migrate across the open ocean, from Hawaiian waters to those of Southeastern Alaska (e.g., Baker *et al.* 1986), and from the Caribbean to near Iceland (e.g., Martin *et al.* 1984). Others apparently migrate through coastal waters, as in the case of those that winter off Western Mexico and summer in California or Southeastern Alaska (Darling and Jurasz 1983; Darling and McSweeney 1985). Migration routes and the location of feeding areas are probably learned by calves as they accompany their mothers (Martin *et al.* 1984; Baker *et al.* 1986).

Dawbin (1966) reported that migrating humpbacks in the Southern Hemisphere appeared to segregate into different age or reproductive classes. During the trip to higher latitudes, females in early pregnancy migrated first, followed by immature animals, then resting females with mature males, and finally females in early lactation. On the return trip to low (breeding) latitudes, females and nearly weaned nurslings migrated the earliest, followed in succession by immature animals, mature males with resting females, and finally females in late pregnancy. One result noted by Dawbin (1966) was that lactating females with their calves spent approximately two months less in cold waters of the summer feeding grounds than did pregnant females.

This sequence has not been as thoroughly documented for Northern Hemisphere humpbacks. Nishiwaki's (1960) data suggested that migrating animals are segregated by length and perhaps reproductive class. However, Baker *et al.* (1985) and Straley (in press) have showed that representatives of all ages, sexes and reproductive classes are found in Southeastern Alaskan coastal waters during autumn and early winter. If there is any segregation of classes in the migration, it cannot be evaluated by existing data.

3. Wintering areas: Reproduction

Most humpback whales appear to spend winter in relatively specific, traditional locations at lower latitudes (usually between about 10° and 35° latitude). The sea water temperatures of those locations, up to 25°C in Hawaiian waters (Herman 1979) and 28°C in the West Indies (Whitehead and Moore 1982), are among the highest experienced by any baleen whale.

Juveniles presumably do not participate in reproductive activities until they reach sexual maturity, usually at age 4 to 6 years (Table 2). Sexually mature females give birth approximately every two or three years (Table 2), although annual and multi-year (up to 5 years, e.g. Baker *et al.* 1988) calving have been observed (Chittleborough 1965; Glockner-Ferrari and Ferrari 1984, 1985a, in press; Clapham and Mayo 1987b, and in press; Perry *et al.* 1988, in press). Annual calving appears to be unusual. About 14% of the calving intervals observed for photo-identified females in Hawaiian waters were only one year (D.A. Glockner-Ferrari, pers. comm.). One female humpack whale in southeastern Alaska was seen with a calf in three consecutive summers (1987-1989) and another was seen with a calf in two consecutive summers (1987-1988). Each calf was seen throughout the summer, suggesting that annual calving can occur with survival of offspring through the first year (Straley 1989; see also Darling, 1983 and Baker, 1987).

On the winter range, most mothers with calves are accompanied by an escort whale (Herman and Antinoja 1977; Glockner and Venus 1983) that is a male (Glockner 1983). Groups of up to 19 (D.A. Glockner-Ferrari, pers. comm.) sexually mature males compete for access to females, ramming each other or pounding with flippers or flukes (Tyack and Whitehead 1983; Baker and Herman 1984; Glockner-Ferrari and Ferrari 1985a). Songs produced by males on the wintering ground appear to have courtship or display functions resembling those of bird songs (Tyack 1981; Tyack and Whitehead 1983). The significance of the few songs recorded on summer ranges (Mattila *et al.* 1987; McSweeney *et al.* 1989) is not known.

No published observations of copulation exist for this species. Tomilin's (1967) examination of 68 embryos taken from humpback whales killed in the North Pacific indicated that conception took place year-around with peaks in February-April and September-October. Tomilin could not explain that result with certainty: some copulation could occur during migration or on the summering grounds, but he also considered the possibility that the autumn peak represented whales that had come from the Southern Hemisphere. Length measurements of 2023 embryos collected from Antarctic waters indicated that mating took place from the latter half of austral winter through spring, with the peak in September (Tomilin 1967).

In the Northern Hemisphere, young calves have been observed mainly during winter, even though Tomilin's (1967) examination of embryos would suggest that some births occur at other times. Lactation continues for up to 12 months (Fig. 2). A summary of information on life history and vital rates is given in Table 2 (also see Winn and Reichley 1985).

Physiographic descriptions are available for two important wintering areas in the Northern Hemisphere. In both locations, there are indications that specific habitat types within the winter range are differentially important to different reproductive classes.

Based primarily on their experiences in the North Atlantic, Whitehead and Moore (1982) and Whitehead (1987) listed general characteristics of Western North Atlantic wintering areas: latitudes between 10° and 22° north or south; sea water temperatures between 24° and 28°C; with areas of flat sea floor; and lying less than 30 km from deep water. According to these authors, concentrations of humpback whales may attract other humpback whales to a site, but excessive human disturbance may cause shifts to other areas. In Whitehead and Moore's (1982) studies at Silver Bank, singing whales were usually found over smooth, flat bottom 20 m to 40 m deep, but only rarely over deep water or among coral heads; and mothers with calves were most frequently found in calm water among coral heads or in the lee of coral reefs. Those authors also noted that calves were "virtually absent" from Navidad Bank, which has no coral reef and presumably no calm water.

Characteristics of Hawaiian waters used for breeding, as described by Rice and Wolman (1978) and Herman (1979) included: between approximately 19° to 22° latitude; sea surface temperature between 24° and 28°C; swells and surf on northeastern shores caused by northeast tradewinds prevailing during 55-65% of December-April, but often interrupted from October through April by southerly "kona" winds; no consistent relationship between wind or swell patterns and distribution of whales; depths utilized always less than 100 fathoms (183 m); clear water with low zooplankton content and little permanent effect on water clarity from land runoff.

In the North Pacific, the major calving areas within waters under U.S. jurisdiction are the Hawaiian Islands (Central North Pacific stock) and Guam (U.S. Trust of the Pacific Islands) (Western North Pacific stock).

In the South Pacific, waters under American jurisdiction around American Samoa are within the winter range of the Central South Pacific stock.

In the winter range of the Western North Atlantic stock, United States protection extends to portions of the Virgin Islands and Puerto Rico where some reproductive activities occur (Mattila and Clapham 1989; Mattila 1982).

E. Natural Mortality

The review of literature for preparation of this Plan has revealed how little is known about natural mortality in humpback whale populations. Natural mortality rates cannot be accurately quantified at this time. Factors probably contributing to natural mortality, including parasites, predation, red-tide toxins, and ice entrapment are discussed below.

Parasites may play a larger role in natural mortality than has generally been acknowledged. For example, the humpback whale is the type host of the giant spirurid nematode *Crassicauda boopis*, which in other species of balaenopterids may cause substantial morbidity and mortality (e.g. extensive and severe mesenteric arteritis, complete occlusion of the blood vessels draining the kidneys; congestive kidney failure and death (Lambertson 1985, 1986, in press; Lambertson *et al.* (1986).

Killer whales (*Orcinus orca*) prey on humpback whales and Katona *et al.* (1988) reported that about 14% (464/3365) of individually identified humpback whales in the Western North Atlantic Ocean showed scars on their flukes from apparent encounters with killer whales. Whitehead (1987) reported two incidents of killer whales attacking humpback whales on the Grand Bank of Newfoundland, but hypothesized that such attacks are mainly directed at disabled or young animals. Killer whale attacks on humpbacks have been documented in southeastern Alaska, but the two species have also been seen there feeding in close proximity without aggressive interactions (Dolphin 1987). Calves have been observed with rake marks on the fin and flippers that D.A. Glockner-Ferrari and M.J. Ferrari (pers. comm.) speculate may result from attacks by false killer whales (*Pseudorca crassidens*). They have observed *Pseudorca* and humpbacks together on three occasions. What appear to be shark bites have been observed on adults. In 1974, divers in Hawaii reported seeing a large shark following a juvenile. The shark and whale were soon lost to sight, but a short time later blood was seen in the water and the juvenile returned to the area missing one of its flippers (E. Robinson, pers. comm.). Glockner-Ferrari *et al.* (1987) reported an increase in the occurrence of sick juveniles, calves with abnormalities and strandings in Hawaiian waters furing 1987. This phenomenon was not observed in following years 1988-1990.

Between December 1987 and January 1988, 14 humpback whales died in Cape Cod Bay of paralytic shellfish poisoning (PSP) (Geraci *et al.* 1990). Another individual died shortly afterwards in waters off New York State. It is not yet clear whether PSP poisoning has occurred previously in this species, but not been recognized. The above incident is the only natural mass mortality of humpback whales on record.

Entrapments of humpbacks in spring pack ice in Newfoundland have occurred several times during the past decade (Merdsoy, Lien and Storey 1979). As many as 25 humpbacks have been ice entrapped in the same entrapment event (Lien and Stenson 1986) and some mortality has been documented.

Other stochastic events, such as weather dependent fluctuations in prey availability might also contribute to natural mortality.

III. CURRENT STATUS OF NORTH ATLANTIC POPULATIONS

A. Summer Distribution and Habitat Use

During summer, humpback whales in the Western North Atlantic migrate and/or feed over the continental shelf and along the coasts of Iceland, southwestern Greenland, the Newfoundland and Labrador coasts, the Gulf of St. Lawrence, and the Gulf of Maine (Leatherwood *et al.* 1976; Whitehead *et al.* 1982; Katona, Rough and Richardson 1983; Perkins *et al.* 1984; Payne *et al.* 1986).

Data for over 3,647 individually-identified North Atlantic humpback whales (Katona and Beard, 1990) showed that individual whales from waters near Iceland, Southwestern Greenland, Newfoundland and Labrador, the Gulf of St. Lawrence, or the Gulf of Maine generally returned to the same area for feeding. The term "feeding aggregations" was used to describe groups of whales using these separate parts of the feeding range.

1. Eastern North Atlantic

In the Eastern North Atlantic (Figure 3), humpback whales feed from the British Isles north as far as Bear Island (75°N) and Spitsbergen (78°N) (Mitchell and Reeves 1983) and as far east as Novaya Zemlya (55°E) (Tomilin 1967). It is not known whether those animals migrate to wintering grounds around the Cape Verde Islands (Townsend 1935; Winn *et al.* 1981; Mitchell and Reeves 1983), in other unknown locations in the Eastern Atlantic Ocean, or even around the Antilles (see Sec. III.B.).

2. Iceland, Greenland and Canadian Maritimes

Most humpback whales in the Western North Atlantic Ocean (Figure 3) appear to feed in Iceland, Greenland and the Canadian Maritimes (Tables 1,3). Their primary prey species around Iceland are capelin (*Mallotus villosus*) and herring (*Clupea harengus*). Stomachs of humpback whales taken off the west coast of Greenland contained small fish and krill (Kapel 1979); photographs in Perkins *et al.* (1982) show the whales eating what appear to be sand lance (*Ammodytes* sp.). The main prey taken around Newfoundland is capelin (Mitchell 1973; Whitehead and Glass 1985; Whitehead and Carscadden 1985), but euphausiids are also important and sometimes haddock (*Melanogrammus aeglefinus*), mackerel (*Scomber scombrus*), sand lance (*Ammodytes* spp.) and squid (*Illex illecebrosus*) are eaten when abundant (Mitchell 1973; Bredin 1983). Herring, capelin, sand lance and krill are all eaten in the Gulf of St. Lawrence (R. Sears, pers. comm.). Little information is available concerning humpback whales on the Nova Scotian shelf, but they are abundant in the lower Bay of Fundy, where they eat herring and krill, *Meganyctiphanes norvegica*, (C. Haycock, S. Katona, pers. comm.; cf. Brodie *et al.* 1978). Peak feeding periods in all these waters are from July through September, but some whales may remain considerably later (Williamson 1961), and indeed some remain all winter. Feeding areas may change between weeks or between years depending on local abundance and distribution of prey (Whitehead 1987; Whitehead and Carscadden 1985). For example, along the Newfoundland coast, the first sightings of humpbacks each year occur in March or April along the South coast. Progressively later sightings are made eastward, with the first whales appearing around the Avalon Peninsula by May and June, along the Northeast coast by June and July and in Labrador by July through August (Lien 1980).

3. U.S. East Coast

Humpback whales regularly inhabit waters under jurisdiction of the United States during spring, summer and autumn (Figure 3). They feed opportunistically all along the continental shelf, but the largest numbers occur from mid-April to mid-November in the western section of the Gulf of Maine, particularly the Great South Channel, Stellwagen Bank and Jeffreys Ledge; and also from July through October in the eastern section around the mouth of the Bay of Fundy. The extended seasonal presence of humpback whales in the western areas of the Gulf of Maine may be explained by the fact that the Great South Channel is very productive and it also probably acts as a funnel for exit and entry of most of the Gulf of Maine feeding aggregation during migration to and from the breeding range (Kenney *et al.* 1981; Kenney and Winn 1985).

Within-season and between-season movements of humpback whales within the Gulf of Maine is probably related to the distribution and abundance of their prey species, but factors, such as social behavior, bottom topography and perhaps others may also be involved (Kenney and Winn 1985; Payne *et al.* 1986). Sand lance is currently the most important prey species in the southwestern Gulf of Maine, supplemented by euphausiids (*M. norvegica*) and mackerel when abundant (Meyer *et al.* 1979; Overholtz and Nicolas 1979; Kenney 1984). Prior to the mid-1970's, neither sand lance nor humpback whales were common in the Western Gulf of Maine (Overholtz and Nicolas 1979; W.E. Schevill, pers. comm.). Following a sharp rise in sand lance abundance, humpbacks became locally abundant and fed voraciously on the fish from 1975-1979 (Watkins and Schevill 1979; Hain *et al.* 1982) and through 1985 (Hays *et al.* 1985; Mayo *et al.* 1988). Very low local abundance of sand lance during 1986 and 1987 apparently caused a shift of local humpback sightings from Stellwagen Bank to the Great South Channel, but both species were again abundant at Stellwagen Bank in 1988 (Mayo *et al.* 1988). Sightings of humpback whales on Georges Bank did not increase concomitantly with increases in sand lance (Payne *et al.* 1986).

From Jeffreys Ledge to the Fundy region, herring is thought to be the most important prey of humpbacks, supplemented by surface shoals of euphausiids (*M. norvegica*) during late summer, particularly on the northern half of Jeffreys Ledge (M.T. Weinrich, S.D. Mercer, S.K. Katona, C. Haycock, pers. comm.).

During the feeding season, humpback whales are less common south of Cape Cod, but they can be found east and southeast of Montauk Point, Long Island, from April to about October (Kenney *et al.* 1981; CETAP 1982; Kenney 1984; Kenney and Winn 1986). Large quantities of euphausiids may be eaten near heads of submarine canyons in spring (Kenney and Winn 1987).

In U.S. waters there is no strong evidence of age or sex class segregation, because the geographic distribution of mothers with calves and of juveniles is similar to that of other humpbacks (Goodale 1982).

B. Winter Distribution and Habitat Use

Humpback whales probably migrate well offshore to their principal winter range around the Greater and Lesser Antilles (Figures 3 and 4), since few sightings are reported along the U.S. coast. A few humpback whales have been sighted during December-February around New England (CETAP 1982; Mayo *et al.* 1988; C. Haycock, pers. comm.) or Newfoundland (Williamson 1961) and may remain all winter. More recent work indicates that humpback whales regularly over-winter in deep water bays in Newfoundland, such as Trinity Bay and St. Mary's Bay, where there are local capelin stocks (Lien, Fawcett and Staniforth 1985). The numbers of animals doing this is not known exactly, but may be in the low hundreds (J. Lien, pers. comm.). Reports of winter sightings of humpback whales along the eastern Florida coast have increased somewhat during recent years (S. Kraus, unpublished data), but this may be the result of increased observer effort. According to Cuni (1918), the humpback whale frequented the Cuban coast and the Gulf of Mexico, as well as the Caribbean Sea. Only one other published observation of this species in the Gulf of Mexico has been found, namely a report of one humpback seen at the mouth of Tampa Bay on 8 April 1962 (Layne 1965). However, in April 1989, a humpback whale was observed swimming off Clearwater Beach, Florida, just north of Tampa Bay, Gulf of Mexico.

From late December through early April, most of the population is found at Silver and Navidad Banks, located at the end of the Bahamian Archipelago, and along the coast of the Dominican Republic (Winn *et al.* 1975; Balcomb and Nichols 1978, 1981; Whitehead and Moore 1982; Mattila *et al.* 1989). Other known areas of concentration include the western edge of Puerto Rico (Winn *et al.* 1975; Mattila 1982); the Virgin Bank (Winn *et al.* 1975; Mattila and Clapham 1989), and the Lesser Antilles south to Venezuela (Winn *et al.* 1975; Winn and Winn 1978). Whales from all summer feeding aggregations intermingle on the winter grounds (Mattila *et al.* 1989), where courtship, mating, calving and other activities are all presumed to take place. Katona and Beard (1990) emphasized that all humpback whales in the Western North Atlantic probably form one interbreeding population, although the possibility that mating might occur preferentially between animals from the same feeding aggregations is under investigation (C.S. Baker, pers. comm.).

Silver Bank, a limestone reef located about 120 km north of Puerto Plata, Dominican Republic, in the Dominican Exclusive Economic Zone, is the most important wintering site. Up to 3000 humpbacks occur there from December to early March (Balcomb and Nichols 1978, 1981). Nearby Navidad Bank also provides significant breeding habitat. Winn *et al.* (1975) estimated that 85% of the entire Western North Atlantic breeding population used Silver and Navidad Banks. Coral heads and reefs that fringe Silver Bank provide a lee from the trade winds and offer relatively calm, protected waters that are used by females with calves (Whitehead and Moore 1982).

Females with calves and other whales exhibiting behaviors associated with mating, such as singing and agonistic interactions between males (Tyack and Whitehead 1983), also occur along the Dominican coast (e.g., Samana Bay, Mattila *et al.* 1988), along the northwest coast of Puerto Rico (Mattila 1982) and on the Virgin Bank (Winn and Winn 1978; Mattila and Clapham 1989). At locations such as these, females with calves are usually found relatively close to shore in the lee of the coast (Goodale 1982). Mattila and Clapham (1989) concluded that the Virgin Bank might be used primarily for calving and nursing, since relatively few of the females with calves they observed were accompanied by escorts (presumed to be male by those authors). A few humpbacks occur on Anguilla Bank (by the islands of Anguilla, St. Maarten, and St. Barthelemy), near Antigua, in the St. Vincent Grenadines, south of Tobago and off Venezuela (Winn and Winn 1978). The remainder of the population may be scattered throughout the Lesser Antilles, with perhaps a few wintering over in northern waters.

The only United States-controlled portions of the breeding range are along the northwest coast of Puerto Rico, including Punta Agujereada and nearby Punta Higuero (Mattila 1982), and in the Virgin Islands. Most humpbacks found by Mattila and Clapham (1989) were in waters surrounding the British Virgin Islands, where survey effort was most concentrated, but the species also occurs around the U.S. Virgin Islands.

According to historical records, humpbacks were found near the Bermuda Islands from February to May, but observations and recordings of vocalizations from 1957-1975 (Payne and Payne 1985) and observations from 1980-1985 (Stone *et al.* 1987) indicated that they currently occur there mainly during April and May, stopping for a few days on their way north from the breeding range and perhaps feeding opportunistically. Escorts (presumed to be male) accompanied approximately 6% of females with calves (Stone *et al.* 1987). Those authors also speculated that humpbacks may have used the Bermuda Islands and banks for calving or mating when the population was larger. Humpback whales were reportedly seen off Bermuda throughout winter, 1988 (E.B. Tucker, pers. comm.).

C. Abundance and Trends

The humpback whale became endangered as a result of over-exploitation from commercial whaling. Early manuscripts summarized in Stone *et al.* (1987), indicated that humpback whales were taken in Bermuda as early as 1611, with catches up to 20 whales per year in the mid-1700's. By 1665, they were hunted along the coast of Maine (Martin 1975). Information on hunting in the Western North Atlantic during subsequent centuries is drawn from Mitchell and Reeves (1983). After about 1725, humpback hunting was combined with fishing for cod during cruises to Georges Bank or Nantucket Shoals. Then shore-based fisheries at Nantucket, Cape Cod and Maine took humpbacks and other species until the Civil War. Up to 19 small schooners hunted humpbacks in the Gulf of St. Lawrence and Strait of Belle Isle in 1819, but this fishery stopped during the 1890's. Between the 1830's and 1870's, New England ports launched multi-year voyages by large vessels as well as shorter trips. Hunting on the West Indies wintering grounds began in 1822 and continued from ships and numerous shore stations. Nordhoff (1856) commented that "...the most stupid of whales [humpback], clings obstinately to the [calving] place it has chosen..." Such behavior in the face of hunting methods that focused on females with calves probably contributed to rapid elimination of whales from some wintering locations. During the 1900's most catches were from Canadian Maritime waters.

Mitchell and Reeves' (1983) analysis of whaling records accounted for at least 9,125 whales killed between 1850-1971 within the North Atlantic Ocean west of Iceland, but noted that additional research could document additional kills. Mitchell and Reeves (1983) used their assembled catch estimates to calculate that the population size in 1865 was greater than 4,700. Breiwick *et al.* (1983) using the same data, but incorporating estimates for annual natural mortality (4%) and net recruitment (3%), revised that estimate to 6,300 whales. Reeves and Mitchell (1982) noted that many more humpback whales could have been present originally, because humpbacks had been hunted for at least 300 years before 1865, although catches were poorly documented. Winn and Reichley (1985) listed 10,000+ as their estimate for the size of the original population in the Western North Atlantic.

Commercial hunting could have reduced the North Atlantic humpback population to as few as 700 animals by 1932 (Breiwick *et al.* 1983). Subsequent to protection of the species in the North Atlantic, which began in 1955, humpback whales have only been taken at three locations: 41 off eastern Canada from 1969-1971 under a scientific permit (Mitchell 1973); up to 10 per year in western Greenland for aboriginal subsistence uses until 1980 (Kapel 1979); and up to 8 (but usually only 1 or 2) per year in a subsistence fishery operating at Bequia Island in the Lesser Antilles (Ward 1987; Price 1985; Adams 1971, 1975). Since 1987, this fishery has had an annual quota of 3 whales, but only one whale was taken in 1987 and none in following years.

The estimated population size is 5505 whales (95% confidence interval, 2888 to 8122) (Katona and Beard, 1990) for the western North Atlantic region. This represents about 90% of Breiwick *et al.*'s (1983) estimate for the population in 1865. However, Reeves and Mitchell's (1982) comment that many more humpback whales may have been present in previous centuries should be considered.

Population estimates for humpbacks in Newfoundland waters have shown an upward trend since the 1960's. Although the increase could result mainly from improvements in sampling effort and methodology (Whitehead 1987), other evidence suggests that abundance has increased. A rough measure of trends in humpback abundance inshore in Newfoundland may be the number of fishing gear collisions and entrapments which have occurred each year during the past decade. From 1977-1980, greater numbers of humpbacks occurred inshore in Newfoundland due to depletion of capelin offshore on the Grand Bank (Whitehead and Lien 1982). This resulted in record high numbers of gear collisions and damage to fishing gear. Since 1981, capelin stocks have recovered and remain in good shape to date. Nevertheless, from 1981-1989, humpback entrapments in Newfoundland fishing gear nearly doubled although fishing effort, which was not carefully measured, appears to be approximately constant. The most likely reason for the increase is an increase in the numbers of humpbacks in those waters (Lien 1989a).

Humpbacks belonging to the Gulf of Maine feeding aggregation, estimated by mark-recapture methods (Katona and Beard, 1990) to include approximately 240 whales in 1986 (Table 3), are the only whales that summer in U.S. waters within the North Atlantic. This may underestimate the number of whales using U.S. waters. Over 600 humpbacks have been photographed in the Gulf of Maine since 1979; and over 400 were photographed in 1988 alone (M.T. Weinrich, S.K. Katona pers. comm.). Furthermore, some whales from the Gulf of St. Lawrence and the Canadian Maritimes may migrate through waters offshore from our coast. The fact that waters along the east coast of the United States currently host only a small percentage of the humpback whales in the North Atlantic Ocean should not diminish U.S. commitment to the recovery of this species in that ocean basin.

IV. CURRENT STATUS OF NORTH PACIFIC POPULATIONS

A. Summer Distribution and Habitat Use

The historic summering range of humpback whales in the North Pacific Ocean (Figure 5) encompassed coastal and inland waters around the Pacific rim from Point Conception, California, north to the Gulf of Alaska and the Bering Sea, and west along the Aleutian Islands to the Kamchatka Peninsula and into the Sea of Okhotsk (Tomilin 1967; Nemoto 1957; Johnson and Wolman 1984). The current status of humpback whales in much of this vast range, particularly from the Aleutian Islands west to Asia, is poorly described and may be considerably reduced as a result of intensive commercial exploitation during this century. In the Eastern North Pacific, aerial and shipboard surveys and observations of naturally-marked individuals during the last decade have provided some information on current distribution, abundance and habitat use along the coast of Central California, Southeastern Alaska and Southcentral Alaska, from Prince William Sound to Kodiak Island. These data indicate that humpback whales, in at least these three regions of the North Pacific, form geographically-segregated feeding aggregations similar to those observed in the Northwestern Atlantic. In geo-political terms, however, available descriptions of summering and wintering grounds (see following Winter Distribution) suggest one important difference between the populations in these two oceans: the majority of humpback whales remaining in the North Pacific spend most of their lives within the territorial waters of the United States, except during migration.

1. California to British Columbia

Humpback whales are observed migrating through Southern California waters during autumn and spring. Most sightings occur along the Santa Rosa-Cortez Ridge (Dohl *et al.* 1980), but some occur in more coastal waters of the San Pedro (Schulman 1984) and Santa Barbara Channels (Dohl *et al.* 1980). Humpbacks have been seen feeding along this apparent migration corridor, as in J. Lecky's (pers. comm.) observation of two individuals feeding on schools of anchovy (*Engraulis mordax*) south of Santa Cruz Island in the Southern California Bight during October 1978. Between 1 to 3 mother-calf pairs were reported to exist in Monterey Bay during Spring 1989 (R.L. Ternullo, pers. comm.). However, the primary feeding ground south of Alaskan waters appears to be the Gulf of the Farallones and nearby offshore banks, referred to here as Central California. During 1986, humpbacks were found mainly in water about 75-105 m deep (Cubbage *et al.* 1986); but in 1987 mean water depth was nearly 150 m (Calambokidis *et al.* 1988).

Aerial surveys by Dohl *et al.* (1980) and recent observations of seasonal residency and yearly return of photographically-identified whales suggest that some individuals summering off Central California spend winter off Mexico (Baker *et al.* 1986; Calambokidis *et al.* 1988). No individuals from the Central California feeding ground have yet been sighted on other known feeding grounds. However, Baker *et al.* (1986) reported one identified whale observed summering off Central California and wintering in Hawaii.

Rice (1974) summarized the history of humpback whale hunting along the California coast. Two whaling stations (Del Monte Fishing Co. and Golden Gate Fishing Co.) operating from Point Pablo on the shore of San Francisco Bay killed 841 humpbacks from 1956 until the species was protected in 1965.

Humpback whales were also hunted off the coast of California, Oregon, Washington and British Columbia. Before the arrival of European people Indians probably hunted humpbacks in coastal waters from Washington to Southeastern Alaska (Kirk and Daugherty 1974; O'Leary 1984). From 1913 to 1919, humpbacks were landed at the Bay City, Washington, whaling station during the months of April through October, with the majority taken during June to August (Scheffer and Slipp 1948). Pike and McAskie (1969) reported: "This species was formerly abundant along the coast of British Columbia. Prior to 1913, whaling stations along the west coast of Vancouver Island annually caught between 500 and 1000 whales, almost exclusively humpbacks." This catch declined dramatically in relation to other species during the 1950's, but humpback whales were taken at the Coal Harbour whaling station, Vancouver Island, until 1965.

At present, sightings of humpback whales along the northwestern coast of the United States and off British Columbia are uncommon compared to the frequency of sightings from Central California and Southeastern Alaska. Although the National Marine Mammal Laboratory's platform of opportunity program has documented humpbacks in every month except February, March and April in these areas (H.W. Braham, pers. comm.), it is not clear whether the whales use these waters for purposes other than migration. Darling and McSweeney (1985) reported photographing 8 individual humpback whales off Vancouver Island between the years 1975 and 1981. One of these individuals was also sighted in Hawaii during winter months and another was sighted in Southeastern Alaska in a subsequent summer. Darling (pers. comm.) has developed a catalog of about 40 individual whales sighted off British Columbia from 1977-1990 with matches to Mexico and Hawaii. Additional sightings of humpbacks from offshore of the British Columbia coast may exist in files of private investigators or Canadian or U.S. fisheries offices (D. Duffus, pers. comm.). Three humpbacks were seen feeding during 1988 in the Broughton Archipelago, along the central British Columbia coast (D. Duffus, pers. comm.).

2. Southeastern Alaska

Humpback whales are regularly sighted in the Inside Passage and coastal waters of the Southeastern Alaska panhandle from Yakutat Bay south to Queen Charlotte Sound (Rice and Wolman 1982; Morris *et al.* 1983). Humpback whales feed in Southeastern Alaskan panhandle waters from about May through December, although some have been seen every month of the year (Baker *et al.* 1985, Fiscus *et al.* 1976; J.M. Straley pers. comm.). Peak numbers of whales are usually found in nearshore waters during late August and September, but substantial numbers usually remain until early winter (Baker *et al.* 1985; Straley, in press).

The Southeastern Alaska feeding aggregation appears to be relatively distinct from others in the North Pacific, since only a few individuals have been observed on more than one feeding ground (Baker *et al.* 1985, 1986). Photo-identified individuals have returned to Southeastern Alaska for many years (Baker *et al.* 1986), sometimes to specific summer ranges as small as a few square kilometers in extent (Perry *et al.* 1985). For example, a number of individual whales have returned to the Glacier Bay-Icy Strait area for as many as 16 consecutive summers (Baker *et al.* 1988; Perry *et al.* in press).

The local distribution of humpbacks in Southeastern Alaska appears to be correlated with the density and seasonal availability of prey, particularly herring (*Clupea harengus*) and euphausiids (Bryant *et al.* 1981; Krieger and Wing 1984, 1986; Baker *et al.* 1985). Important feeding areas include Glacier Bay and adjacent portions of Icy Strait, Stephens Passage/Frederick Sound, Seymour Canal and Sitka Sound (Baker *et al.* 1985; Perry *et al.* 1985; Straley, in press). Glacier Bay and Icy Strait appear to be an important feeding area early in the season, when whales prey heavily on herring and other small, schooling fishes. Frederick Sound is important later in summer, when whales feed on swarming euphausiids (Perry *et al.* 1985; Krieger and Wing 1984). During autumn and early winter, humpbacks move out of the Sound to areas where herring are abundant, particularly Seymour Canal (C.S. Baker, W.D. Blankenbecker, R. E. Haight, J.M. Straley, pers. comm.). Other areas of Southeastern Alaska may also be important for humpbacks and need to be evaluated. These include Cape Fairweather, Lynn Canal, Sumner Strait, Dixon Entrance, the west coast of Prince of Wales Island, and offshore banks such as the Fairweather Grounds (Baker *et al.* 1985).

3. Southcentral Alaska: The Gulf of Alaska Including Prince William Sound and the Alaska Peninsula

Humpback whales are known to summer throughout the central and western Gulf of Alaska (Rice and Wolman 1982; Leatherwood *et al.* 1983; Morris *et al.* 1983), especially in Prince William Sound, along the coast of Kodiak Island, including Shelikof Strait and the Barren Islands, and along the southern coastline of the Alaska Peninsula. Their former abundance in this region once supported a shore-based whaling station operated at Port Hobron, Kodiak Island, from 1926 to 1937 (Reeves *et al.* 1985). In the 1960's, the waters south of the Alaska Peninsula were considered to be the center of the summer distribution of humpback whales in the North Pacific (Berzin and Rovnin 1966). Japanese scouting vessels continued to observe high densities of humpback whales near Kodiak Island during 1965-1974 (Wada 1980). In Prince William Sound, during recent years, humpback whales have congregated near Naked Island, in Perry Passage, near Chenega Island, in Jackpot, Icy and Whale Bays, in Port Bainbridge and north of Montague Island between Green Island and the Needle (Hall 1979, 1982; von Ziegesar 1984; von Ziegesar and Matkin 1986). The few sightings of humpbacks in offshore waters of the central Gulf of Alaska are usually attributed to animals migrating into coastal waters (Morris *et al.* 1983), although use of offshore banks for feeding is also suggested (Brueggeman *et al.* 1987).

Although it is difficult to draw firm conclusions about this geographically large region, recent studies suggest a dramatic reduction in the number and distribution of humpback whales in comparison to early records of commercial catches (Rice and Wolman 1982; Brueggeman *et al.* 1987; Hall 1977; von Ziegesar and Matkin 1986). In Prince William Sound, for example, annual use is variable and less than 100 individuals use this area during any given year (von Ziegesar and Matkin 1986). In the Shumagin Island region south of the Alaska Peninsula, Brueggeman *et al.* (1987) reported that humpback whales were generally found along shallow shelf breaks near islands and offshore banks. Although this distribution was similar to that reported in commercial whaling records, Brueggeman *et al.* (1987) reported some interesting exceptions. Extensive aerial surveys failed to find any humpback whales over the Davidson Bank, an area that was harvested regularly by the Akutan Whaling Station. A similar absence of humpback whales in the eastern Aleutian Islands is reported by Stewart *et al.* (1987). Brueggeman *et al.* (1987) attributed those absences to intensive exploitation of local herds and their failure to recover.

4. The Aleutian Islands, Bering Sea and Asia

The waters along the continental shelf of the central Aleutian Islands were once considered the center of the North Pacific humpback whale population (Berzin and Rovnin 1966; Nishiwaki 1967). Japanese and Soviet whaling fleets harvested whales intensively throughout the Aleutian Islands from 1905 to 1929 and again from 1960 to 1965 (Rice 1978). A shore-based whaling station operated at Akutan from 1912 to 1939 (Stewart *et al.* 1987; Reeves *et al.* 1985). Nikulin (1946) and Berzin and Rovnin (1966) described the northern Bering Sea, Bering Strait, and the southern Chukchi Sea along the Chukchi Peninsula as the northern extreme of the humpback's range. Within the Bering Sea, humpback whales were sighted with greatest frequency south of Nunivak Island and east of the Pribilof Islands (Berzin and Rovnin 1966; Braham *et al.* 1977; Nemoto 1978; Braham *et al.* 1982; Leatherwood *et al.* 1983).

Humpback whales were also known to summer along the Asian coast, particularly around the Kamchatcha Peninsula and the Sea of Okhotsk (Tomilin 1967), but there are few data on their distribution south of the Sea of Okhotsk. A few coastal sightings have been reported in recent years, but no systematic studies have been carried out (Wang 1984). Existing information on distribution in the Bering Sea and along the Aleutian Islands indicates a dramatic decline since commercial whaling commenced, but little evidence of any marked recovery since protection. Brueggeman *et al.* (1987) reported no sightings of humpback whales in the North Aleutian and St. George Basin OCS planning zones to the north and west of the Alaska Peninsula. Similarly, Stewart *et al.* (1987) reported that no humpback whales were observed during aerial surveys on or near areas hunted by vessels from the Akutan whaling station in the eastern

Aleutians. Braham *et al.* (1977) saw 14 humpbacks in the northern Bering Sea in August 1976, and Braham *et al.* (1982) documented 25 humpbacks between 1958-1978 in the southern Bering Sea between Unimak Pass and the Pribilof Islands.

B. Winter Distribution and Habitat Use

Humpback whales in the North Pacific now winter on three geographically separated wintering grounds (Rice 1978): (1) the coastal and insular waters along western Baja California and the mainland of Mexico extending out to the Revillagigedo Archipelago; (2) the main islands of Hawaii; and (3) the islands south of Japan, including the Ryukyu, Bonin, and northern Mariana Islands.

1. Hawaiian Islands

Surveys during the 1970's (Wolman and Jurasz 1976; Herman and Antinoja 1977; Rice and Wolman 1978) found humpback whales concentrated in certain areas around the larger Hawaiian Islands (Figure 6). Highest population densities were typically reported in the "four island area" (Maui, Molokai, Lanai, Kahoolawe), on Penguin Bank, around Niihau Island and along the leeward coast of Hawaii Island, from Keahole Point north to Upolu Point. Kauai, Oahu and the eastern and southwestern coast of Hawaii had lower densities. Few animals have been reported around the atolls, islands, banks, and reefs of the northwestern Hawaiian Islands. The whales principally use shallow waters within the 100-fathom isobath.

Humpbacks arrive in Hawaiian waters as early as November and a few whales remain until early June (Herman and Antinoja 1977; Herman *et al.* 1980). Individual whales have been observed in Southeastern Alaska as late as December 8 and resighted in Hawaii 79 days later on February 25 (Baker *et al.* 1985). From 1977 to 1979, the earliest influx of whales occurred near the Island of Hawaii. Islands to the northwest had progressively later dates of arrival and relative peak abundance (Baker and Herman 1981). The highest overall density of whales occurred between February and April, but the timing of the seasonal peak shifted from year to year (Herman and Antinoja 1977; Baker and Herman 1981). The average duration of stay is not known for either sex or any age class. The maximum reported residency for an identified female with calf was 56 days (Glockner-Ferrari and Ferrari 1985a).

Newborn and nursing calves with cows are seen throughout the winter. Approximately 6-11% of all animals sighted during aerial surveys were calves (Bauer 1986; Herman *et al.* 1980). Cows with calves appear to preferentially use leeward, nearshore waters within the 10-fathom isobath, especially along the north coast of Lanai (Herman *et al.* 1980; Forestell 1986), Maalaea Bay, Maui (Hudnall 1978), and the west Maui area (Glockner-Ferrari and Ferrari 1985a; Glockner and Venus 1983).

No all-island surveys have been done since 1979, but the general habitat use pattern described above has remained fairly consistent, with minor exceptions. Recent shifts in local habitat use by cows with calves have been noted and attributed to increasing coastal development and increasing use of high-speed boats, parasail boats and jet skis near shore (Glockner-Ferrari and Ferrari 1985a; Forestell 1986). According to D.J. McSweeney (pers. comm.) a "five to tenfold" increase over "usual" numbers of whales along the Kona coast of the Island of Hawaii occurred during the 1986-87 winter season.

Photo-identification of individual whales has revealed movements between the Hawaii wintering grounds and other locations (Darling and Jurasz 1983; Darling and McSweeney 1985; Baker *et al.* 1986). The Hawaiian wintering ground appears to be most closely connected to the Alaskan summering grounds and less so to the Central Californian summering grounds. From a catalog of photographs contributed by researchers throughout the central and eastern North Pacific from 1977 to 1986 Perry *et al.* (1990) reported the following number of resightings between Hawaii (n = sample size = 634) and other regions: 82 to southeastern Alaska (n = 464); 17 to the Western Gulf of Alaska including Prince William Sound (n = 95); 1 to Central California (n = 18); and 2 to Mexico (n = 36).

2. Mexico

Humpback whales winter along the Pacific coast of Mexico, approximately 4,800 km from the Hawaiian Islands (Figure 6). Whales in Mexican waters are distributed in four subregions (Urban and Aguayo 1987): (1) southern coast of Baja California from Isla Cedros around Cabo San Lucas to Loreto; (2) northern Gulf of California; (3) Mexican mainland from Mazatlan to Tehuantepec, including Islas Isabel, Islas Tres Marias and Bahia de Banderas; and (4) Revillagigedo Archipelago, including Islas Soccoro, San Benedicto and Clarion. Humpbacks are present from autumn until spring throughout this range; as in Hawaii they occur mainly within the 100 fathom isobath. Some are also reported in the northern Gulf of California during summer months.

Humpbacks from the Mexican wintering grounds are found with greatest frequency on the Central California summering ground (Johnson and Wolman 1984; Baker *et al.* 1986; Calambokidis *et al.* 1988). The whales from this eastern Pacific coastal group may be somewhat segregated from those in the Central North Pacific (Baker *et al.* 1986). However, at least one whale from Southeastern Alaska and one whale from the Western Gulf of Alaska have also been seen in Mexican waters (Baker *et al.* 1986). Some interchange with the Hawaiian wintering ground is also demonstrated by Darling and Jurasz's (1983) report of two whales sighted in both Hawaii and Mexico and Baker *et al.*'s (1986) report of a third. Other evidence of interchange is suggested by the close similarity in humpback songs from these two wintering grounds (Payne and Guinee 1983).

3. Asia

Prior to intensive commercial exploitation, humpback whales were known to winter in the vicinity of the Mariana, Bonin and Ryukyu Islands, and the Island of Taiwan (Nishiwaki 1967; Ivashin and Rovnin 1967; Townsend 1935). A shore-based whaling station in the Ryukyu Islands took substantial numbers of humpback whales during the late 1950's and early 1960's. Recovery of Discovery-type tags by the commercial whaling fleets prior to the protection of humpbacks documented the movement of six individuals from U.S. waters in the Eastern Bering Sea, north of Unimak Pass, to the Ryukyu Islands (Ohsumi and Masaki 1975; Nishiwaki 1967). The degree of interchange with other wintering or summering grounds in the North Pacific is unknown.

Darling (1989) found humpback whales common during March and April, 1989, in the Ogasawara Islands, an archipelago of small islands about 1200 km south of Tokyo. Darling's team identified a total of 60 individual humpback whales by fluke photographs obtained during 1987-1989. Since the identified whales included mothers and calves, courtship groups and singers, Darling concluded that the Ogasawara Islands (also called the Bonin Islands) are used for mating and calving and estimated that the population may be at least in the low hundreds. Songs recorded on the Ogasawara range were similar (but not identical) to songs recorded in Hawaii at the same time. No photographic matches were found between 20 of the Ogasawara whales and 2000 humpbacks identified from the Eastern North Pacific (Darling 1989).

Darling (1989) identified several other Asian locations that appear to be used during winter by humpback whales, including waters southwest of Okinawa; southeast of Taiwan; and southeast of the Ogasawara Islands to the Northern Mariana Islands. No conclusions can be made yet about the relationships among those groups of whales or among them and the Central or Eastern North Pacific stocks.

C. Abundance and Trends

According to Rice (1978), the North Pacific humpback whale population may have numbered approximately 15,000 individuals prior to exploitation. Intensive commercial whaling removed more than 28,000 animals from the North Pacific during the 20th century and may have reduced this population to as few as 1,000 before it was placed under international protection after the 1965 hunting season (Rice 1978).

1. Summering Grounds

Current information from aerial and shipboard surveys or individual identification is limited to three regions within the territorial waters of the United States: (1) the coast of Central California; (2) Southeastern Alaska; and (3) Southcentral Alaska, including Prince William Sound, Kodiak Island and the Alaska Peninsula.

Available data suggest that the humpback populations off Central California are separate from those off Alaska. Estimates of abundance for those regions are therefore probably independent. However, the degree to which various estimates for areas within Alaska are additive or overlapping is not yet known. There may be some overlap between whales in Southeastern and Southcentral Alaska, and between those in Southcentral Alaska and the Bering Sea-Eastern Aleutian Islands region. A reliable estimate of the total number of humpback whales summering in U.S. Pacific waters will not be possible until those relationships are clarified. These cautions should be considered when interpreting the following regional population estimates.

Aerial surveys off Central California from 1980 to 1983 indicated an annual population of 338 (95% confidence limits, 149 to 537) (Dohl *et al.* 1984). Capture-recapture estimates from individual identification data collected off Central California in 1986 and 1987 are in relatively close agreement with the aerial surveys, suggesting a regional population of about 230 individual (95% confidence limits, 200 to 260) (Calambokidis *et al.* 1988).

In Southeastern Alaska, capture-recapture analyses of individuals between 1979 and 1983 suggested a regional population of 310 (95% confidence limits, 290 to 360) (Baker *et al.* 1985). Similar studies in Prince William Sound indicated a regional population of about 100 humpbacks (von Ziegesar and Matkin 1986), with the suggestion that they were part of a larger Southcentral Alaska feeding aggregation that might extend out into the Gulf of Alaska along Kodiak Island and further to the southwest.

Shipboard surveys along the coast of the Gulf of Alaska from Yakutat Bay to Kodiak Island, and including Prince William Sound, provided an estimate of 364 individuals, although sample size was too small to calculate confidence intervals (Rice and Wolman 1982). Aerial surveys along the Alaska Peninsula for the combined Shumagin and Kodiak/Cook Inlet planning areas of the Shumagin planning zone in 1987 yielded an estimate of humpback whale abundance of 1247 (standard error, 855 to 1639) (Brueggeman *et al.* 1988).

2. Wintering Grounds

In Hawaiian waters, shipboard surveys in 1979 indicated a seasonal population of 550 to 790 (Johnson and Wolman 1984). More recently, Baker and Herman (1987) used capture-recapture methods to estimate 1,407 (95% confidence limits, 1113 to 1701) for this population across a three-year period.

In the first attempt to census humpbacks in Mexican waters, Rice (unpublished, summarized in Rice 1974) counted 102 whales during 68 days of shipboard surveys between January 26 and March 15, 1965, and concluded that he had seen a fairly large proportion of the population, which probably contained only a few hundred individuals. Urban and Aguayo's (1987) ability to photo-identify over 100 humpbacks near Islas Socorro and Isabel during winter and spring of 1986, led those authors to conclude that the overall Mexican population is larger than Rice (1974) reported. Alvarez F. (1985) used photo-identification and capture-recapture methods to estimate that in one breeding season, approximately 300 humpback whales pass through a circle of 15 nautical miles radius around Isla Isabel. As previously mentioned, movements of several whales between Mexico and Hawaii have been reported (Darling and Jurasz 1983; Baker *et al.* 1986).

No formal population estimates are available from the Asian wintering grounds. Rice (1978) thought that less than 100 animals used those waters.

It seems likely that the large majority of animals in the North Pacific currently winter in Hawaiian waters (Baker *et al.* 1986). Baker and Herman's (1987) estimate of 1,113 to 1,701 for the regional population can be considered a minimum for the entire oceanic population (c.f. Darling and Morowitz 1986). This suggests that the number of humpback whales in the North Pacific might be currently at only about 7-11% of the estimated 15,000 in the unexploited population. This must be considered a very rough approximation, since the estimate of an aboriginal population of 15,000 is uncertain.

V. KNOWN AND POTENTIAL IMPACTS

Though hunting caused a major decline in all humpback whale populations, they are no longer endangered by that activity. However, humpback whales occur adjacent to human population centers and are affected by human activities throughout their range. Both habitat and prey are affected by human-induced factors that could impede recovery. These factors include subsistence hunting, incidental entrapment or entanglement in fishing gear, collision with ships, and disturbance or displacement caused by noise and other factors associated with shipping, recreational boating, high-speed thrill craft, whale watching or air traffic. Introduction and/or persistence of pollutants and pathogens from waste disposal; disturbance and/or pollution from oil, gas or other mineral exploration and production; habitat degradation or loss associated with coastal development; and competition with fisheries for prey species may also impact the whales. These factors could affect individual reproductive success, alter survival, and/or limit availability of needed habitat.

A. Subsistence Hunting

Commercial whale hunting, the single most significant impact on humpback whales ceased in the North Atlantic in 1955 and in all other oceans in 1966. The last remaining hunt was carried out from the Island of Bequia, St. Vincent and the Grenadines, Lesser Antilles, using small boats and methods employed by 19th century Yankee whalers (Ward 1987). In 1987, the International Whaling Commission (IWC) set a quota of 3 humpback whales per year for each of the years 1987 through 1989 for that harvest, but only one whale was killed in 1987. The Bequia hunt probably did not adversely affect the overall population of humpback whales within the Western North Atlantic, but it probably slowed recovery of the species in the Lesser Antilles region since it focused on reproductively mature females (Winn and Scott 1981). Humpback hunting at Bequia has probably terminated, since the men who organized the tradition are now aged or dead.

B. Entrapment and Entanglement in Fishing Gear

Entrapment and entanglement in active fishing gear (O'Hara *et al.* 1986) is the most frequently identified source of human-caused injury or mortality to humpback whales. Humpback whales are large enough to break through netting before becoming entangled, but they occasionally entangle in the lead or anchor ropes which they cannot break. Drowning or starvation may result if humans do not intervene to free the whales. The incidence of entanglements could at least slow, and perhaps prevent population recovery, especially if human efforts to rescue the whales were reduced or if fishing effort increased. Entanglement in debris, especially lost or discarded fishing gear, could be another source of mortality.

The most significant known entanglement problem occurs in northeastern continental shelf waters around Newfoundland, Canada, where humpbacks are entrapped during June and July in traps and gillnets set for cod (*Gadus morhua*); and gillnets set for salmon (*Salmo salar*), lumpfish (*Cyclopterus lumpus*), herring and various groundfish. The numbers of humpbacks entrapped per year have ranged from 26 to 68 (Lien *et al.* 1989a). Collisions with fishing gear involving all large animals ranged from 174-813 per year (Lien 1989a), but some of this damage was attributable to other large whales, basking sharks (*Cetorhinus maximus*) (Lien and Fawcett 1985), and other marine species (Goff and Lien 1989). In the past decade (1979-1989), there have been nearly 600 humpback entrapments in fishery gear reported in Newfoundland and Labrador; 93 of the animals died as a result of entrapment (Lien *et al.* 1989b).

From 1976-1986, the NMFS Northeast Fisheries Laboratory reported 18 humpback whale entanglements in fishing gear in northeastern U. S. continental shelf waters (T.P. MacKenzie, pers. comm.). Gillnets caused 39% of the entanglements; other gear included unspecified ropes and lines, scallop gear, and seine gear. Nine animals were freed by volunteers, 6 were known to have died, and 3 were never resighted after disappearing with gear on them.

The NMFS Southeast Region stranding network reported two humpback whale strandings related to entanglement.

The number of humpback whale entanglements reported along the Pacific coast of the continental United States is lower than that reported for the Atlantic Coast. Since the NMFS Southwest Region began collecting stranding reports in 1978, only two dead humpback whales have been reported. Both were entangled in gill nets and were drifting in the Santa Barbara Channel, California (C. Woodhouse, pers. comm.). Another humpback was released from a gill net outside of Los Angeles harbor in 1982 (M.T. Weinrich, pers. comm.). Factors that could contribute to the apparent lower incidence of entanglement are: (1) migration offshore of fishing areas; and (2) lower risk of entanglement during migration than when feeding. One of three humpbacks feeding in the Broughton Archipelago, central British Columbia coast, became entangled in a prawn trap, a section of which it was dragging when last seen (D. Duffus, pers. comm.).

As summarized by von Ziegesar (1984), one humpback whale became entangled in seine nets set for salmon in Prince William Sound during each of the years 1980, 1981 and 1983. Two of those animals tore large holes in the nets and freed themselves. The animal entangled in 1983 submerged with most of the gear attached and was not seen again during an intensive 3 hour search. It was presumed to have drowned. From 1984 through 1989, NMFS Alaska Region (J. Sease, pers. comm.) received reports of about 18 humpback whale entanglements in addition to those reported by von Ziegesar (1984). Of those, 13 were entanglements in fishing gear: 6 in gill nets, 3 in long lines or buoy lines; and 4 in unidentified nets. Ten were freed by volunteers, one freed itself, one died in a gill net and the fate of one is unknown. The other incidents reported include one entangled in cables from an abandoned logging operation and presumed drowned; one freed from entanglement in the anchor line of a small motor vessel; and three reported entanglements in fishing gear that were never confirmed by resightings.

Humpback whales presumably encounter the high seas driftnet fishery for squid and salmon in the North Pacific during migration between Hawaii to Alaska, but no reports or anecdotal information regarding cetacean entanglements from this fishery are available.

Memorial University of Newfoundland, in cooperation with the Department of Fisheries and Oceans, the Newfoundland and Labrador Department of Fisheries and the Newfoundland Fishermen's Union, has operated an entrapment assistance program for over a decade. Fishermen who incidentally catch whales can call a toll-free number and trained crews are dispatched to retrieve fishing gear and release entrapped animals unharmed. The program has been designed to minimize costs of accidents to both fishermen and whales (Lien 1989b). Prior to the program, entrapped humpbacks died in about 50% of incidents (Lien 1980). In the early years of the program, mortality was reduced to 30% (Lien 1981). In recent years, mortality has typically been about 10% (Lien *et al.* 1989c; Lien 1989a).

In the Northeastern United States, several private research organizations have assisted NMFS by designing disentanglement equipment and developing expertise in releasing entangled endangered species. They released alive 9 of the 18 humpbacks entangled there.

C. Collisions with Ships

Collisions with ships are an increasing threat to many whale species. If ships get larger and faster and if the numbers of vessels and/or whales increase, the incidence of encounters can be expected to increase. Major shipping lanes cross important humpback feeding grounds. For example, commercial shipping into Boston crosses Stellwagen Bank and the Great South Channel in the Gulf of Maine; commercial and military shipping into San Francisco crosses the Gulf of the Farallones. If such whales either accommodate to disturbance (Beach and Weinrich 1989) or pay less attention to ships when actively feeding, they would have increased risk of collision. M.T. Wienrich and coworkers (pers. comm.)

documented at least four humpback whales probably scarred by collisions with ships during 1989. Those workers considered this a greater number of strikes than has been seen in 8 previous seasons of comparable fieldwork.

At least 5 humpbacks photographed in Southeastern Alaska have large dents or gashes on the upper body that were probably caused by collision with vessels. Most of those whales were also noticeably skittish when approached by boats or skiffs for fluke photography (J. M. Straley, pers. comm.).

Large ships, tugboats with barges on long towlines and recreational vessels are potential collision threats in some portions of the Hawaiian wintering range and in portions of some migration routes. According to Glockner-Ferrari *et al.* (1987), the number of physical injuries to calves, juveniles, and adult humpbacks as a result of collisions with boats has increased in Hawaiian waters.

D. Acoustic Disturbance

1. Noise from ships, boats and aircraft

It would not be surprising if loud noises from ship engines or powerful sonar could potentially adversely affect humpback whales by disrupting resting, feeding, courtship, calving, nursing migration or other activities. Supertankers or other large ships may create potentially disturbing noise for many kilometers around the vessel (Tyack 1989), but noise production is not necessarily a function of ship size and smaller vessels can also be very loud. Many factors can influence the intensity and frequency spectrum of sounds produced by boats and the potential effects on whales. Vessel factors requiring consideration include type of hull construction, engine type and mounting, exhaust configuration, power and frequency of sonar units, operation of the boat (e.g. abrupt changes in speed or gears) and others. However, the most significant source of noise in waters off Alaska, cavitation produced by ship propellers, may be difficult to eliminate. Physical oceanographic factors (Payne and Webb 1971; Watkins and Goebel 1984) and submarine topography influence sound propagation and therefore the distance at which sounds might affect a whale's behavior.

Short-term disturbance of humpback whales by vessels has been investigated in Alaska (Hall 1982; Baker *et al.* 1982, 1983); Kreiger and Wing 1984; Baker *et al.* 1988) and in Hawaii (Bauer and Herman 1986). Observed responses to vessels included attempts to move away, changes in patterns of breathing and diving and occasional displays of possibly agonistic behavior. Baker *et al.* (1983) described two responses of whales to vessels: (1) "horizontal avoidance" of vessels 2000 to 4000 m away, characterized by faster swimming with few long dives; and (2) "vertical avoidance" of vessels from 0 to 2000 m away, during which whales swam more slowly, but spent more time submerged. Other responses observed, such as trumpeting (Watkins 1967) or breaching (Whitehead 1985), lobtailing, or flipper slapping may sometimes indicate disturbance, but may also signify general excitability (Baker *et al.* .1988). The significance of the extra energetic costs incurred by whales responding in these ways is not known. Whales appear to respond less to vessels when actively feeding (Baker *et al.* 1988) or energetically involved in any other behavior (Hall 1982; W.A. Watkins, J.M. Straley, pers. comm.).

Humpback whales are also known to approach boats. The frequency with which this behavior is expressed may vary between different populations and may change over time as individuals develop learned responses to particular vessels or vessel activities. For example, Watkins (1986) analyzed log book entries and other descriptions of humpback whale behavior observed during research cruises in Cape Cod Bay and concluded that humpback whales approached boats more frequently following the start of commercial whale watching in that area in 1976. He also reported that some individual humpbacks apparently learned to approach boats that visit regularly, behaving like trained animals. Humpback whales that approach boats sometimes remain next to or under the vessel even though the idling diesel engine seems noisy to a human observer. Similarly, fishermen in southeastern Alaska often report humpbacks circling or following their boats without apparent disturbance to fishing activities or to the whales (J.M. Straley, pers. comm.).

Herman *et al.* (1980) noted low densities of whales near Lahaina, Maui Island, Hawaii, where boats are concentrated, and suggested that whales preferred locations away from human activity. Forestell (1986) conducted a similar survey in 1985 and noted low densities of whales near Lahaina and near Keawakapu, Maui. During the years between Herman's survey and Forestell's survey, a boat launching ramp was constructed at Keawakapu which increased access to the adjacent waters by small boat operators. Forestell (1986) suggested that mothers with calves and groups of large animals, at least, avoided locations with high levels of vessel traffic.

Glockner-Ferrari and Ferrari (1985a) have also reported a change in distribution associated with increasing levels of vessel traffic. According to their observations, the percentage of females with calves seen resting and nursing in shallow waters (10 fathoms or less) adjacent to Maui's northwestern shore declined from 77.6% for the period 1976-1979 to 17.5% in 1983. In 1988, only 1.5% of their mother-calf sightings occurred within 0.4 km of shore (D.A. Glockner-Ferrari, pers. comm.). Although noise from boats and high-speed thrill craft activities are a likely causative agent, Glockner-Ferrari and Ferrari (1987) pointed out that pollution and runoff may also be factors contributing to the changing distribution of whales around Maui.

Noise from airplanes and helicopters presents another source of disturbance for whales. In Hawaii, inter-island commuter traffic and small private planes are the major sources of potential aerial disturbance. These planes fly regularly between the islands, often crossing areas of high whale concentrations at altitudes of 1,000 feet or less. Pilots occasionally divert from their flight path to circle whales so that passengers can watch or photograph. Helicopter tour operators also disturb humpback whales by flying low or hovering (Tinney 1988). Noise from low flying aircraft has declined in the past few years, in response to greater awareness and recognition of the potential for disturbing whales.

Noise from military airplanes and other exercises are also sources of disturbance. In Hawaii, aerial exercises are executed from Hickam Air Force Base, Kaneohe Marine Corps Air Station, and Barbers Point Naval Air Station on Oahu. The major impact of tactical military aircraft is their use of Kahoolawe Island as a target. Concerns about the effect of military activities on humpback whales were addressed in a consultation between the U.S. Navy and NMFS regarding the use of Kahoolawe as a target island in 1979. Since then, there have been no reported instances of aircraft-delivered ordnance missing the island. Herman *et al.* (1980) suggested that humpback whales arriving in Hawaiian waters may be disturbed by military aircraft flying low over portions of the Auau Channel between the Islands of Hawaii and Maui. Other ordnance ranges in humpback wintering areas are Kaula Island, Hawaii; Vieques, Puerto Rico; and Farallon de Medonilla, Commonwealth of the Northern Mariana Islands.

Two new military activities are also being considered in summering areas. In southern Southeastern Alaska, the U.S. Navy plans to construct a nuclear submarine testing base. The plans include intensive sonar arrays and high speed movement by submarines. Little is known about humpback whales in that region or about the potential effects of those activities on them (J.M. Straley, pers. comm.). The Canadian government is planning to establish a large bombing range off the Labrador coast, between Cartwright and Nain, where NATO forces could practice attacking enemy shipping. The environmental impact study on the establishment of the largest NATO base in North America at Goose Bay, Labrador, has not yet been released (J. Lien, pers. comm.).

2. Commercial Whale Watching Boats and Research Boats

Whale watching boats and boats from which scientific research is being done specifically direct their activities toward whales and may remain in their vicinity for long periods. Commercial whale watching boats are usually less than 30 meters long, although larger vessels have been used on some occasions. There is some overlap between whale watching and scientific boats, since many commercial whale watch boats carry naturalists who are affiliated with research groups and collect data and photographs as part of their duties. Boats used strictly for scientific research include outboard-powered inflatable boats or runabouts less than 6 m long, sailboats up to about 12 m long, and inboard-powered boats up to about 15 m long. Owing to their expense, few larger vessels are used for research on humpback whales.

Depending on water clarity and other factors, whales may sometimes see the hull or superstructure of such boats, and visual factors may cause disturbance in some situations. For example, humpbacks approaching the surface in Hawaiian waters sometimes appear to be startled by seeing the hull of a drifting boat (D. Glockner-Ferrari, pers. comm.). The potential for such disturbance seems greater in clear water, such as on the Hawaiian winter range. Visual disturbance might occur less often when boats are under power, since a whale would probably hear the boat before it could see it.

Commercial whale watching trips focusing on stocks of humpback whales that may enter waters under U.S. jurisdiction are already significant tourist industries in the following locations: Canada, the United States (including coastal states from Maryland to Maine, California, Hawaii and Alaska); the Dominican Republic; Virgin Islands; and Mexico. Rapid expansion of this industry, plus increased whale watching by small private boats and (occasionally) large cruise ships, is indicative of the current high aesthetic and economic value of the humpback whale (Scott 1985; Kraus, submitted for publication). Since commercial whale watch businesses usually operate scheduled tours out of specific ports, they have an economic interest in the long-term welfare of the whales they visit. They are perhaps more likely to cooperate readily with efforts to protect the animals than are the numerous private recreational whale watchers, which have proliferated wherever small boats have access to whale habitats, and have become problematic in some areas.

In November 1988, NMFS, in cooperation with the Center for Marine Conservation, convened a workshop to seek professional and public input regarding guidelines and regulations for operation of commercial and private whale watch vessels (Atkins and Swartz 1988). The consensus of workshop participants was that the impact of whale watching needed to be evaluated, but that it will not be easy to quantify the possible disturbance caused by whale watching, especially as the potential for such disturbance may be different in different regions.

Since whale watch trips and scientific research trips frequently operate at locations where humpback whales aggregate for feeding or reproduction, it could be feared that such activities might displace whales from important habitat. This does not appear to have happened during more than a decade of intensive commercial whale watching near Cape Cod Bay, Massachusetts.

The situation may be different in Hawaii, as described above, however, it is not yet possible to separate the effects of whale watch boats and scientific research boats from the general increase in recreational and commercial boat traffic.

The harm of possible disturbance (Beach and Weinrich 1989) or behavioral habituation (Watkins 1986) should be weighed against the potential benefits of commercial whale watching, which include the availability of platforms for research at no cost to scientists, the opportunity for members of the public to learn about humpback whales and other aspects of marine biology, and stimulation of public support for whale conservation.

3. Noise from industrial activities

The major sources of industrial underwater noise appear to be offshore oil, gas or mineral exploration and exploitation. These activities increase vessel traffic, produce loud sounds for seismic profiling, place structures in areas used by whales, and introduce noises from drilling and production into the environment. Malme *et al.* (1985) exposed feeding humpback whales in southeastern Alaska to noise from a single air gun (1.6×10^3 cm^3) or to playback of recorded sounds of oil drilling, production platforms and aircraft. Whales showed no overall pattern of avoidance during 13 experiments, each of which included between 10 and 40 different animals. Whales dived as soon as the airgun was turned on in three experiments. These "startle responses", which occured at received sound levels between 150 to 169 dB (re 1 mPa), were thought to be caused more by the novelty of the air gun sound than by its intensity.

E. Habitat Degradation

1. Chemical pollution, including petroleum

The overall impact of pollution on habitats used by humpback whales is not known. Contaminants may be introduced by rivers, coastal runoff, wind, ocean dumping, dumping of raw sewage by boats and various industrial activities, including offshore oil and gas or mineral exploitation. Concentrations of organochlorine pesticides, heavy metals, and PCB's have been reported in humpback whale tissues from Canadian, United States, and Caribbean waters (Taruski *et al.* 1975). According to Geraci and St. Aubin (1982) and St. Aubin *et al.* (1984), short-term exposure to spilled oil or other petroleum compounds is unlikely to have serious direct effects on baleen whales. However, the biological appropriateness of the model used by those authors to evaluate effects of oil on baleen function has been questioned (Lambertson *et al.* 1989). R.H. Lambertson (pers. comm.) contends that the possibility that these whales could ingest a lethal dose of oil in a short time needs to be re-evaluated. It is not known whether humpbacks avoid oil spills. In 1979, for example, CETAP observers found humpback whales feeding in a small oil spill on George's Bank. The consequences of potential long-term exposure from catastrophic events such as the March 1989, spill of over 10 million gallons of crude oil in Prince William Sound caused by the wreck of the supertanker Exxon Valdez, are being evaluated, but no information has been released.

The greatest impact of an oil spill on humpback whales could occur indirectly. Local depletion of food resources may occur as a result of displacement and mortality of food species. Some species of euphausiids and other crustaceans may be highly susceptible to the toxic effects of oil and they are essentially unable to move away from the site of a spill (Rice *et al.* 1984). Other species such as herring, capelin, and sand lance could be effected by mortality of eggs and immature life stages, thereby reducing recruitment to the size classes used by the whales. Populations of pelagic spawners, such as anchovies, might be impacted less severely by an oil spill, since their eggs and larvae would be more widely distributed. Under most circumstances, a large portion of a year class is not likely to encounter the same spill. However, disasters on the scale of the Exxon Valdez oil spill, which spread over more than 2,000 km^2, could cause large perturbations in the productivity or distribution of many prey species, including pelagic breeders.

Current levels of offshore oil and gas development do not appear to prevent the potential for recovery of humpback whale populations. However, the problems of transporting oil may become increasingly serious. The Wall Street Journal (Wednesday, June 20, 1990, page 1), "On two out of every three days, on average, an oil tanker in U.S. waters catches fire, explodes, collides with a dock or another ship, breaks apart, experiences mechanical failure, runs aground or winds up in some other accident, Coast Guard accidents indicate." NMFS has raised the issue of cumulative effects in consultations with the Minerals Management Service (MMS). Currently, offshore oil production occurs off of the Atlantic coast of Canada, in the Gulf of Mexico, off of Central and Southern California, in Cook Inlet, Alaska, and in the

Beaufort Sea near Prudhoe Bay. MMS is considering leasing tracts of outer continental shelf lands for exploration and development in U.S. North Atlantic waters, particularly George's Bank; and in Northern California, Oregon, Washington, and Alaska (MMS five-year plan). Several of the areas proposed for leasing include, or are adjacent to, humpback whale foraging areas.

2. Habitat Degradation From Coastal Development

Although Reeves *et al.* (1978) speculated that intensive human use of Delaware and Chesapeake Bays has precluded their use by North Atlantic right whales (*Eubalaena glacialis*), we cannot be certain that such effects have stopped humpback whales from occupying or repopulating any habitats. One place where this might have occurred is Oahu Island, Hawaii. Herman (1979) summarized evidence from newspaper reports and other sources to suggest that humpbacks occurred along the coast of Oahu from the 1930's to 1950's, but not after the later 1960's. Although the apparent disappearance could be related to increased commercial hunting in the North Pacific during the early 1960's, Herman (1979) speculated that accelerated coastal development of Oahu may have displaced the whales, citing potential disturbance by pile drivers and other construction noises, increased runoff, and increases in boat and air traffic. This interpretation is complicated by the complete lack of documentation of the existence of humpback whales around the Hawaiian Islands prior to about 1850 (Herman 1979), and also by Herman *et al.*'s (1980) report that whales, including some calves, occur along the Oahu coast during March and April, perhaps as they begin the northward migration.

Coastal development could have particularly significant impacts in wintering ranges, where humpback populations concentrate. It may not be a coincidence that the primary remaining breeding site in the Antillean range, Silver Bank, is located over 100 km from land, relatively inaccessible to people, and protected from much ship traffic by a fringing reef. Most other apparently suitable wintering habitat in the Greater and Lesser Antilles is exposed to rapid growth of human populations, and concomitant increases in industry, shipping, harbor construction and dredging, small boat recreation, fishing, tourism and resort development, and local pollution. The degree to which these activities have restricted repopulation of the Lesser Antillean wintering range is not known.

Among the activities occurring in Hawaiian humpback whale habitat are harbor and boat ramp development, installation of permanent vessel moorings, recreational water sports, increased boat traffic, dumping of raw sewage by boats, commercial thrill craft activities, construction of outfalls for waste water discharge, runoff from the Olowalu dump site, agriculture and associated runoff, and development of thermal turbines for energy generation. Underwater noise and chemical contamination may be the most important potential impacts, but increased turbidity or other factors could also be locally significant. Similar lists could be constructed for coastal areas in many states or countries. However, these activities are particularly significant in Hawaii, because local waters are the primary site for reproduction of the eastern North Pacific feeding aggregation.

Water-dependent construction activities frequently involve blasting, dredging, and filling which could result in displacement, injury, or mortality of humpback whales. These adverse effects can and should be mitigated or eliminated through seasonal timing or construction design modifications. While the actual physical loss of habitat may be small in comparison to the total habitat available, secondary effects associated with the initial habitat modification may have negative consequences on the distribution and reproductive success of humpback whales. Examples of such impacts might include increased vessel traffic associated with harbors, ramps, moorings, and hotels; development of tourism focusing on watching whales or diving with them; degradation of water quality resulting from increased surface runoff (agricultural, industrial, and residential); and sewage effluent from land and vessels. For example, only one Hawaiian marina has a sewage pumping station. Consequently, boats dump sewage directly into the water and sewage slicks can be seen at the surface (Glockner-Ferrari and Ferrari 1985b).

Both the mainland shore of Western Mexico and the coast of southern Baja California are currently undergoing rapid development for tourism. Evidence from photo-identification studies indicates that waters along those shores are the primary wintering ground for humpbacks of the Central California feeding aggregation. Protective actions in U.S. waters used by this population in summer will be less effective in promoting population recovery if development produces a decline in the suitability of their winter habitat.

The effects of the Alaskan logging industry are increased soil erosion and runoff, plus infusion of large quantities of bark into nearshore waters where humpbacks concentrate. Discharges from pulp mills containing numerous toxic chemicals occur where whales congregate to feed on herring in Sitka Sound (J.M. Straley, pers. comm.). Increased vessel traffic and log rafting could negatively impact whales directly or indirectly in local feeding areas (C.S. Baker, pers. comm.).

F. Competition for Resources with Humans

Cetaceans are important components of marine ecosystems (Katona and Whitehead 1988). Recent information indicates that marine mammals probably consume at least as much fish as is harvested by humans (Kenney *et al.* 1985; Laws 1985; Winn *et al.* 1987). Humans and humpbacks may be competing for prey if either takes a large fraction of a fishery stock, even if those takes occur at different times.

Humpback whales are known to feed on several species of fish that are harvested directly by humans. In addition, they feed on species which are the prey of harvestable fishes. The magnitude and details of potential resource competition between humans and humpback whales is not known, but expanding human and whale populations and the increased demand for fish products may create new problems. The issue could become especially severe if new or expanding fisheries target on species used extensively by humpbacks, such as sand lance in the North Atlantic and capelin and herring in Alaska.

The relationship between humpbacks and fishermen in Newfoundland demonstrates that recovery of the whale population may create some practical difficulties. Humpbacks are seen as pests by Newfoundland fishermen. Perhaps the chief reason that fishermen tolerate the level of fishing damages caused by the whales is that the animals are classified as endangered (Lien *et al.* 1985). If damages increase on a scale similar to trends in the last 10 years, it seems likely that Newfoundland fishermen will not continue to cooperate with programs that encourage population growth and that they will demand full compensation for damages that the animals inflict (Lien 1989a; Lien *et al.* 1989a). Thus, the degree of additional humpback population recovery that can be sustained along the Newfoundland coast may depend in large part on whether it will be possible to make technological changes in fishing practices or fishing gear which minimize damage by the whales.

VI. RECOMMENDED RECOVERY ACTIONS

A. Goals

This Plan recommends actions designed to help humpback whale populations to grow to at least 60% of their abundance before commercial hunting and to expand into formerly occupied ranges. Since it is not yet possible to estimate pre-hunting population sizes sufficiently accurately, an interim goal is recommended that humpback whale populations addressed in this Plan double in size within the next 20 years. The Plan sets out four major objectives: (1) maintain and enhance habitat; (2) identify and reduce human-related mortality, injury and disturbance; (3) measure and monitor key population parameters to determine if recommended actions are successful; and (4) improve administration and coordination of the overall recovery effort for this species. Recommended legislative, enforcement, management, and research tasks are detailed below.

The ultimate goal of this Plan is to be "biologically successful." Biological success will be achieved when humpback whales occupy all of their former range in sufficient abundance to buffer their populations against normal environmental fluctuations or anthropogenic environmental catastrophes (e.g. a large oil spill). The best estimator of continued biological success will be if the Plan is "numerically successful." Numeric success will occur when humpback whale populations grow to levels where their population dynamic responses indicate density dependent reductions in productivity. Such changes will indicate that the population is nearing its carrying capacity under prevailing environmental conditions. Managers will then have to judge whether that population is sufficiently large to expect long-term biological success, or whether some environmental parameters might be modified to allow the population to increase further. Finally, this Plan will be "politically successful" when humpback whales are abundant enough to allow them either to be reclassified from "endangered" to "threatened"; or possibly removed from the list of protected species.

This Plan cannot now identify specific target population sizes at which such "downlisting" might be considered. Different populations of large mammals achieve maximal productivity at approximately 60% to 80% of environmental carrying capacity. Since neither pre-commercial whaling historical abundance nor current environmental carrying capacity can yet be estimated sufficiently accurately for humpback whales, such percentages cannot now be used as goals. The desirability of downlisting a population may be considered when its population dynamic parameters indicate that it is approaching the environmental carrying capacity.

Given the interim goal of doubling the size of populations within 20 years, acceptable evidence of ongoing population recovery will be (1) statistically significant trends of population increase as determined by accepted methods of population analysis; and (2) statistically significant trends of population increase in portions of the range known to have been occupied in historical times. Such evidence must be collected separately for the populations which either breed and/or feed largely in waters under the jurisdiction of the United States. This Plan recommends the development of improved, standardized methods for estimation of current population sizes and trends, so that recovery can be monitored more precisely. Additional research to estimate historical population sizes is also recommended in order to put current and future population levels into a broader context.

Underlying this Plan is the necessity that humans and humpback whales share the marine habitat. Human use of the ocean will not cease, so it is unlikely that the humpback whale could or should return to its full abundance of previous millennia. On the other hand, recovery to the degree identified above will still require some restraints on the part of humans. In seeking this balance, any interference with human activities that may be proposed in this Plan should be based on reasonable evidence that there would be some corresponding benefit to the whales.

B. Step-down Outline

OBJECTIVE 1. MAINTAIN AND ENHANCE HABITATS USED BY HUMPBACK WHALES CURRENTLY OR HISTORICALLY.

1.1 Identify essential habitat.

1.11 Identify essential habitat in Hawaiian waters.

1.12 Identify other essential habitat in U.S. waters.

1.13 Encourage protection of essential habitat under the jurisdiction of other nations.

1.14 Refine description of habitats and habitat features utilized by humpback whales.

1.2 Examine history of occupancy and potential for repopulation of important habitats.

1.21 Gulf of Mexico and northwestern Caribbean.

1.22 Hawaiian Islands.

1.23 Western North Pacific and Trust Territories of the Pacific (Guam).

1.24 American Samoa.

1.25 Lesser Antilles.

1.3 Identify and minimize possible adverse impacts of human activities and pollution on important habitat.

1.31 Develop protocol for monitoring physical and chemical factors that could decrease habitat suitability.

1.311 Investigate responses of humpback whales to human-related habitat changes.

1.3111 Reduce disturbance from human-produced underwater noise in Hawaiian waters and in other important habitats when humpback whales are present.

1.4 Monitor parasite load, biotoxins and anthropogenic contaminant level in tissues of whales and their prey.

1.41 Develop standardized protocol for sampling tissues of whales using strandings and biopsies.

1.42 Develop protocol to sample anthropogenic contaminant levels in tissues of prey.

1.43 Implement base-line study of parasite load in whale tissues and contaminant levels in tissues of whales and prey.

1.44 Monitor biotoxin concentration in tissues of prey species and whales.

1.5 Provide adequate nutrition.

1.51 Monitor levels of prey abundance.

1.52 Identify and evaluate fisheries competition.

1.53 Prevent initiation of new large-scale fisheries for primary prey of humpback whales.

1.54 Improve cooperation with commercial fishermen.

1.6 Develop Federal-State-Local partnerships for protecting humpback whale habitats.

1.61 Encourage government entities at all levels to correct existing impacts on habitat of humpback whales.

1.611 Convene workshop on habitat protection of humpback whale winter ranges in waters under U.S. jurisdiction.

1.612 Convene workshop on protecting humpback whale habitats in Alaska.

1.613 Convene workshop on protecting humpback whale habitats in California and Mexico.

1.614 Convene workshop on protecting humpback whale habitats along the east coast of the United States.

1.7 Encourage multinational cooperation to protect humpback whale habitats.

1.71 Distribute U.S. Humpback Whale Recovery Plan to other countries and provide follow-up communication as appropriate.

1.72 Integrate plan recommendations with goals of the International Whaling Commission (IWC).

1.73 Encourage habitat and environmental protection for humpback whales by other nations.

1.74 Encourage other nations to develop recovery plans for conservation and management of humpback whales.

1.75 Negotiate bilateral or multilateral agreements to protect humpback whale habitats.

OBJECTIVE 2. IDENTIFY AND REDUCE DIRECT HUMAN-RELATED INJURY AND MORTALITY.

2.1 Continue prohibition on commercial hunting of humpback whales.

2.2 Continue to identify sources and rates of human-induced injury and mortality and use information to reduce those factors.

2.21 Reduce mortality and injury from entanglement in fishing gear or other obstacles.

2.211 Improve reporting of entangled whales and rescue them when possible.

2.212 Use standardized forms for entanglement reports.

2.213 Investigate and modify fishing gear to prevent entrapment or entanglement.

2.214 Identify and implement seasonal and/or geographic regulations for fishing gear that may kill or injure humpback whales.

2.215 Require fishing gear to be removed when fishery ends.

2.22 Evaluate impact on humpback whales from collisions with ships or boats.

OBJECTIVE 3. MEASURE AND MONITOR KEY POPULATION PARAMETERS.

3.1 Estimate and re-evaluate historic population sizes.

3.2 Improve current population estimates by evaluating and re-analyzing existing data with improved techniques.

3.21 Convene workshop to develop capture-recapture estimate of humpback whale abundance in the North Pacific Ocean using existing photographs.

3.3 Systematize sampling methods for estimating population size.

3.4 Maintain and develop facilities for obtaining, archiving and analyzing data on humpback whales.

3.41 Archive existing data.

3.411 Maintain centers for comparative analysis of identification photographs.

3.412 Identify, accumulate and archive existing sightings survey data.

3.42 Dedicate research vessels to study humpback whales and other endangered cetaceans.

3.421 Build or retrofit research vessels.

3.422 Charter research vessels.

3.43 Extend photo-identification studies.

3.5. Perform new field studies on population dynamics.

3.51 Examine rates of birth, survivorship and mortality.

3.511 Convene workshop to estimate survivorship of calves based on existing individual-identification photographs.

3.512 Identify and quantify causes of natural mortality in juvenile and adult humpback whales.

3.52 Define geographic subdivisions of population.

3.521 Analyze and evaluate existing information on population subdivisions.

3.522 Implement immediately initial surveys of selected regions.

3.523 Describe migration routes and transit times.

3.5231 Employ long-term radio tags.

3.5232 Employ underwater listening stations.

3.5233 Utilize genetic techniques.

3.53 Estimate abundance of humpback whale populations.

3.531 Perform new census surveys.

3.532 Encourage and participate in international sightings surveys.

3.533 Implement improved sampling program for capture-recapture estimate of population abundance.

3.6 Assess population status and trends.

OBJECTIVE 4. IMPROVE ADMINISTRATION AND COORDINATION OF RECOVERY PROGRAM FOR HUMPBACK WHALES.

4.1 Select Director and implement Recovery Plan.

4.2 Improve governmental coordination.

4.3 Improve coordination with non-governmental agencies.

4.4 Expand or reconstitute a Recovery Implementation Team, update the Recovery Plan and prepare Comprehensive Work Plans for each stock.

4.5 Collect and archive available information on humpback whales, including translations of foreign literature.

4.6 Improve process for obtaining permits to do research on marine mammals and make appropriate changes.

4.7 Maintain coordination with other recovery programs.

4.8 Reassess as appropriate the goals for population recovery.

4.81 Change listings in Endangered Species Act (ESA) as appropriate.

4.9 Develop educational materials in support of Recovery Plan objectives.

4.91 Produce and distribute educational materials.

4.92 Improve cooperation with the whale watching industry.

C. NARRATIVE

OBJECTIVE 1. MAINTAIN AND ENHANCE HABITATS USED BY HUMPBACK WHALES CURRENTLY OR HISTORICALLY.

Humpback whale populations in each ocean basin occupy broad geographic ranges. The extent and quality of those habitats must be maintained so that current populations may increase. Modification or destruction of essential habitat or food resources from pollution and/or other human activities may become a major limiting factor for humpback whale populations. While further studies are being done and ameliorative measures are accomplished (see below), an interim objective is to prevent further habitat degradation. This can be accomplished by carrying out measures identified throughout Objective 1. Compliance with existing environmental laws at all levels will eliminate many, but not all, threats to humpback habitats. Federal, state and local agencies and their international counterparts must be encouraged to maintain and protect natural populations through appropriate legislative, enforcement and management activities. Federal, state and local agencies, as well as private institutions that operate facilities or programs, authorize or fund such activities, or otherwise retain jurisdiction or control over portions of the marine environment where populations of humpback whales now exist, will be asked to take part in maintaining existing populations under the appropriate steps described below.

1.1 Identify essential habitat. NMFS should identify areas essential to the survival or population growth of existing humpback whale populations. Winter habitats are especially critical to humpback whales. Winter ranges are typically restricted in geographical extent and may be used by whales from several feeding locations. In order for recovery of populations to occur, winter breeding habitat must not be constricted further, and mothers must be able to bear and nurse their calves without disruption.

1.11 *Identify essential habitat in Hawaiian waters.* Coastal waters less than 100 fathoms deep around the main Hawaiian Islands are essential to humpback whales. These waters are of paramount importance for reproductive activities of the Central Pacific stock, which includes the majority of humpback whales in the North Pacific Ocean. Since these waters are threatened by increased coastal development activities and possible habitat disruption, determination of appropriate protection for essential areas should be completed.

1.12 *Identify other essential habitats in U.S. waters.* Seasonal protection of other winter or summer ranges within U.S. waters also enhance population recovery. A determination of appropriate protection for these areas should be completed.

1.13 Encourage protection of essential habitats under the jurisdiction of other nations. Winter ranges crucial to reproduction of various humpback whale stocks are located in waters under the jurisdiction of many countries (Fig. 1). NMFS should encourage and assist, as appropriate, initiatives to protect such habitats in ways that will benefit the recovery of humpback populations.

1.14 Refine description of habitats and habitat features utilized by humpback whales. More accurate characterization of humpback whale habitats and their use will contribute to effective decisions for managing this species. Meaningful description of use of habitats must combine basic information on the whales' biology and behavior with detailed descriptions of physical and biological characteristics of habitats currently utilized. Factors to be evaluated more precisely include depth, bottom type and topography, water temperature, turbidity, acoustic characteristics, current speed and direction. Features offering protection from currents or storms need to be identified for wintering ranges. Seasonal abundance of prey species needs to be characterized for summering ranges. Sampling duration on the summer range should be extended through the winter, where possible, to ascertain the number, age, sex, reproductive state and behavior of humpback whales that do not migrate to the breeding grounds. Any differences in spatial and/or temporal use of summering or wintering habitats by sex, age, different reproductive classes or whales from different feeding aggregations should be described. The resulting data should be incorporated into methods for population estimation and other management decisions, including environmental impact statements. When possible, this information should be obtained by using or modifying existing sampling programs (e.g. MARMAP, NMFS surveys, EPA environmental assessment programs, etc.). New sampling initiatives may also be needed, and additional factors to be sampled may be identified in the future.

1.2 Examine history of occupancy and potential for repopulation of important habitats. A goal of this Plan is to give humpback whale populations the opportunity to expand into habitat occupied during historical times. Further information is needed on the history of occupancy of the following regions, the location and extent of habitats utilized, and their potential for repopulation by this species. The regions listed below are at least partly under U.S. jurisdiction, include winter range currently or historically used by humpback whales, or are particularly important to recovery of selected populations.

1.21 Gulf of Mexico and northwestern Caribbean. Humpbacks now visit the Gulf of Mexico and northwestern Caribbean Sea only infrequently. However, portions of that region could be suitable for the species and may have been used in earlier times. Surveys of existing literature should be undertaken to provide baseline information regarding any historical humpback whale occurrence in these areas. Examination of Spanish log books from the early periods of American colonization could be useful in this task. Resulting information plus data from any recent or ongoing cetacean census surveys should be used to evaluate whether additional field surveys are needed. In support of this subtask, it is recommended that international collaboration with Mexico, Jamaica and Cuba be initiated. Appropriate vehicles for this collaboration could be the IWC, MEXUS-GULF, or the Western Atlantic Turtle Symposium (WATS) model.

1.22 Hawaiian Islands. A discrepancy exists between the current high use of the Hawaiian Islands as winter range for humpback whales and the lack of historical documentation of the presence of this species in Hawaiian waters. Further research is needed to evaluate whether humpback whales have only colonized Hawaiian waters in recent centuries, and if so, to determine where else they might have wintered.

1.23 Western North Pacific and Trust Territories of the Pacific (Guam). As summarized in Rice (1974), humpback whales have historically wintered around the Mariana Islands, Bonin Islands, and from southern Honshu, Kyushu and South Korea southwest through the Ryukyu Islands to Taiwan. A long history of shore-based hunting and pelagic whaling reduced this population to the low numbers seen today. Ecological characterization of historically important wintering areas within this general range may help to evaluate their potential for repopulation. Darling's (1989) ongoing research on humpback whales in the Ogasawara Islands (Bonin Islands) includes updated information on occurrence at various locations in this region. Further information on historic abundance is needed.

1.24 American Samoa. In order to evaluate possible changes in abundance and distribution, it is recommended that NMFS describe current and historical abundance of humpback whales in waters surrounding American Samoa.

1.25 Lesser Antilles. The Lesser Antilles include winter habitat historically important to humpback whales, but current population size appears to be depressed. Further research is needed to examine the reasons for this difference and to evaluate whether the subsistence hunt at Bequia Island, St. Vincent and the Grenadines (Ward 1987), affected population recovery. In support of this subtask, collaborative research with the Caribbean nations of the region should be initiated. Appropriate vehicles for this research may be through IWC, IOCARIBE, or using the WATS model.

1.3 Identify and minimize possible adverse impacts of human activities and pollution on important habitat. Now and for the foreseeable future it will be necessary to monitor the occurrence and abundance of human-related chemical and physical factors that could decrease the ability of habitats to support humpback whales or their prey. Among the environmental factors that could affect the suitability of habitats for humpback whales are: (1) physical structures, such as oil drilling platforms or rigs; (2) industrial activities, byproducts, effluent, and/or domestic waste disposal; (3) dredging or disposal of dredge spoil; (4) runoff from agriculture, mining, lumbering or other activities; (5) underwater noise from ships or boats. As effects of human activities become more pervasive throughout the ocean, the possibility increases that habitats or populations might become unsuitable by insignificant stages, each too small to command notice or action. Evaluation of results should also take into consideration the possibility of cumulative or synergistic interactions between various factors. Better compliance with existing environmental laws is also needed to reduce potential impacts on habitat quality.

1.31 Develop protocol for monitoring physical and chemical factors that could decrease habitat suitability. Increases in the amount of human-made noise, turbidity caused by erosion or eutrophication, and perhaps other physical factors could affect the suitability of habitats currently or potentially used by humpback whales. A plan for long-term sampling and monitoring of physical and chemical factors at selected locations known to be important to humpback whales should be constructed and incorporated, where possible, in existing environmental sampling programs or in new programs recommended in this Plan. Among agencies already conducting related monitoring activities are NMFS (groundfish surveys, Status and Trends Benthic Surveillance Program, Mussel Watch Program), MMS (environmental impact assessment), EPA (monitoring of disposal sites for dredge spoils, sewage sludge, industrial wastes), ONR and the Army Corps of Engineers (environmental impact assessment).

1.311 Investigate responses of humpback whales to human-related habitat changes. Investigations of short- and long-term responses of humpback whales are needed when human-related habitat changes, such as pollution, waste disposal, oil spills, vessel traffic, or others, occur near known feeding or breeding areas. The resulting information should be used to predict potential effects of future changes and to identify previous modifications to habitat that may have affected distribution or population size of the humpback whale. Agencies such as MMS, Navy, U.S. Forest Service, Army Corps of Engineers and others that oversee development activities that can result in habitat alteration should be involved in such research. Valuable information may be gained when such incidents occur within foreign or international waters, but other provisions for leadership in this task will then be necessary.

1.3111 Reduce disturbance from human-produced underwater noise in Hawaiian waters and in other important habitats when humpback whales are present. Acoustic information is important in the life of a humpback whale. Feeding humpbacks may key in on sounds produced by other individuals or by prey. Migrating humpbacks may listen for sounds produced by other individuals, animals on the bottom, or echoes of their own vocalizations. They may also listen for calls of killer whales (*Orcinus orca*), as warnings of the presence of those potential predators. The exact functions of calls produced by humpback males on the winter range, and possibly at other times, are not fully understood, but they appear to have extremely important functions in reproduction and social organization.

Human-produced noises could potentially reduce information available to whales, physically disturb them, prevent them from carrying out some activities, or even displace them from preferred habitats. It is not possible to predict these effects on humpback whales by generalizing from information known about other species. Some information is available for this species (Baker 1982, 1983; Malme *et al.* 1985). Additional research could be performed, but it is likely to be expensive and may provide ambiguous results.

A more direct and cost-effective approach will be to work toward minimizing human-produced underwater noise, particularly in critically important areas such as Hawaiian waters or other winter ranges, but also at other locations when whales are present. For example, whale watch boats and some research or commercial boats should be designed (or chosen) and operated with noise reduction in mind. Choice of features such as exhaust configuration, engine and generator types and mountings, should include noise reduction as a design goal. Boat operators should be instructed in the importance of underwater sound and taught how to maneuver quietly so as to reduce the intensity (amplitude) of underwater sounds and avoid abrupt changes in sound intensity. Reduction of human-produced underwater noise could also benefit other marine species present, including some endangered species. Efforts to reduce industrial noise should also be undertaken by MMS and other appropriate agencies, where possible.

1.4 Monitor parasite load, biotoxins and anthropogenic contaminant level in tissues of whales and their prey. Contaminants such as pesticides, PCB's, hydrocarbons (e.g. crude oil), heavy metals and others, could affect survival of humpback whales. Systematic, long-term monitoring of the presence and quantity of such substances in humpback whales and in their prey species is needed to determine trends in environmental quality. Tissues sampled should be analyzed by a standardized laboratory protocol to allow comparability. Samples should be archived in a centralized location for future verification of results or use in further analyses. The EPA, NOAA/NOS/OAD and MMS should take the lead in contaminant monitoring studies.

1.41 Develop standardized protocol for sampling tissues of dead or living whales utilizing strandings and biopsies. NMFS should consult with veterinarians, physiologists, biochemists and field biologists to develop a list of tissues that should be sampled from dead or living whales and analyses performed in order to evaluate the amounts of contaminants they contain. This list should also include detailed information on procedures for obtaining, preserving, storing and ultimate disposition of samples. In order to make best use of samples, tissues and resulting information, construction of this list should be coordinated with other photographic and tissue sampling needs identified in this Plan. Material prepared by Geraci and St. Aubin (1978), Becker *et al.* (1988), Wise *et al.* (1988) and Heyning (in press) may be helpful in this task. Implementation of this protocol should utilize, supplement and support stranding and salvage networks already in place. Synthesis of existing information or new research should be undertaken to ascertain whether and how biopsy samples taken at sea could be used for physiological analysis (e.g. hormone levels) or analysis of anthropogenic contaminants.

1.42 Develop protocol to sample anthropogenic contaminant levels in tissues of prey. Concern over the accumulation of chemical residues in human foods has stimulated programs to monitor their occurrence in commercial fishes. Similar initiatives should be undertaken to monitor chemical and biological toxicants in humpback whale prey species. Federal agencies that commonly monitor the marine environment for contaminant levels, including the EPA, NOAA/NOS/OAD and MMS, should take lead responsibility for this monitoring activity.

1.43 Implement baseline study of parasite load in whale tissues and contaminant levels in tissues of whales and prey. Information developed in fulfillment of previous tasks should be put to use in implementation of a continuing program for sampling, analysis and evaluation of parasite levels and levels of contamination in whales and their prey. This information will contribute to better understanding of natural mortality and human-related mortality.

1.44 Monitor biotoxin concentration in tissues of prey species and whales. Biotoxins are poisons produced naturally by living organisms. The involvement of toxins produced by dinoflagellates in the deaths of humpback whales (Geraci *et al.*, 1990) and possibly bottlenose dolphins (*Tursiops truncatus*) (Geraci 1989) in the Western North Atlantic underscores the importance of developing a standardized program for sampling and analyzing the occurrence and quantity of substances such as saxitoxin, brevetoxin, or other biologically-produced toxins in humpback whale prey species and in the whales themselves. Appropriate sampling procedures should be developed and coordinated with other long-term sampling programs called for in this Plan. The degree to which recent appearances of biotoxins in baleen whales and porpoises are related to human-induced changes in habitat quality should also be evaluated. NMFS should take the lead in these activities.

1.5 Provide adequate nutrition. Humans can assist humpback whales to achieve their maximal productivity by providing, maintaining and optimizing their access to suitable habitats and prey. Humpback whales need access to their prey populations over a feeding range sufficiently widespread to buffer them from local fluctuations in productivity or fisheries take. Despite the tendency of individual whales to return to traditional summer grounds, the locations where humpback whales feed may change somewhat in response to naturally-occurring short- or long-term ecological changes. Parts of the summer range which are not currently used for feeding may produce more prey or attract more whales in the future. Therefore, maintaining quality and sufficient availability of prey throughout the current overall extent of humpback whale summer ranges is an important objective. It is also important to improve our understanding of the natural processes underlying the productivity and distribution of prey species as an aid to defining more exactly what portions of the summer range are required for feeding.

It will be necessary to strike an equitable balance between the whales' need for prey resources and the continuing need for humans to utilize fishery resources. Close consultation with appropriate Fishery Management Councils during accomplishment of tasks in this section will help find that balance.

1.51 Monitor levels of prey abundance. Much information on the abundance and ecology of some potential prey populations may already exist from surveys such as MARMAP, NMFS groundfish or scallop surveys, or others. However, NMFS should evaluate, refine and systematize these or other methods to maximize their utility for measuring or indexing the population sizes of humpback whale prey species. Appropriate methods should be applied to determine whether any trends in prey availability are occurring which might affect recovery of humpback whale populations.

As part of this subtask, NMFS should determine the degree to which the distribution and abundance of humpback whales is correlated with the distributions and abundances of their prey species. Available fishery resource data sets such as MARMAP, SEAMAP and Groundfish

Surveys should be compared with available information on relative abundance of humpback whales. If available data are not sufficient, NMFS should recommend ways to improve sampling or other factors in order to permit such comparisons.

1.52 Identify and evaluate fisheries competition. Initiate research to evaluate direct competition for resources between human fisheries and humpback whales. Use resulting information to assist fisheries management plans to ensure adequate escapement of prey species to meet the needs of humpback whales on traditional feeding grounds. The Recovery Team is aware that this task has complex ramifications and potential conflicts. For example, fishes eaten by humpbacks are themselves predators on zooplankton. Encouraging large populations of herring or other humpback prey could potentially reduce the abundance of copepods required by right whales (*Eubalanea glacialis*), and could conflict with goals of the recovery plan for that species.

1.53 Prevent initiation of new large-scale fisheries for primary prey of humpback whales. No new large-scale fisheries should be initiated that target important humpback prey species, such as sand lance along the southern New England coast or krill in Alaskan waters. Prevention of such fisheries will help preserve existing feeding opportunities for humpback whales. Management of existing fisheries for humpback prey species, such as herring or capelin, should consider the feeding requirements of humpback whales as a factor in determining harvest size.

1.54 Improve cooperation with commercial fishermen. Many conflicts could be resolved more efficiently and cooperatively through better communication between fisheries managers and commercial fishermen. NMFS should work with Regional Fishery Management Councils, appropriate State agencies (e.g. Departments of Fish and Wildlife) or others, and appropriate segments of the fishing industry to ensure that fishing activities will not cause direct or indirect adverse affects to the humpback whale. Information on the status of humpback whales should be provided to commercial and recreational fishermen. Fishermen should be involved from the start in planning and implementation of tasks involving fisheries-related topics. The importance of reporting injured, entangled or dead humpback whales should be explained and emphasized. Instructions for making such reports should be prepared and distributed. Obstacles to reporting of incidentally entangled whales, such as fear of legal consequences for fishermen, should be eliminated. Canadian scientists at the Memorial University of Newfoundland, St. John's, have considerable experience balancing the needs of fishermen with the needs of humpback whales (Lien *et al.* 1989a,b) and should be consulted in this Task.

1.6 Develop Federal-State-Local partnerships for protecting humpback whale habitats. Although management of the humpback whale is primarily a Federal responsibility delegated to NMFS, some states have important humpback whale habitat within or adjacent to waters under their jurisdiction. Actions by these states may have a direct bearing on the accomplishment of recovery objectives.

For example, states can aid the recovery of humpback whale populations by: (1) reviewing relevant local laws and making changes where appropriate to enhance habitats; (2) identifying potential impacts of proposed construction and/or habitat modification activities on humpback whales and their habitats; and (3) using the Federal Coastal Zone Management Act of 1972 (CZMA), as amended (P.L. 92-583) and other legislative processes to ensure protection for the whales and their habitats. Use of the CZMA to protect humpbacks or their habitats requires that states CZM plans include specific provisions to that effect. All components of CZM plans require approval by the Department of Commerce.

For these reasons, and because Federal actions to protect humpback whales and their habitat may affect state or local programs and interests, states and some local representatives should be closely involved in reviewing recovery needs and cooperating to carry out appropriate actions. NMFS should take the lead in developing such productive Federal-State-Local partnerships.

1.61 Encourage government entities at all levels to correct existing impacts on habitat of humpback whales. When aware of activities in state waters that appear to threaten humpback whales or their habitat, NMFS should initiate actions to mitigate or prevent those threats. A series of workshops to explore ways to protect humpback whale habitats should be implemented and federally funded. They should identify policy problems, discuss recovery or management plans, and present current research that may relate to species recovery. Input from representatives of private research facilities, academic institutions and other non-governmental organizations should be solicited as appropriate in order to stimulate cooperation.

1.611 Convene workshop on habitat protection of humpback whale winter ranges in waters under the jurisdiction of the U.S. The United States has jurisdiction over portions of several winter ranges used by humpback whales, including waters in Hawaii, Samoa, Guam, the U.S. Virgin Islands and Puerto Rico. NMFS should convene a workshop attended by appropriate representatives from those locations to address problems concerning protection of humpback whales and their winter habitats. Continued suitability of the wintering range is necessary to meet the goals of this Plan. The workshop should assess actions that could be taken to maintain or upgrade habitat quality for humpback whales.

1.612 Convene workshop on protecting humpback whale habitats in Alaska. Alaskan waters host the majority of humpback whales that feed along the U.S. Pacific coast. Continued growth of this historically large population will be the main impetus to recovery of the North Pacific humpback population. Suitability of Alaskan habitat is essential to this population. The recent Exxon Valdez oil spill disaster emphasizes that industrial activities threaten portions of the Alaskan coast. At the same time, fisheries could potentially reduce the amount of prey available for humpbacks. A workshop to discuss short-term and long-term plans for ensuring the health of Alaskan humpback whales and their habitat will help to meet the goals of this Plan.

1.613 Convene workshop on protecting humpback whale habitats in California and Mexico. Federally- regulated waters adjacent to the California coast host the majority of humpback whales found along the west coast of the Continental United States (coastal Eastern North Pacific stock). Shipping, industrial activities and pollution could affect the long-term suitability of this habitat. Most whales that feed along the California coast migrate to Mexican waters during winter. Their winter habitat faces threats from increasing human development. A workshop to discuss short-term and long-term plans for ensuring the health of the California and Mexico habitats that sustain the coastal Eastern North Pacific stock of humpbacks will contribute to meeting the goals of this Plan.

1.614 Convene workshop on protecting humpback whale habitats along the east coast of the U.S. Federally- regulated waters in New England host the majority of humpback whales found along the U.S. Atlantic coast. Continued suitability of habitats such as the Great South Channel and Stellwagen Bank, for example, is essential to maintain a population of humpback whales along the U.S. east coast and meet the goals of this Plan. A workshop to discuss short-term and long-term plans for ensuring the health of this population and its habitat should receive high priority, as should implementation of those plans. Designation of Stellwagen Bank as a National Marine Sanctuary should be discussed at this workshop if it has not already been accomplished.

1.7 Encourage multinational cooperation to protect humpback whale habitats. The humpback whale is a migratory species that occupies broad geographical ranges, spending portions of its annual life cycle in different habitats under the jurisdiction of various countries. Effective actions to achieve population recovery will not only require an understanding of all regions and ecosystems used by the species, but will also require strong multinational cooperation. Nations, whose waters are inhabited by humpback whales or whose overseas activities take place in such waters, may have opportunities to perform actions that can aid the success of this Plan. NMFS should encourage such actions as may be identified by bringing them to the attention of colleagues from other nations or the Department of State. If the recommendations of this Plan become strong priorities in U.S. foreign policy and in the foreign policy of other Nations, this Plan will be more likely to succeed.

1.71 Distribute U.S. Humpback Whale Recovery Plan to other countries. A first step toward fostering international cooperation should be distribution of this Recovery Plan, and other relevant information about U.S. actions for humpback whale recovery, to governments of all countries where humpback whales are found; countries whose fisheries or other industries might affect humpback whales in international waters; and appropriate international agencies identified by NMFS. The Director of implementation for the Recovery Plan should arrange follow up communications with personnel in other countries as appropriate.

1.72 Integrate plan recommendations with goals of the International Whaling Commission (IWC). Since NMFS cannot directly determine IWC goals, consultation between the Proposed Recovery Director (Task 4.1) and the U.S. Commissioner to the IWC will be necessary to see how the IWC can contribute to the recovery effort most effectively.

1.73 Encourage habitat and environmental protection for humpback whales by other Nations. Agencies responsible for marine environmental protection in other nations whose waters are inhabited by humpback whales, such as Canada, Greenland, the Dominican Republic and other island nations of the Caribbean region, Mexico, Japan, Colombia, Brazil, Australia, New Zealand, and Tonga, among others, should be consulted to determine what actions they are taking to maintain and enhance the quality of habitats used by this species. Mutual exchange of information and appropriate resources between those Nations and the United States is encouraged.

1.74 Encourage other nations to develop recovery plans for conservation and management of humpback whales. Any Nation, whose waters may be used by humpback whales, could make an important contribution by constructing a recovery plan detailing appropriate actions that could be initiated to foster recovery of this species.

1.75 Negotiate bilateral or multilateral agreements to protect humpback whale habitats. NMFS should request the Department of State to negotiate for bilateral or multilateral agreements to protect critical habitat or regions of particular significance for humpback whales that visit or pass through U.S. waters or other stocks that could benefit by such actions. High priority should be given to agreements for protecting habitats at Silver Bank, the Ogasawara Islands and Ryukyu Islands, and along the Pacific coast of Mexico, including the Revillagigedo Archipelago, Puerta Vallerta and Cabo San Lucas.

OBJECTIVE 2. IDENTIFY AND REDUCE DIRECT HUMAN-RELATED MORTALITY, INJURY AND DISTURBANCE.

The rate of change of population size is the net result of four processes, birth (+), immigration (+), death (-) and emigration (-). Techniques for artificially increasing birth rate are not yet feasible for this species. Rates of immigration and emigration between stocks are probably low, if such movements occur at all, and probably cannot be speeded up. Thus, the major ways that we can increase humpback whale population growth is to optimize natural fecundity by providing adequate feeding opportunities (Task 1.5) and by reducing death or injury caused by human activities, as recommended in the following tasks.

2.1 Continue prohibition on commercial hunting of humpback whales. Since hunting was responsible for the decline of humpback whale populations throughout their range, existing prohibitions against hunting of this species should remain in force at least until recovery is complete.

2.2 Continue to identify sources and rates of human-induced injury and mortality and use information to reduce those factors. NMFS should investigate and identify sources and rates of injuries and mortality attributed to human activities. Useful information already exists in collections of photo-identified whales, necropsy reports from Regional Stranding Networks and the Smithsonian Institution's Marine Mammal Event Program (MMEP) and other sources. Recent amendments to the Marine Mammal Protection Act require reports of incidental take of any marine mammal by U.S. fisheries. The impact of other fisheries, such as the widespread North Pacific driftnet fishery for squid, needs to be studied. All dead humpback whales should be photographically identified to provide information on variation in mortality by age, reproductive class or other variables. Successful accomplishment of this task will be enhanced by increased support of Regional Stranding Networks.

After compiling available information, NMFS should initiate actions to reduce the causes and rates of human-induced injury and mortality. Based on current information, the largest source of direct human-related mortality for humpback whales appears to be incidental entrapment or entanglement, primarily in fishing gear, but occasionally in other obstacles such as abandoned logging cable. Injury or death from collision with ships is also known to occur.

2.21 Reduce mortality and injury from entanglement in fishery gear or other obstacles. The current rate of injury and mortality from fishing gear and other potential obstacles such as logging cable or sonar arrays, does not threaten the humpback whale with extinction. However, it could retard the recovery of segments of the population. In most locations the species is not sufficiently endangered to require exceptionally expensive or heroic measures to save every entrapped or entangled whale. However, reasonable efforts are appropriate for humanitarian reasons, to minimize damage to fishing gear and to aid in population recovery. Where possible, such rescues should be attempted by existing groups experienced in appropriate techniques. Insurance should be provided for approved personnel who attempt to save entangled whales. Whenever possible, whales should be photographically identified and biopsy sampled before release. These occurrences may also provide good opportunities for attachment of long-term radio tags for use in Task 3.5231. All carcasses that can be retrieved through reasonable efforts should be photographically identified and thoroughly examined and sampled using standardized techniques. Material prepared by Hare and Mead (1987) will be helpful in identifying causes of mortality. These data may help to identify classes of whales that become entangled with increased frequency. Biopsy or tissue samples can also be used to increase the sample size available for genetics studies (Task 3.5233) and environmental contamination (Task 1.4). Performance of these and related tasks will benefit from coordination with recommendations included in the Right Whale Recovery Plan.

2.211 Improve reporting of entangled whales and rescue them when possible. NMFS, U.S. states and other Nations with interests in this species should continue to assist in developing a communications network to facilitate timely reporting of entangled whales and rapid dispatch of experienced personnel and equipment to save whales or salvage their carcasses for necropsy. Agencies that may become involved in rescue or salvage operations (e.g., U.S. Coast Guard, Air National Guard, etc.) should be included in development of contingency plans for rescue or carcass retrieval. A major objective of this

Plan should be to streamline authorization and deployment of personnel and equipment, thus reducing the time needed to take appropriate action. Development of this Plan should be coordinated with other related efforts, such as the Right Whale Recovery Plan.

The current reporting program is likely to underestimate large whale mortality from entanglement, because some whales will tear away nets or lines and swim away carrying a portion of the gear. This could encumber swimming, diving, feeding or other functions, but if such a whale is not seen again there is no way to evaluate the outcome of the entanglement event. Improved reporting of living or dead whales carrying pieces of fishery gear may reduce this problem, but the outcome of some events will never be known.

2.212 Use standardized form for entanglement reports. A standardized form for reporting entangled whales should be used. A comparable form was developed for reporting stranded marine mammals and has been useful to the Regional Stranding Networks.

2.213 Investigate and modify fishing gear to prevent entrapment or entanglement. Lien *et al.* (1989b) have demonstrated that acoustic warning signals can substantially increase the ability of humpback whales to detect fishing gear and can decrease both the probability and cost of collisions with gear. Research on large-scale implementation of acoustical protection for nets is underway in Canada (Lien and Guigne 1989). Incorporation of breakaway links might help whales to escape drowning and perhaps minimize damage to gear. These and other potential innovations should be investigated and incorporated as appropriate into new gear specifications. Canadian scientists should be consulted during implementation of this Task.

2.214 Identify and implement seasonal and/or geographic regulations for fishing gear that may kill or injure humpback whales. Information from evaluation of injuries and mortality caused by fishing gear will provide a basis for deciding whether to modify existing seasonal or geographic regulations to minimize impacts on humpback whales. This form of management should only be implemented as a last resort, following documentation of several impacts on humpback whales, and only after consultation with any affected States. This task should be coordinated with the reporting program required by the Marine Mammal Protection Act, as amended in 1988, and with new information gathered in Tasks identified in this Plan. If sufficient evidence for adverse effects is gathered, driftnet fisheries along humpback migratory paths should be prohibited during the times of year when the whales are present there.

2.215 Require fishing gear to be removed when fishery ends. If evidence indicates that humpback whales become entangled or entrapped in fishing gear still in place after a fishery ends, regulations requiring gear removal should be enacted.

2.22 Evaluate impact on humpback whales from collisions with ships or boats. Collisions with ships have been identified as an important cause of death in right whales (Kraus, in press), but no comparable body of information has been assembled for humpback whales. Information existing in photographic collections, strandings reports or other sources should be analyzed and synthesized to fulfill this Task.

OBJECTIVE 3. MEASURE AND MONITOR KEY POPULATION PARAMETERS.

More accurate assessment of present and historical changes of humpback whale populations throughout the range of the species is necessary for evaluating the success of this Plan. It will be important to reach early agreement on the indices used to track population status over the long term. Consistent long-term data are needed to identify spatial and temporal trends in abundance. Interpretation of data is hampered by inconsistent methodology, high variance surrounding estimates of the mean, and biological considerations such as low intrinsic rate of whale population growth and temporal variations in geographical distribution. Research methods must be designed to provide reliable and comparable results, funding must be provided for long-term research and monitoring efforts must continue long enough for population trends to be detected. Research collaboration between scientists from different Nations will be needed in many of the tasks outlined in this section.

3.1 Estimate and re-evaluate historic population sizes. Better estimates of historic population sizes are needed as a context for evaluating current sizes and establishing future objectives. NMFS should review existing descriptions of historic populations of humpback whales to determine whether they are adequate for recovery planning. If additional information is needed to determine historical population sizes, NMFS should allocate funds for analysis of any relevant whaling logs and literature on humpback sightings or fisheries that have not already been studied.

3.2 Improve current population estimates by evaluating and re-analyzing existing data with improved techniques. If any data relevant to estimation of population sizes exist that have not been analyzed or that could provide better information if re-analyzed, efforts should be made to improve estimates by applying new or different analytical techniques to that information. For example, a re-analysis of available shipboard and aerial survey data is necessary.

3.21 Convene workshop to develop capture-recapture estimate of humpback whale abundance in the North Pacific Ocean using existing photographs. The NMML is curating photographs of at least several thousand humpback whales contributed by research workers throughout the North Pacific Ocean (Mizroch, *et al.*, 1990). This collection may contain enough resightings to permit calculation of an improved estimate of population size using capture-recapture methods. NMFS should convene a workshop to review relevant data and photographs and prepare a population estimate. Preliminary data compilation and analysis will need to be accomplished in the first year as preparation for the workshop in year two.

3.3 Systematize sampling methods for estimating current population sizes. The research community must continue to evaluate, refine and systematize methods for measuring population size. Particular consideration should be given to improving sampling consistency, precision, accuracy and frequency. Improving comparability between different studies is an important goal. Standardized techniques for analyzing relative trends in population size, including the use of index areas, should be adopted.

3.4 Maintain and develop facilities for obtaining, archiving and analyzing data on humpback whales.

3.41 Archive existing data. Recovery of humpback whale populations will take many years. The time period needed to detect a trend in abundance will often exceed the average career length of individual scientists. Therefore, access to data on which population estimates were based should be preserved for years to come. NMFS should, whenever possible, take appropriate actions to gather and archive relevant existing data, as well as new data to be collected. Emphasis should be placed on peer-reviewed information published in scientific journals, but other sources of information should not be overlooked.

3.411 Maintain centers for comparative analysis of identification photographs. The information that individual research workers derive from photo-identification studies can be extended through collaborative studies. Such studies are already providing data on natality, survivorship, population size and sub-structure, migrations and habitat use. Photographic collections can also be analyzed to determine types and frequencies of injuries; habitat use and partitioning; and other relevant demographic and behavioral factors. Such analyses benefit from collaboration between researchers so that the photographic database includes a sufficiently large and widespread sample. Analysis of all photographs at central locations facilitates such collaboration and also provides improved opportunities for communication and quality control of data. Whole ocean catalogues of humpback whale fluke photographs are now curated at the National Marine Mammal Laboratory, Seattle (mainly Pacific Ocean); and at the College of the Atlantic, Bar Harbor, Maine (Atlantic Ocean). NMFS should continue to provide financial support for central analysis and archiving of the international collections of photographs curated at those locations. Incentives for collaboration and cooperation with those projects should be provided as appropriate by NMFS, IWC, other countries, and concerned non-governmental organizations. NMFS should encourage those facilities to apply new technology to facilitate standardization, storage, analysis and publication or distribution of photographs (e.g. Mizroch *et al.*, 1990).

3.412 Identify, accumulate and archive existing sightings survey data. A large number of sighting surveys for humpback whales have been conducted. Many analyses of temporal trend will require access to raw data. NMFS should identify, accumulate and archive these data sets in a fashion that will allow access for present and future analyses.

3.42 Dedicate research vessels to study humpback whales and other endangered species. The success of this Plan requires increased seagoing research capabilities. At least 200 days per year of sea-time will be required for each ocean basin. Sharing time on existing research vessels and working from platforms of opportunity is feasible for some tasks. Other tasks require vessels to be available for specific periods for several years. Existing large oceanographic vessels are not always practical for some tasks such as photographic-identification, biopsy, and behavioral observations. Small boats are available for such tasks in local or inshore waters, but no appropriate vessels exist for extended cruises in the continental shelf and slope waters of North America. Two vessels are needed, one for the east coast and one for the west coast. Funding and use of these vessels should be coordinated with other recovery plans, such as the Right Whale Recovery Plan, and in conjunction with such problems as assessment of the impacts of incidental take associated with the 1988 Amendments of the MMPA.

3.421 Build or retrofit research vessels. The most cost-effective way to provide the seagoing research capabilities needed for this Plan may be to construct or retrofit two research vessels. This approach would guarantee availability of appropriate vessels and would maximize chances for success of required research. If such vessels are constructed, funds required for research vessel charter (Task 3.422) would be much less than budgeted in Appendix A.

3.422 Charter research vessels. If dedicated research vessels are not constructed, substantial levels of support will be required for charter of available vessels best-suited for research needs. Current charter costs for oceanographic and/or commercial vessels needed for some tasks are on the order of $5,000 to $10,000 per day. As an example, 180 days for winter surveys in Hawaii and Mexico and summer surveys in Alaska and California would cost about $1,000,000 at the lower daily rate.

3.5. Perform new field studies on population dynamics. NMFS should implement new research to estimate the sizes and rates of change of humpback whale populations. The research is essential for evaluating actual and potential rates of population recovery. Some of these studies will also provide information about habitat use or other topics important for determining management actions.

identification of the studies and highest priority data needs should be based on the review and analysis of existing data. In some cases, a useful way to determine population trends may be to extend an existing database by duplicating an earlier study. This strategy may be cost-effective even when new methods or technology have superseded those used previously.

3.51 Examine rates of birth, survivorship and mortality. Estimates of birth rate, survivorship and mortality are important for evaluating the potential rate of recovery of humpback whale populations and comparing reproductive success in different geographic regions. Survivorship and mortality rates should be detailed as a function of age, sex, or other characteristics. Resulting data should be used to refine estimates of parameters used in models of population dynamics.

3.511 Convene workshop to estimate survivorship of calves based on existing individual-identification photographs. Photo-identification studies are already providing documentation of calf production by humpback whale females. Existing photographic samples of females with calves on the winter range should be compared with samples of the same females six months later on the summer range. Absence of calves will provide an estimate of mortality during the first year of life. NMFS should convene a workshop during which such photographs and data could be reviewed and analyzed for that purpose. Participants in this workshop should also consider whether implantation of long-term radio tags in mothers nursing on the winter ranges could provide significant improvement in sample size on the summer ground; or whether small enough tags could be developed and safely implanted to justify tagging calves directly.

3.512 Identify and quantify causes of natural mortality in juvenile and adult humpback whales. Information resulting from activities recommended in this Plan will lead to a better understanding of natural mortality. Episodic events, such as entrapment of humpback whales in ice along the coast of Newfoundland, should be documented when they occur. Better information on parasite load, biotoxin occurrence and effects and natural pathology of stranded whales may shed new light on the role of those factors in causing death.

3.52 Define geographic subdivisions of population. Further information on seasonal and longer-term differences in geographic movements of individuals is needed to describe the behavioral and genetic relationship between groups of humpback whales frequenting different regions. Isolation of existing sub-populations could affect population recovery at two levels. First, flow of individuals for replenishment of depleted sub-populations might be limited; second, inbreeding and subsequent loss of genetic variation could occur in small, isolated or remnant populations.

3.521 Analyze and evaluate existing information on population subdivisions. Studies using photo-identification have indicated that humpback whales in both the North Pacific and the North Atlantic Ocean aggregate into different feeding groups, between which there is apparently relatively little interchange. Furthermore, little interchange appears to occur between whales on the Hawaiian and Mexican Pacific wintering ranges. Some information on migration has been obtained from photo-identification and from earlier work using artificial (e.g. Discovery) tags. Following evaluation of existing information, studies using new techniques should be implemented, if needed, to provide more details on habitat use of individual whales.

3.522 Implement immediately initial photographic surveys of selected regions. Broad-ranging photo-identification studies are among the most powerful techniques available for determining migrational end points, population subdivisions, abundance and other important population parameters. Data need to be collected from the entire population range, much of which is outside of U.S. territorial waters. The Eastern North Atlantic, Azores Islands, and Cape Verde Islands; offshore waters of the Gulf of Maine and New York Bight; and Western Alaska, the Aleutian Islands and the western North Pacific are known areas of current and former distribution where inadequate sampling takes place. NMFS should promote extended sampling in those and other regions through directed effort in waters under U.S. jurisdiction and by encouraging collaborative or cooperative research programs with other countries in distant waters. Such efforts will contribute substantially to the objectives of Task 3.52. Scientists from many Nations have already contributed photographs to humpback whale fluke catalogues in both the North Atlantic and North Pacific Oceans, and such efforts are developing at several locations in the Southern Hemisphere.

3.523 Describe migration routes and transit times. Long-range movements of humpback whales are now known only by beginning and end points. The route travelled in between those observations is unknown. Better descriptions of migration routes are needed in order to know whether additional habitats might require protection and to ascertain the likelihood that migrating humpbacks might be exposed to serious environmental threats, such as high seas driftnet fisheries.

3.5231 Employ long-term radio tags. Studies using new tagging techniques, particularly long-lived radio tags tracked by satellite or other methods, should be carried out to provide detailed long-term and long-range information on habitat use and migration. Detailed charting of migration paths may reveal additional potential threats to the whales and may suggest additional management needs. Radio tags employed should minimize disturbance to the tagged whale and to other individuals with which it may physically interact. MMS, which has considerable experience in funding or carrying out such studies, should be consulted when planning these projects.

3.5232 Utilize underwater listening stations. Humpback whales begin vocalizing at the end of the feeding season while still on the summer range (Mattila *et al.* 1987). Listening for vocalizations may reveal information about migration routes (Clapham and Mattila 1990). Additional opportunistic acoustic sampling should be done. NMFS should urge the Department of Defense and the Office of Naval Research to share information on whale vocalizations obtained by military listening posts.

3.5233 Utilize genetic techniques. Recently developed molecular techniques for describing genetic variability at the DNA level (Lambertson *et al.* 1988; Hoelzel and Dover 1988; Amos 1989; Baker *et al.* 1990 and unpublished manuscript; Amos and Hoelzel, in press; Lambertson *et al.*, in press) facilitate examination of the genetic exchange or isolation between population sub-divisions. Such studies have just begun for humpback whales and should be extended. Biopsy sampling of several species of large whales for genetic analysis has already occurred. Naturally sloughed skin may also be useful for some analyses. Following evaluation of recent work, new studies should be implemented to obtain appropriate samples (from photographically-identified individuals, when possible) for genetic analysis of population sub-structure and degree of isolation between population sub-units. Genetic analysis of tissue from dead whales should also be performed when appropriate. Genetic techniques may also be useful to augment demographic studies by identifying sex and corroborating individual identification of naturally marked whales (Amos and Hoelzel, in press; Baker *et al.*, in review).

3.53 Estimate abundance of humpback whale populations. Present and future sizes of humpback whale populations need to be estimated using existing or improved methods for census surveys or capture-recapture experiments. Fulfillment of this and related tasks is essential for monitoring and evaluating progress toward the numerical goal of this Plan.

3.531 Perform new census surveys. As part of tasks identified elsewhere in this plan, new census surveys should be designed and implemented to estimate population abundance and trends. New tools such as acoustic census methods, high-resolution high-altitude photography, satellite imagery or others should be utilized if feasible and appropriate in order to improve or verify existing estimates of population size or growth trend.

3.532 Encourage and participate in international sightings surveys. Throughout the period of humpback whale population recovery, shipboard and aerial census surveys will be needed to monitor population changes in the waters of many countries and in international waters. International cooperative census surveys have already produced valuable information on humpback whales and other species in the North Atlantic, North Pacific and Southern Ocean. The IWC is the appropriate focus for coordinating such efforts.

3.533. Implement improved sampling program for capture-recapture estimation of population abundance. Application of capture-recapture analysis to collections of individual-identification photographs is a powerful method for estimating population size of baleen whales. The accuracy and precision of such estimates can be improved by designing improved photographic sampling and analysis protocols. The major goals of such a protocol should be to equalize the probability of being sampled for each animal in the population and to minimize or eliminate other sampling biases that could affect population estimates.

3.6 *Continue long-term photo-identification studies at current sites*. Photo-identification of humpback whales has been carried out for many years in the summer and winter ranges of populations which use waters under United States jurisdiction. Photographic collections spanning more than a decade exist for humpbacks from the Gulf of Maine and portions of their West Indies winter range; the coast of Central California and the Mexican winter range; and the coast of Alaska and the Hawaiian winter range used by those animals. Continuation of research at those sites to build on previous results is a cost-effective way to provide data required by the Plan; to identify long-term trends; and to evaluate progress toward goals specified in the Plan.

3.7 Assess population dynamics and trends. All of the data resulting from fulfillment of tasks listed in this Plan should be incorporated into an assessment of status and trends of humpback whale populations. An assessment incorporating other fisheries data and ecological information will help predict rates of population recovery. All relevant data should be characterized and reviewed in light of newer methods of analysis, such as the dynamic response method to determine whether a population is likely to be at or near carrying capacity (Goodman 1988; Gerrodette and DeMaster 1990).

OBJECTIVE 4. IMPROVE ADMINISTRATION AND COORDINATION OF RECOVERY PROGRAM FOR HUMPBACK WHALES.

Successful planning for the recovery of an endangered species is complex and requires the efforts of individuals, the collective public and branches of government at all levels, as indicated in the tasks below. Failure to cooperate effectively could seriously jeopardize population recovery. Additional tasks requiring administration and cooperation at the international level were detailed above.

4.1 Select Director and implement Recovery Plan. This Plan recommends many actions, including some that are broad in scope and span long periods of time. Successful implementation of these recommendations will require sustained attention and initiative from an individual who understands governmental processes at all levels and who can work effectively with scientists, fishermen, fisheries managers, shipping interests, the general public and other sectors. Designating a Director of the Humpback Whale Recovery Effort, who will have autonomy, a dedicated budget and responsibility for overseeing the implementation of this Plan will increase the chances for its overall success. It may be advantageous for this person to serve also as Director of the right whale recovery effort, if feasible.

4.2 Improve governmental coordination. Achievement of the goals of this Plan will require long-term coordination between many government agencies at local, state and Federal levels. NMFS should take the lead in developing effective communications between agencies involved in the recovery effort, for example in Task 1.6. Expansion or reconstitution of the Recovery Team to improve representation of responsible agencies will also be important (Task 4.4).

4.3 Improve coordination with non-governmental agencies. Non-governmental agencies make important contributions to the success of recovery efforts. NMFS should develop effective communications with appropriate groups interested in conservation and marine affairs, so that they may have the opportunity to direct some of their resources toward tasks identified in this Plan.

4.4 Expand or reconstitute a Recovery Implementation Team, update the Recovery Plan and prepare Comprehensive Work Plans for each stock. During consideration of the tasks and priorities contained in this Plan, it has become apparent that implementation will benefit by having representatives of several additional constituencies on the Recovery Team. For example, MMS, the U.S. Fish and Wildlife Service, and the National Park Service should be represented. Representation is also desirable from states containing critical habitat for humpback whales. Representation from other public and private institutions or by knowledgeable individuals should be continued. The reconstituted Recovery Team and Recovery Director should prepare Comprehensive Work Plans for each stock that identify and schedule recovery actions specific for each area. The Team and Director should also update the Recovery Plan or Comprehensive Work Plan when necessary.

4.5 Collect and archive available information on humpback whales, including translations of foreign literature. A comprehensive library of publications and information on humpback whales should exist in order to facilitate tasks called for in this Plan. NMFS should implement such a collection or assist in maintaining and extending an existing collection.

4.6 Improve process for obtaining permits to do research on marine mammals and make appropriate changes. Permits are required for working with free-living, entangled or dead humpback whales (and other marine mammals). Obtaining such permits has become a cumbersome task, requiring considerable paperwork and long periods of time. NMFS is currently reviewing its public display and scientific research permit program and making changes as appropriate to create integrated, efficient permitting procedures that will facilitate research recommended in this Plan. Additional coordination with the USFWS should be carried out in order to streamline the process for obtaining CITES permits, which will also be needed to carry out research recommended in this Plan.

4.7 Maintain coordination with other recovery efforts. It may be possible to save effort and expense by coordinating with other recovery efforts currently in progress. For example, opportunities for coordination with the tasks identified in the Right Whale Recovery Plan might include combined educational or public relations efforts; collaboration in carrying out fieldwork or analyzing results; cooperation in reporting and saving entangled whales; and sharing resources for archiving data and collecting published literature. NMFS should identify such opportunities and implement coordination as desirable.

4.8 Reassess as appropriate the goals for population recovery. The ultimate goal of this plan is to facilitate the growth of humpback whale populations until they reach at least 60% of their abundance before the species was impacted by commercial whale hunting.

4.81 Change listings in Endangered Species Act (ESA) as appropriate. If the Recovery Plan is successful, there will eventually be a need to reclassify ("downlist") one or more stocks or feeding aggregations from "endangered" to "threatened"; or to remove them entirely ("delist") from the list of protected species. This Plan includes criteria for evaluating whether its Goals are being achieved. It does not include criteria for downlisting or delisting stocks or feeding aggregations. Those criteria should be developed by the Recovery Director and the Recovery Implementation Team and agreed upon well ahead of the time when they might be employed.

4.9 Develop educational materials in support of Recovery Plan objectives. Public awareness of the recovery planning process in general and the goal and objectives of this Plan in particular will help achieve recovery objectives. An effective program to educate and learn from the public about how different sectors can help in recovery efforts will stimulate public cooperation in the tasks outlined throughout this Plan. NMFS should develop and distribute information materials in coordination with states, the Office of Coastal Zone Management, Sea Grant, Fishery Councils and other public and private groups, to: (1) advise the public of the protected status of humpback whales; (2) summarize Recovery Plan recommendations and ongoing recovery efforts; (3) solicit appropriate involvement of the public in actions related to this Plan; (4) provide instructions for field identification of humpback whales to facilitate reporting of injured, entrapped or dead specimens; and (5) foster attitudes that will enhance the habitats used by this species.

4.91 Produce and distribute educational materials. NMFS should consult with persons experienced in education and public relations to plan the most effective instruments for stimulating public cooperation, including brochures, pamphlets, media presentations and others. Information on appropriate vessel behavior when in the vicinity of whales should be included with materials distributed with boat registrations. Accompanying distribution of these or other instruments should be an evaluation of their utility in producing the desired behaviors. When possible, this Task should be accomplished in cooperation with appropriate State agencies or private groups active in public education.

4.92 Improve cooperation with the whale watching industry. NMFS should work with organizations of commercial whale watch operators and others to enlist their cooperation in achieving the objectives of this Plan. Ways in which whale watch tour operators can contribute to the humpback whale recovery effort include minimizing the potential for harassment, and incorporating information about the Plan into their own public education efforts or presentations by naturalists accompanying trips.

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TABLE 1. World population levels of humpback whales by stock or regional geographic area, according to guidelines set up by the International Whaling Commission. Data summarized from Breiwick and Braham (1984) and literature cited. (n.e. = no estimate; initial = before commercial whaling).

Population or stock	Population size initial	Population size current	Approximate % of initial
Eastern No. Atlantic	n.e.	n.e.	n.e.
Western No. Atlantic	>4,400-6,300[a]	5,505[b]	85%?[c]
Eastern No. Pacific	15,000[d]	>1,407[e]	13%?
Western No. Pacific		n.e.	n.e.
No. Indian Ocean	n.e.	n.e.	n.e.
Southern Oceans	100,000	>3,000[f]	>3%

a Breiwick et al. (1983) and Mitchell and Reeves (1983) analyzed only a portion of the available whaling logbooks, and concluded that initial population size is probably underestimated.

b 5,505 (95% C.I. 2,888-8,122) from Katona and Beard (1990).

c this percentage may be based upwards if initial numbers were greater than Breiwick et al. (1983) estimated.

d Rice (1978) for the entire North Pacific.

e 1,407 (95% CI 1,113-1,701) from Baker and Herman (1987).

f The Western South Pacific (eastern Australian coast) stock shows signs of recovering from excessive hunting. Simmons and Marsh (1986) reported an increase in sightings within waters of the Great Barrier Reef and Paterson and Paterson (1989) estimated that the population had increased from fewer than 500 when whaling ceased in 1962 to approximately 1100 in 1987.

TABLE 2. Summary of humpback whale life history data. Data are from the Northern Hemisphère, except where otherwise noted. (n.e. = no estimate).

Parameter/event	Estimate	Source
Conception	January	Nishiwaki (1959), Rice (1963)
	Year around[a]	Tomilin (1967)
	Dec.-Mar.	NMML (unpublished)[b]
Gestation	10-12 mo.	Nishiwaki (1959), Rice (1963)
ca. 12 mo.	NMML (unpubl)[b]	
Parturition	January	Nishiwaki (1959), Rice (1963)
	Dec.-Mar.	NMML (unpublished)[b]
Lactation	10-12 mo.	Nishiwaki (1959), Rice (1963)
	10.5 mo.	NMML (unpublished)[b]
Age at:		
sex.mat.-female	4-5-6 yr.	Clapham and Mayo (1987a)
	4-5	Chittleborough (1958,1965)[c]
	7-9 yr.	NMML (unpublished)[b]
-male	7-15 yr.	NMML (unpublished)[b]
max.age -female	61 yr.	NMML (unpublished)[b]
-male	57 yr.	NMML (unpublished)[b]
Length at:		
birth	4.1 m	Nishiwaki (1959), Rice (1963)
weaning	8.0 m	" "
sex.mat.-female	12.0 m	" "
sex.mat.-male	11.6 m	" "
phys.maturity	15.6 m	" "
phys.mat.-female	14.5 m	NMML (unpublished)[b]
-male	13.5 m	"
maximum-female	15.9 m	"
-male	14.3 m	"
Proportion of mature females	0.25	Nishiwaki (1959)

Pregnancy rate	0.42 $yr.^{-1}$	NMML (unpublished)[b]
	0.40 $yr.^{-1}$	Nishiwaki (1959)
Annual rate of calf production	0.30-0.43 $yr.^{-1}$	Clapham and Mayo (1987b)
	0.37 & 0.58 $yr.^{-1}$	Baker et al. (1986)
Calving interval	2.39 yr.	Clapham and Mayo (1987b)
	2.70 yr.	Perry *et al.*, in press
	2.38 yr.	NMML (unpublished)[b]
	1.2 yr.-3.1 yr.	Glockner-Ferrari & Ferrari (in press)
Sex ratio of calves	48.8% female	Glockner-Ferrari & Ferrari (1984)
	44% female	Clapham and Mayo (1987b)
Proportion of calves in population	10.3%	Chittleborough (1965)[c]
	3.9-11.8%	Whitehead (1982)
	6-11%	Bauer (1986), Herman *et al.* (1980)
	7.5%	Clapham and Mayo (1987b)

[a] Peaks noted from Feb.-Apr. and from Sept.-Oct.

[b] From humpbacks taken by commercial whalers along Central California coast, 1958-1965, compiled by D.W. Rice, A.A. Wolman, National Marine Mammal Laboratory, NOAA, Seattle, Washington

[c] Data gathered from the southern oceans.

TABLE 3. Variance-weighted means for estimated humpback whale populations of regions of the North Atlantic summer and winter range, based on capture-recapture analysis of photographically identified individuals.
(Modified from Katona and Beard, in press).

	MEAN[1]	95% Confidence Interval
EASTERN ATLANTIC	----	(no estimate)
Iceland	----	(no estimate)[2]
Greenland	194	1 to 478
Newfoundland	2310	1730 to 2890
G. St. Lawrence	155	94 to 206
G. of Maine	240	147 to 333
Bermuda	104	(only one annual estimate)
Dominican Rep.	1349	1 to 6953
Puerto Rico	359	1 to 1344
Virgin Bank	----	(no estimate)

[1] Variance-weighted mean.

[2] Sigurjonsson (1989) estimated the population of humpback whales in Icelandic waters to be less than 2000.

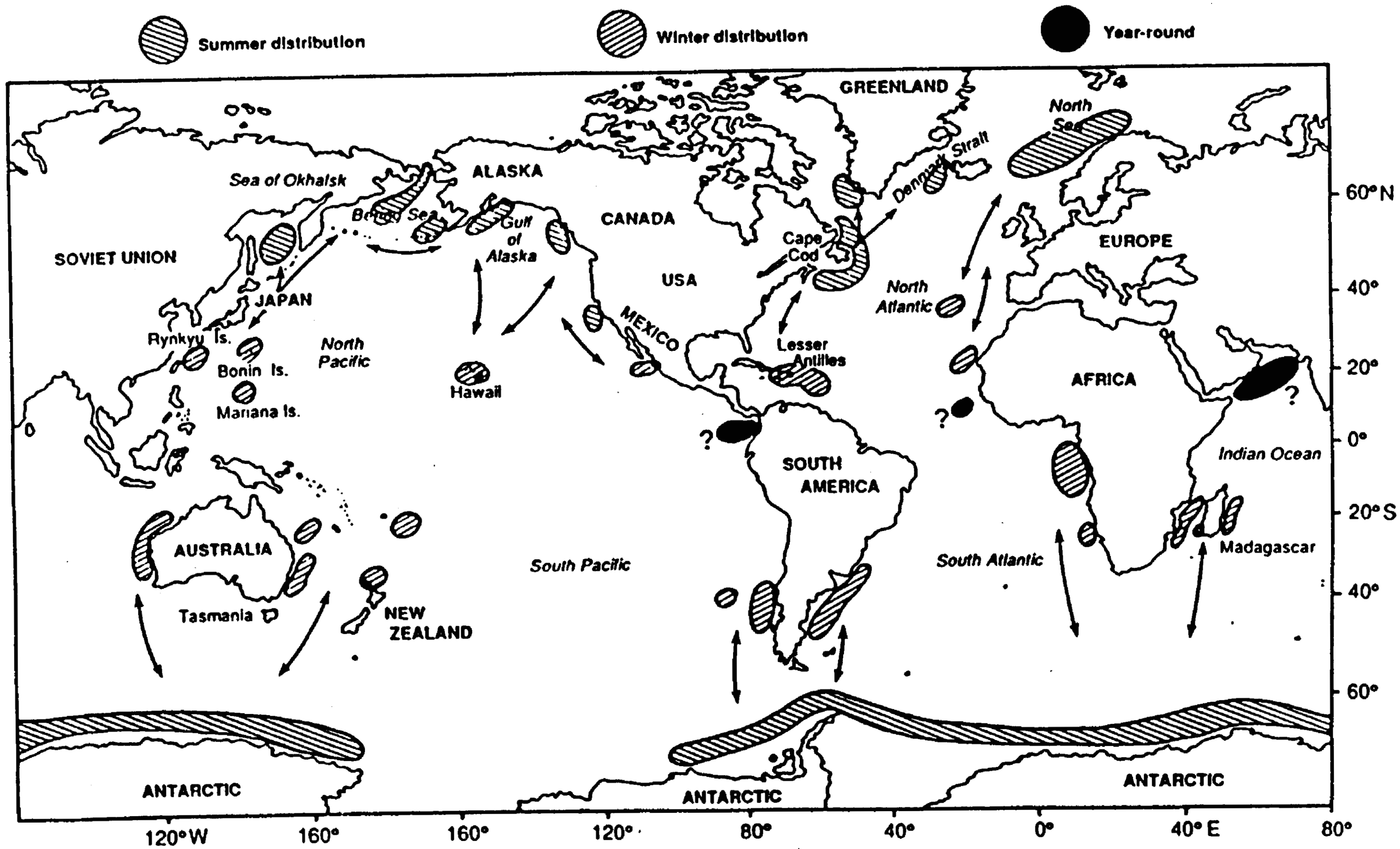


FIGURE 1. World-wide distribution of humpback whales.

FIGURE 1. STOCKS OF HUMPBACK WHALES. OVERALL WINTER AND SUMMER RANGES ARE LISTED FOR EACH STOCK, WHERE KNOWN.

STOCK	**WINTER RANGE**	**SUMMER RANGE**
Western North Atlantic	Lesser Antilles, Virgin Islands, Puerto Rico, Dominican Republic	Gulf of Maine, Canadian Maritimes, Western Greenland, Denmark Strait
Eastern North Atlantic	Cape Verde Islands, West Africa to Southern Morocco	European Coast North to Bear Island and East to Novaya Zemlya
Western South Atlantic	Southern Argentina to Southern Brazil	Antarctic Area II
Eastern South Atlantic	Angola, Gabon, Sao Tome and Principe	Antarctic Areas II, III?
Western North Pacific	Northern Mariana Islands, Ogasawara Islands, Ryukyu Islands Taiwan	Western North Pacific, Bering Sea, Okhotsk Sea, Eastern Aleutian Islands
Central North Pacific	Main Hawaiian Islands	Coast of Alaska and British Columbia
Eastern North Pacific	Islas Revillagigedo Central Baja California, West Coast of Mexico	Central California Coast
Western South Pacific	Eastern Australia, Chesterfield Island, Northern New Zealand, Tonga, Samoa	Antarctic Area V

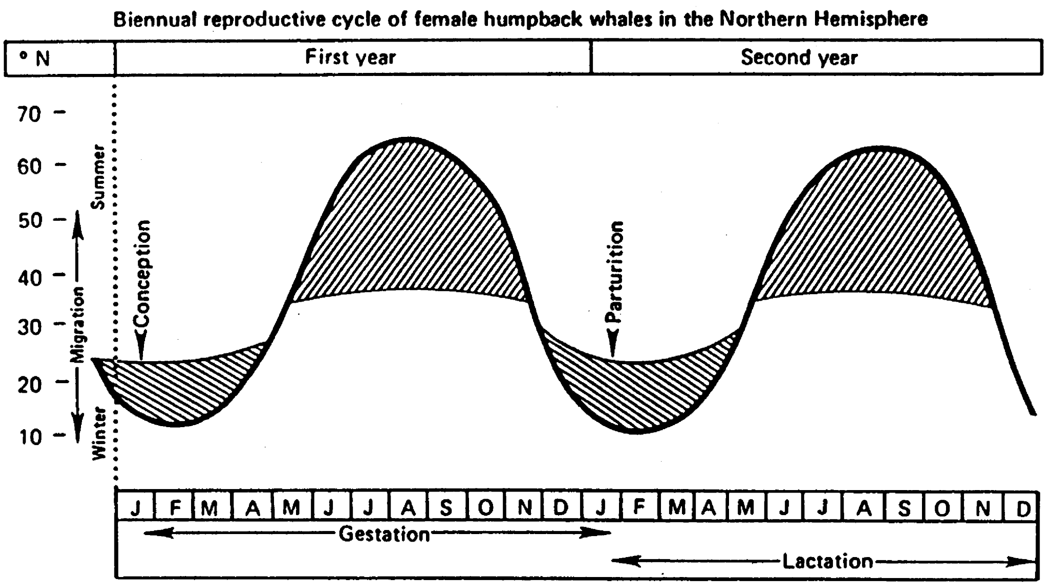
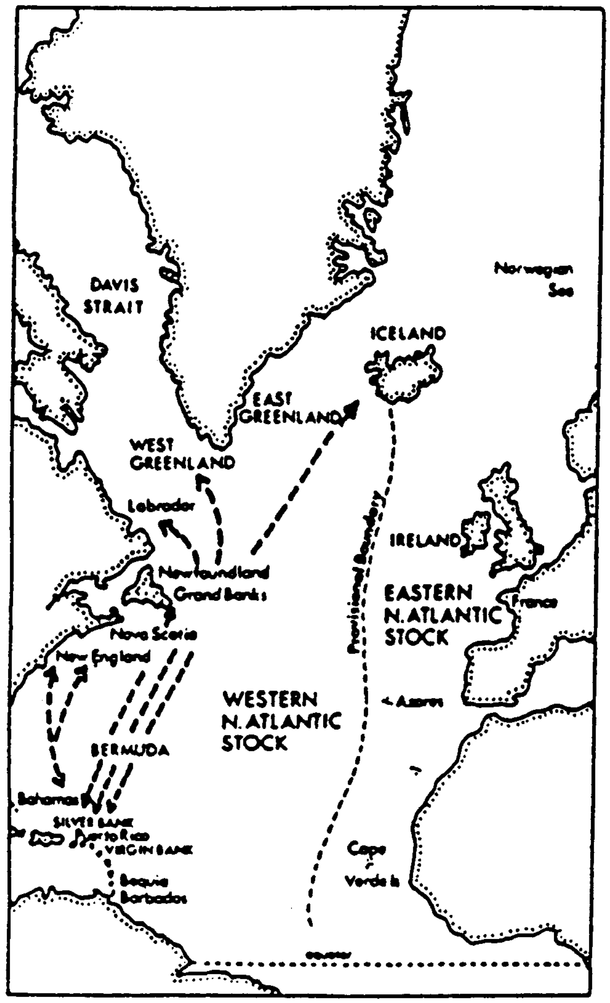


FIGURE 2. Schematic annual cycle of humpback whales in the Northern Hemisphere (adapted from the design of Lockyer and Brown 1981). Seasonal distributional patterns were averaged. Some whales do not leave the summer or winter grounds until well past the average departure time. Arrows indicate the approximate extent of latitudinal movements during the course of a year.

FIGURE 3. North Atlantic Ocean - Showing Locations Mentioned in text.



From Eannister, J.L., Mitchell, E.D.; Balcomb, K.C., Brown, S.G., and Martin, A.R. 1984. Report of the Subgroup on North Atlantic humpback boundaries. Rep. Int. Whal. Commn. 34:181.

FIGURE 3. North Atlantic Ocean - Showing Locations Mentioned in text.

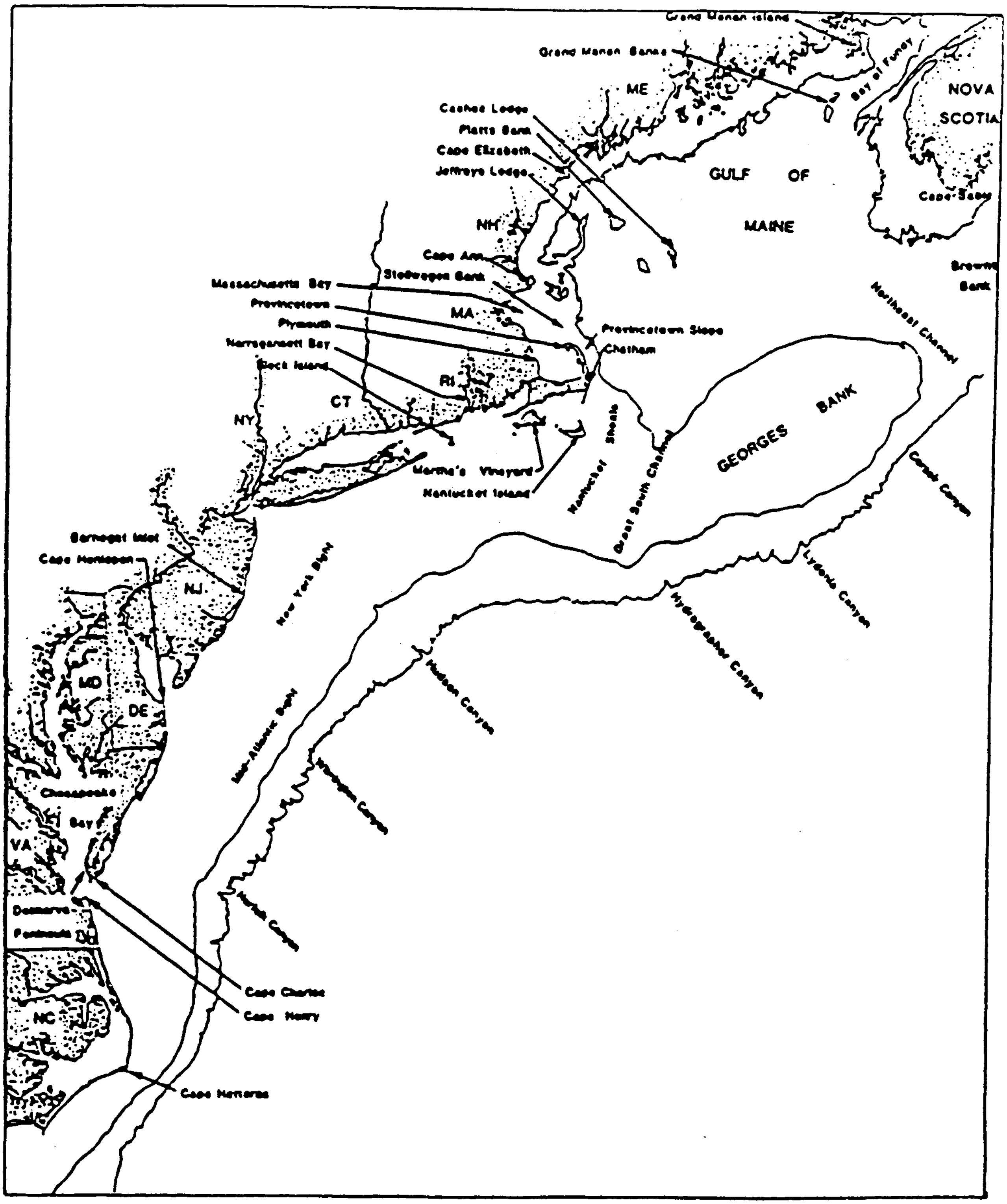


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FIGURE 3. North Atlantic Ocean - Showing Locations Mentioned in text.

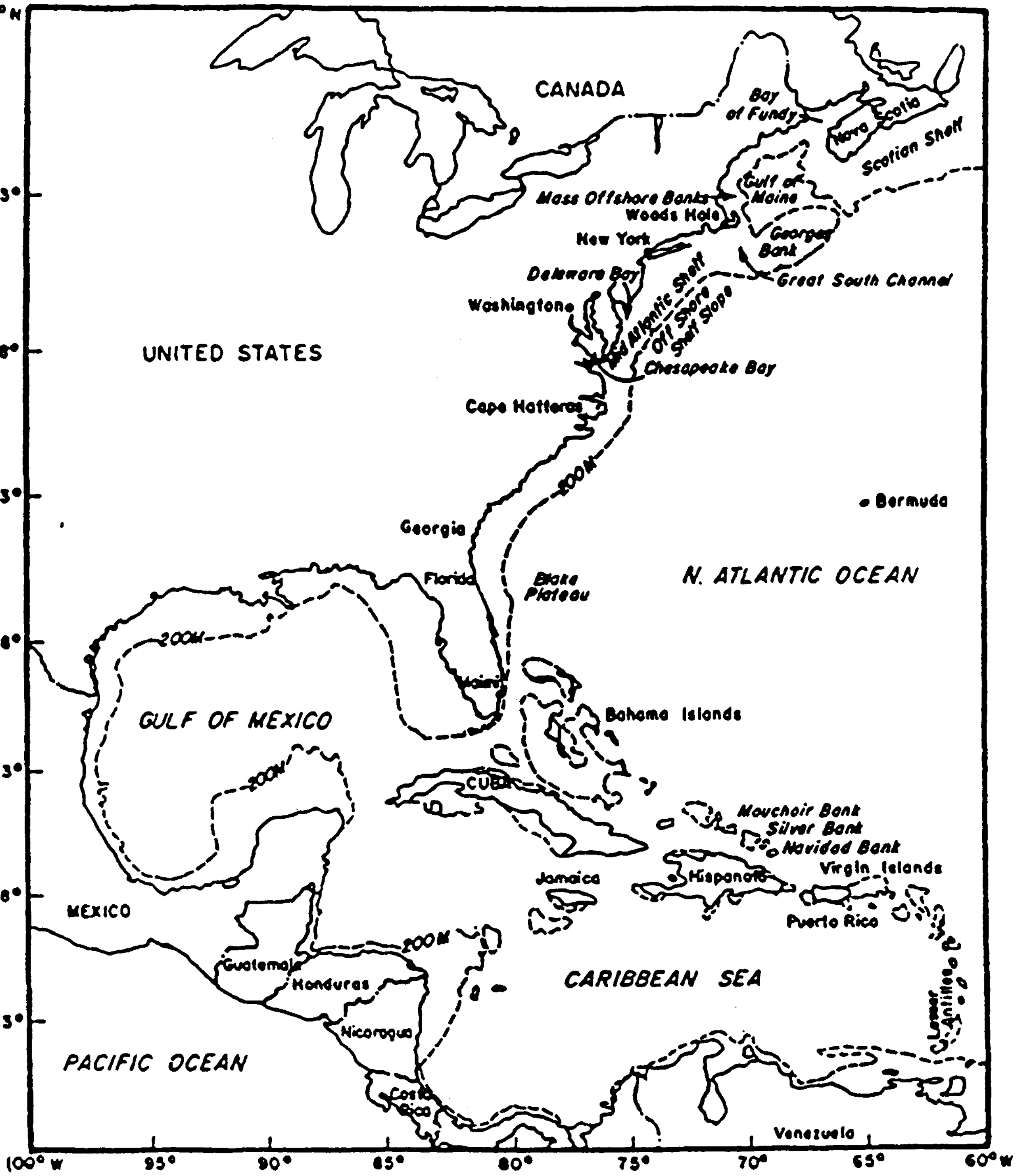
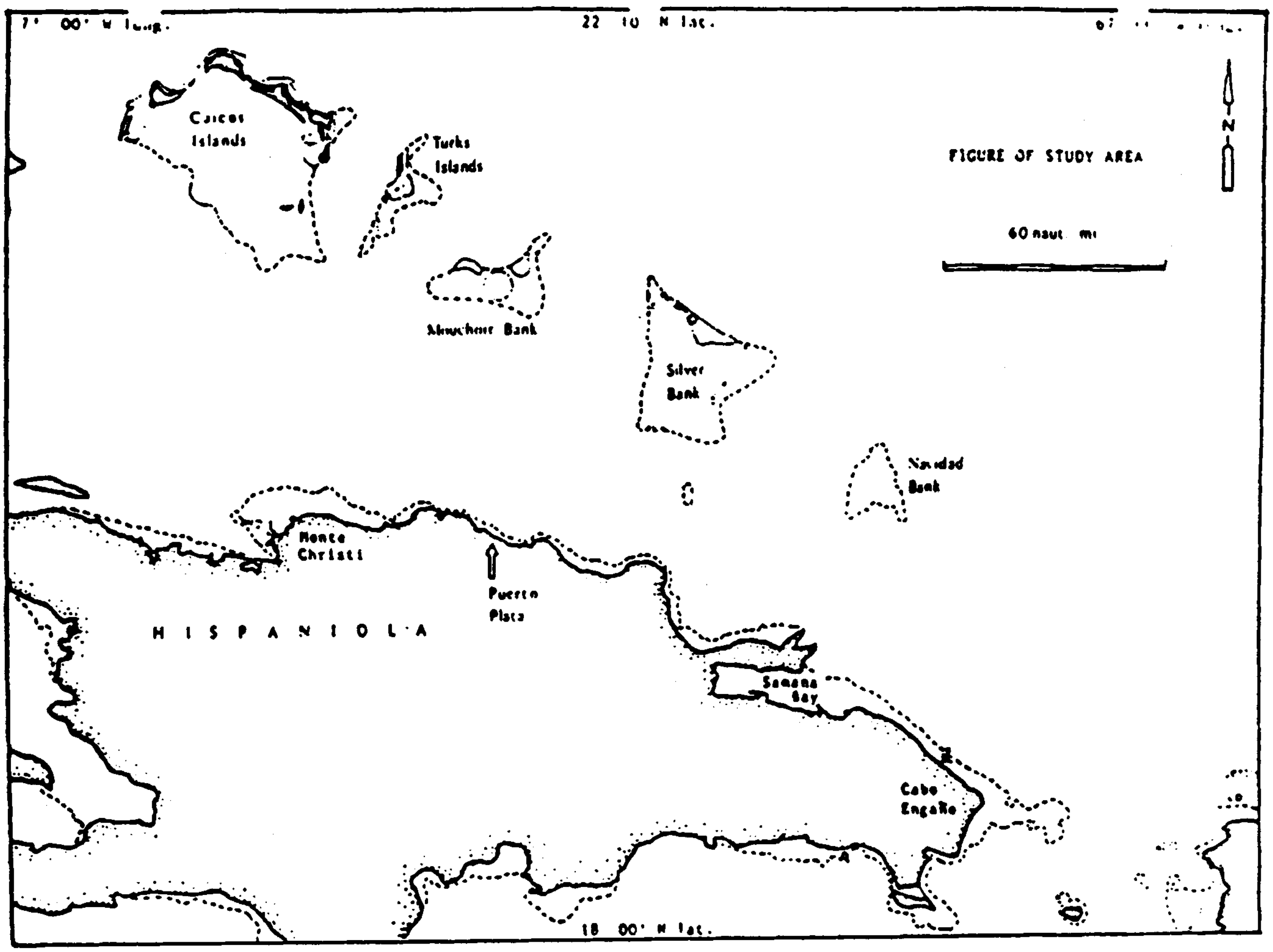
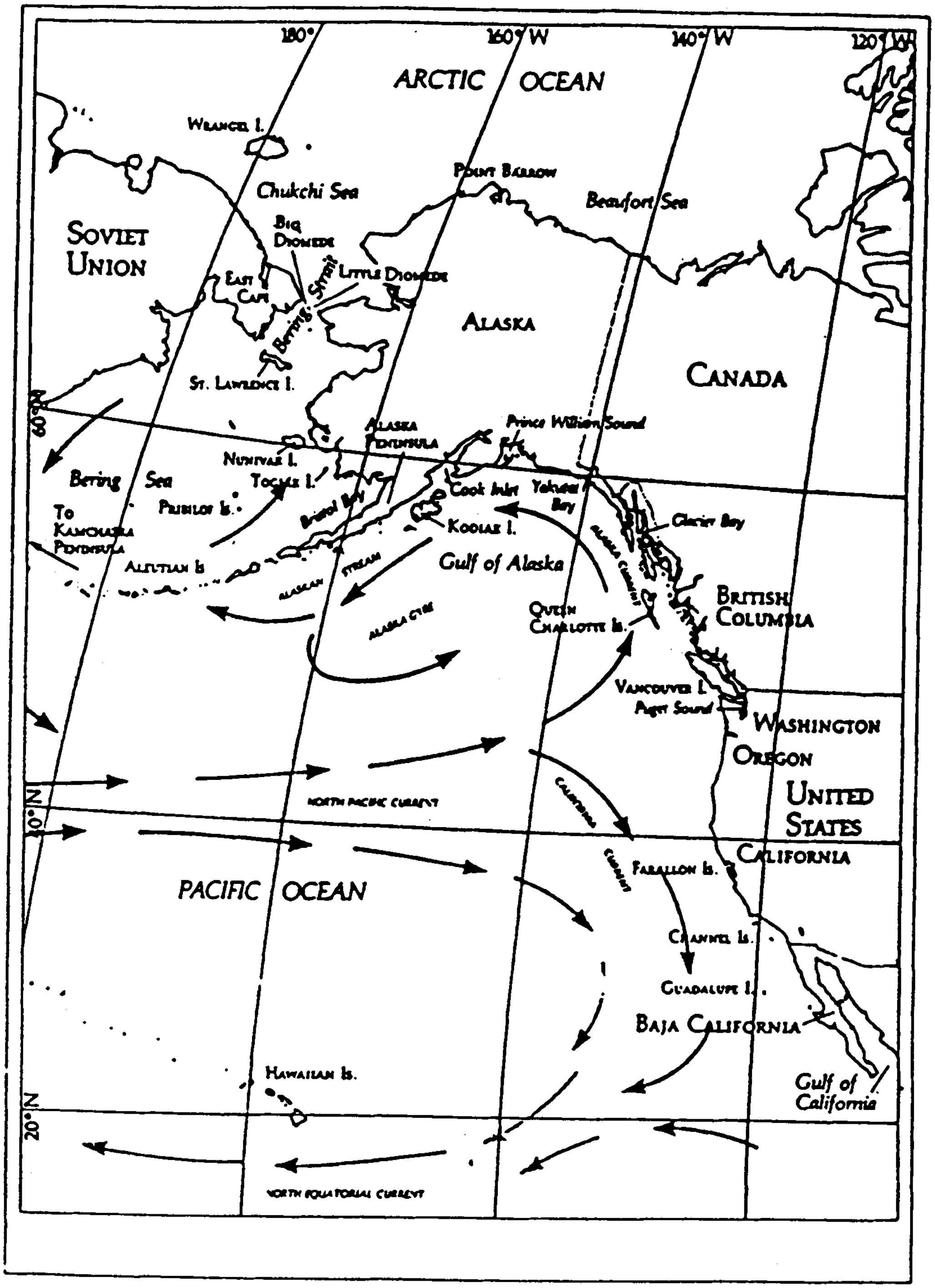


FIGURE 4. Caribbean winter range for humpback whales in the western North Atlantic Ocean.



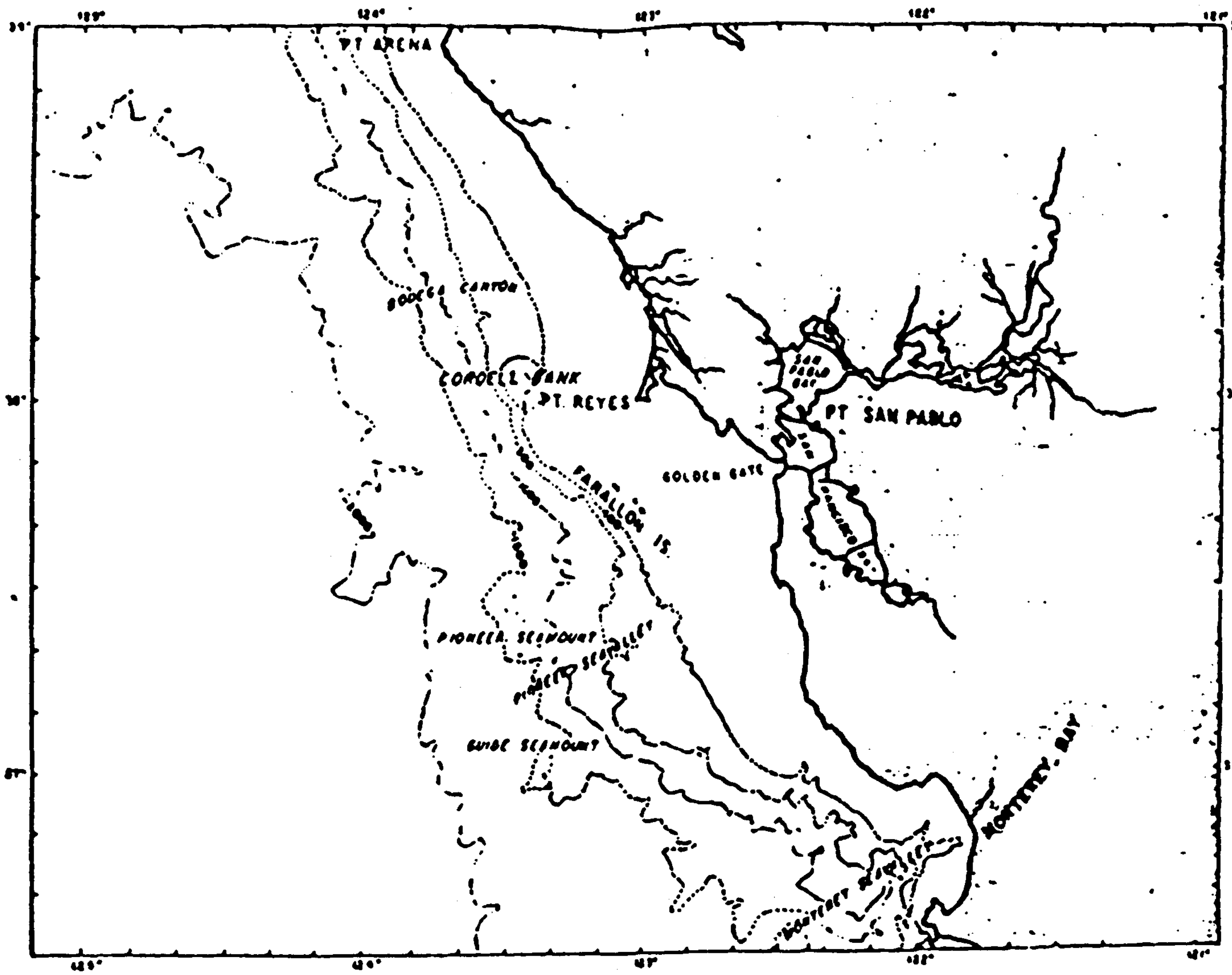
From Matilla et al. (1988).

FIGURE 5. North Pacific Ocean, showing locations mentioned in text



From Haley, H. (ed.). 1986, Marine Mammals, Seattle, Pacific Search Press. 295 pp.

FIGURE 5. North Pacific Ocean - Showing locations mentioned in text.



From Rice (1963).

FIGURE 6. Hawaiian and Mexican winter ranges for humpback whales in the North Pacific Ocean.

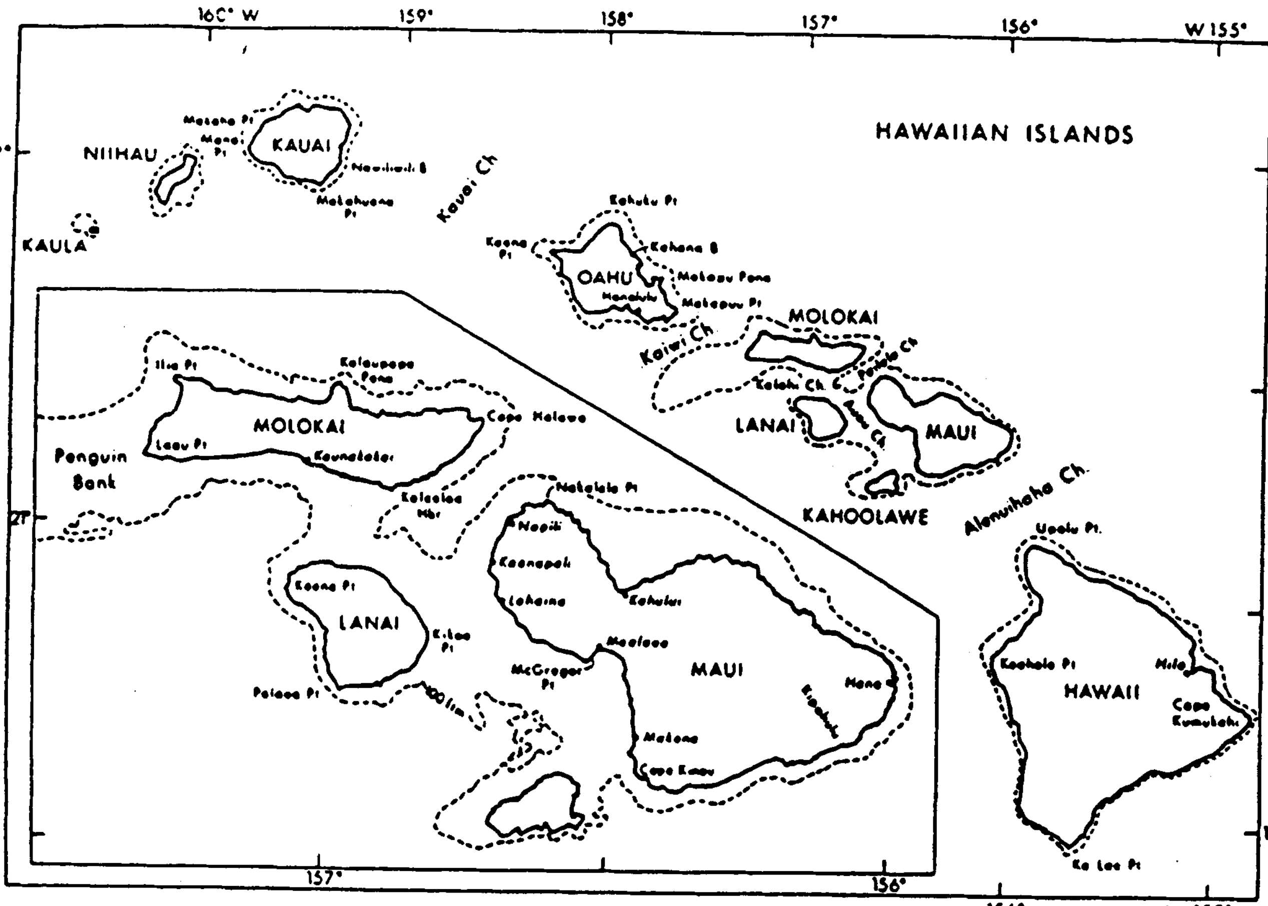


FIG. 1. The main Hawaiian Islands. The 182-m isobath is shown by the broken lines. The inset expands the major study area.

From Baker, C.S. and Herman, L.M., 1984. Agressive behavior between humpback whales (Megaptera novaengliae) wintering in Hawaiian waters. Can. J. Zool. 62: 1922-1937.

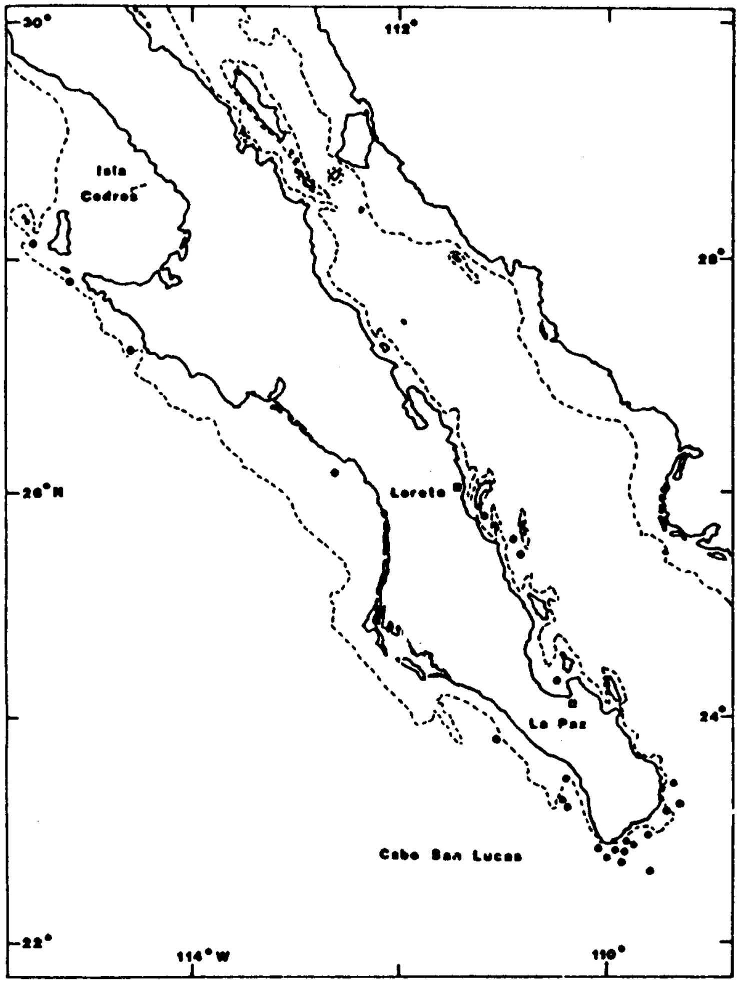


Figure 1. Subregion of the southern coast of Baja California, showing the spatial distribution of the sightings.

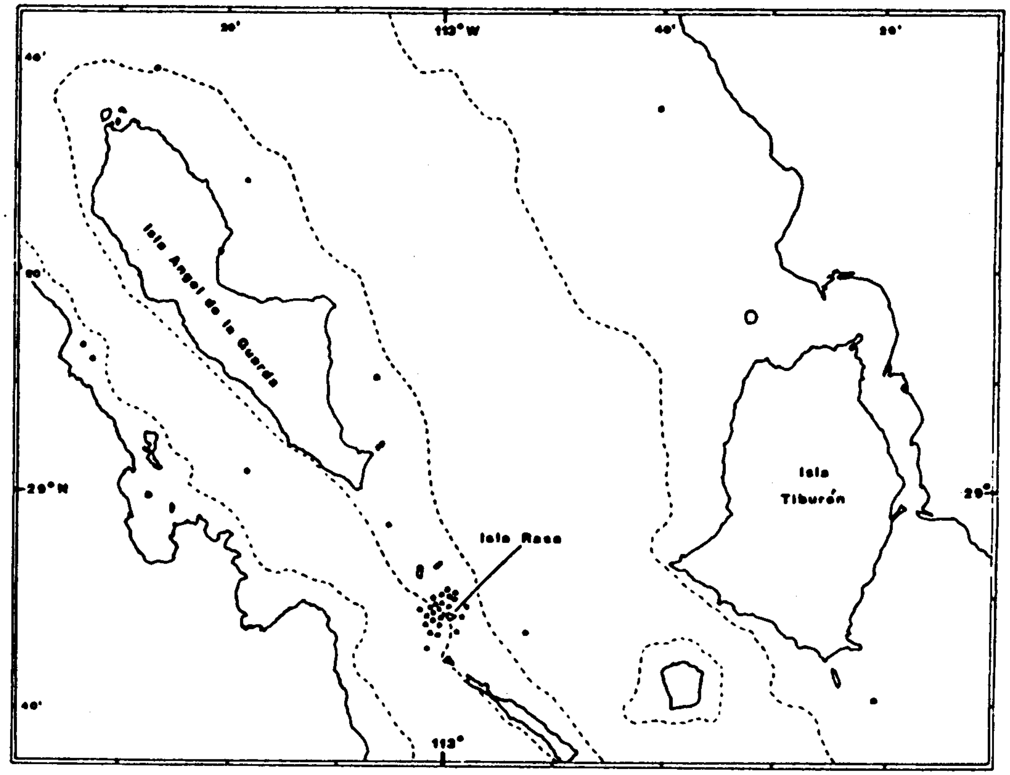


Figure 2. Subregion of the northern Gulf of California, showing the spatial distribution of the sightings.

FIGURE 6. Hawaiian and Mexican Winter Ranges for Humpback Whales in the North Pacific Ocean. From Urban, R. and Aguayo, L. (1987).

FIGURE 6. Hawaiian and Mexican Winter Ranges for Humpback Whales in the North Pacific Ocean.

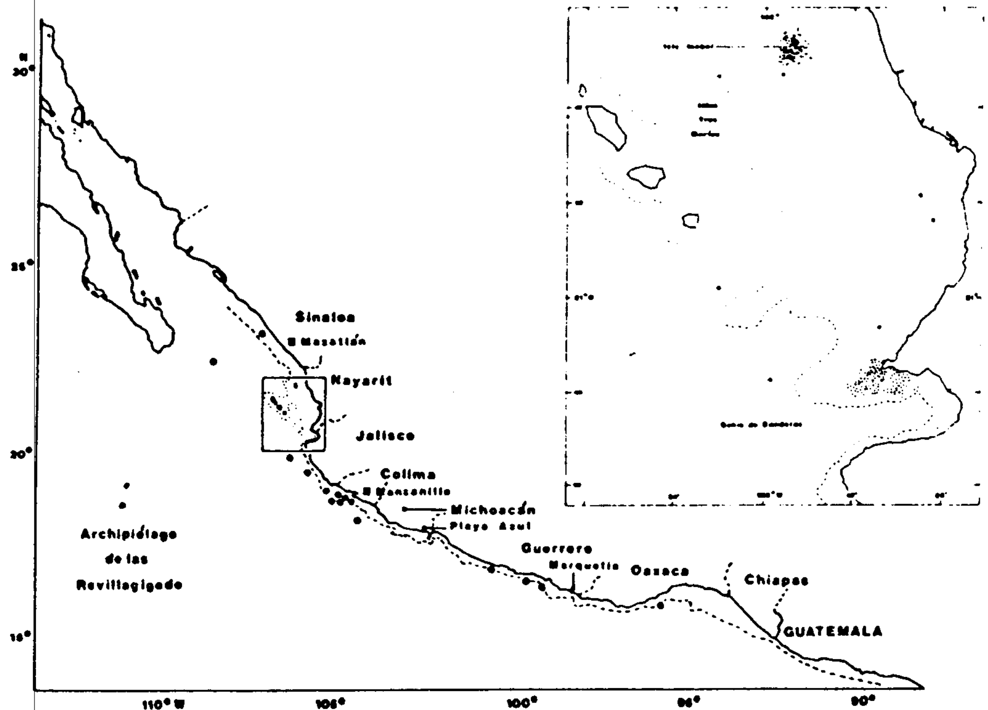


Figure 3. Subregion of the mainland coast of Mexico, showing the spatial distribution of the sightings.

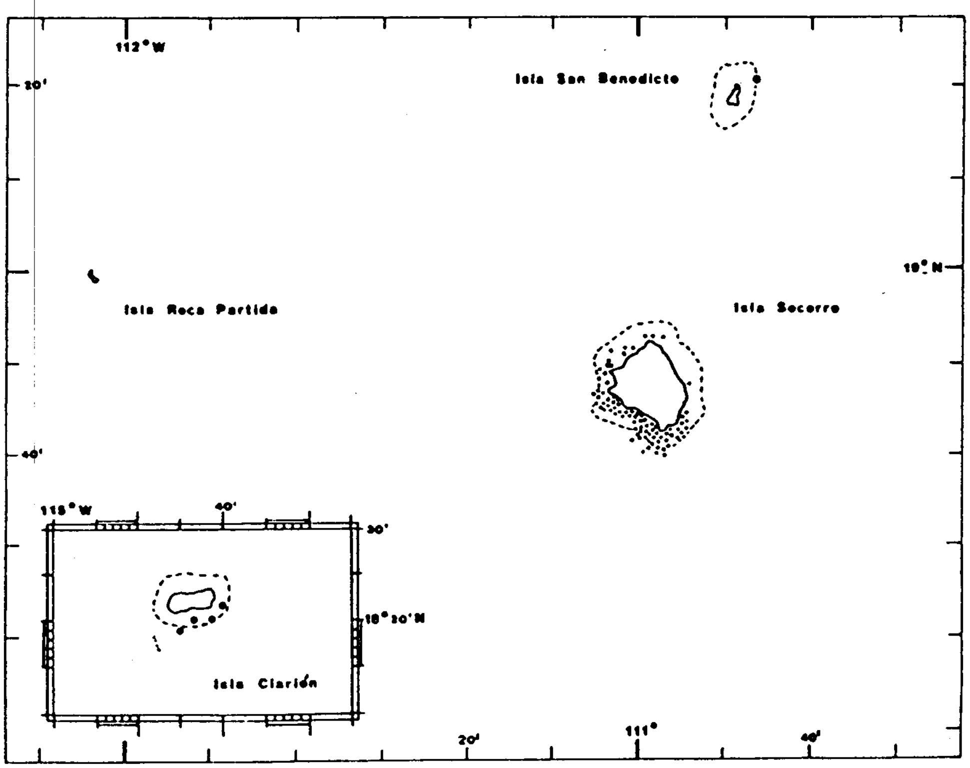


Figure 4. Subregion of the Revillagigedo Archipelago, showing the spatial distribution of the sightings.

From Urban, R. and Aguayo, L. (1987).

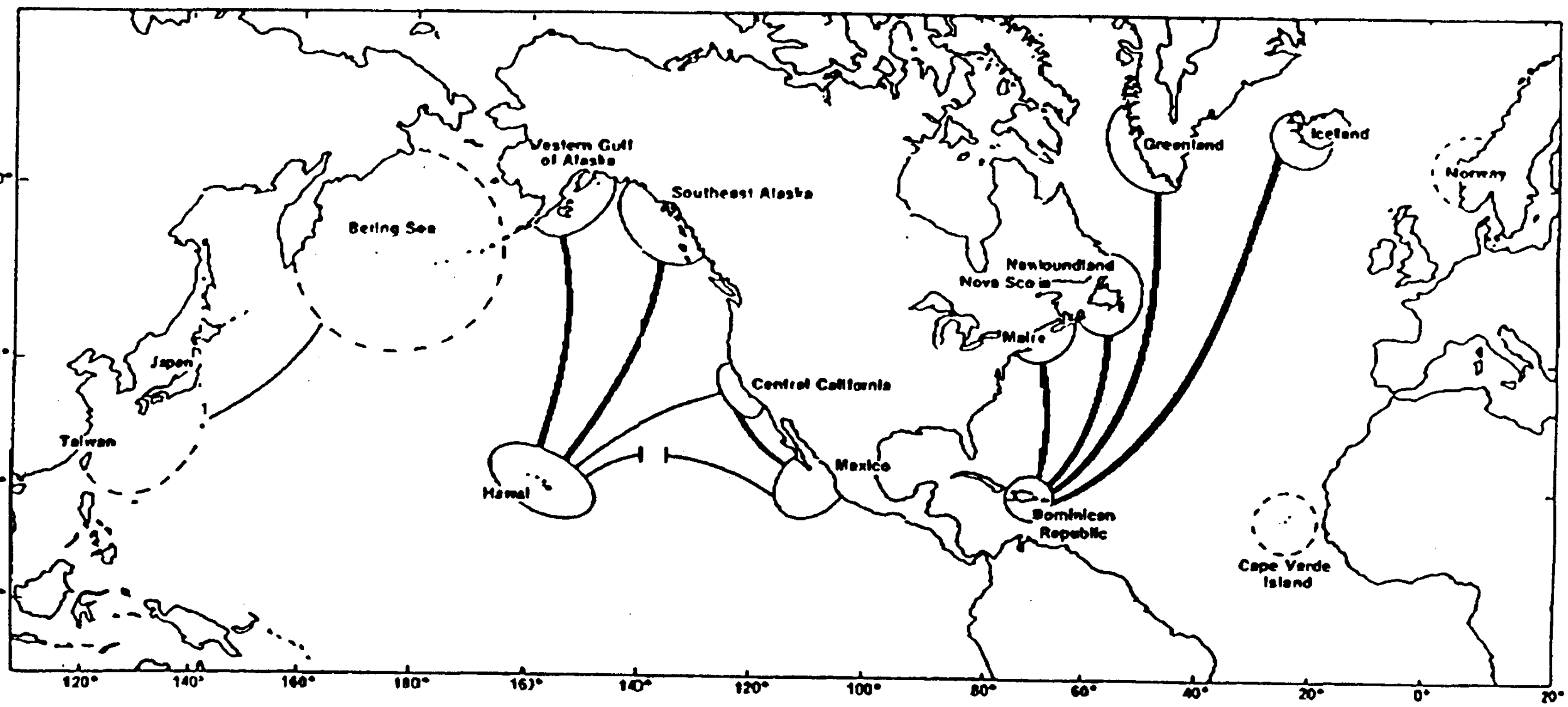


FIGURE 7. Migrations of humpback whales in the Northern Hemisphere.

APPENDIX A. IMPLEMENTATION SCHEDULE AND COST ESTIMATES

1. Tasks identified in the implementation schedule are described more fully in the Narrative (Section VI).

2. Lead agencies identified have the legal responsibility for tasks in the schedule, subject to constraints imposed by appropriations and personnel availability. Cooperating agencies share responsibility for a task, have expertise needed for accomplishing it, or have an interest in its fulfillment. Lead agencies should develop a schedule specifying the methods and timing for accomplishing each task.

3. Cost estimates were prepared based on personnel time, equipment and materials projected to be needed for tasks. Costs for ship time are itemized separately as Tasks 3.42 and 3.421. Cost estimates may change in response to new research findings or management information. Costs may also change as a result of budgetary considerations, unforeseen needs, or other factors. For reasons discussed below in Item 4, costs within a column cannot be summed; some of them will actually be incurred in different years. N (nominal) in a cost column indicates that no costs are anticipated in excess of the normal duties of the agencies specified. TBD (to be determined) in a cost column indicates that costs cannot be determined at this time.

4. Time periods shown for recommended actions are task-specific and represent the number of years estimated to be necessary for completion. Some tasks are contingent upon the prior initiation or completion of others, but additional scientific, logistic, economic or political factors must also be considered in deciding when tasks should begin.

5. Priorities for tasks included in the implementation schedule are assigned as follows:

   Priority 1 - An action that must be taken to prevent extinction or to prevent the species from declining irreversibly in the foreseeable future.

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

   Priority 3 - All other actions necessary to facilitate or encourage full recovery of the species.

6. Agencies identified are sections of U.S. or State governments with legal responsibilities related to the task described or which could be particularly helpful in completing the task. Representatives from the private sector and from academic institutions will also be involved in many tasks.

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
1.	MAINTAIN AND ENHANCE HABITATS USED BY HUMPBACK WHALES CURRENTLY OR HISTORICALLY								
1.1	Identify essential habitat.	2	NMFS	5	35	15	25	25	25
1.11	Identify essential habitat in Hawaiian waters.	2	NMFS/HAWAII,USCG	2	35	35			
1.12	Identify other essential habitat in U.S. waters.	2	NMFS/MMS,USCG	3	TBD	TBD	TBD	TBD	TBD
1.13	Encourage protection of essential habitat under the jurisdiction of other nations.	3	NMFS/DOS,IWC	3	N	N	N	N	N
1.14	Refine description of habitats and habitat features utilized by humpback whales.	3	NMFS	5	50	50	50	50	50
1.2	EXAMINE HISTORY OF OCCUPATION AND POTENTIAL FOR REPOPULATION OF IMPORTANT HABITATS								
1.21	Gulf of Mexico and northwestern Caribbean.	3	NMFS/NPS	1	10				
1.22	Hawaiian Islands.	3	NMFS/HAWAII FWS	1	15				
1.23	Western North Pacific and Trust Territories of the Pacific (Guam).	3	NMFS	3	10	10	10		
1.24	American Samoa.	3	NMFS	1	10				
1.25	Lesser Antilles.	3	NMFS	2	10	10			
1.26	Mexico	3	NMFS, IWC, Mexico	1	15				
1.3	IDENTIFY AND MINIMIZE POSSIBLE ADVERSE IMPACTS OF HUMAN ACTIVITIES AND POLLUTION ON IMPORTANT HABITATS								
1.31	Develop protocol for monitoring physical and chemical factors that could decrease habitat suitability.	2	NMFS/EPA,MMS,ONR, ACOE	1	100				
1.311	Investigate responses of humpback whales to human-related habitat changes.	3	NMFS	5	20	20	20	20	20

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
1.3111	Reduce disturbance from human-produced underwater noise in Hawaiian waters and in other important habitats.	2	NMFS/ONR,MMS	5	50	50	TBD	TBD	TBD
1.4	MONITOR PATHOGENS, BIOTOXINS AND ANTHROPOGENIC CONTAMINANT LEVEL IN TISSUES OF WHALES AND THEIR PREY								
1.41	Develop standardized protocol for sampling tissues of whales utilizing strandings and biopsies.	2	NMFS/EPA,NIH,NCI,FWS , FDA,NIS	1	50				
1.42	Develop protocol to sample anthropogenic contaminant levels in tissues of prey.	2	NMFS/EPA,NIH,FDA, NCI,NIS	1	50				
1.43	Implement baseline study of pathogens in whale tissues and contaminant levels in tissues of whales and prey	3	NMFS/EPA,MMS,APHIS, FDA,NIS	3	TBD	TBD	TBD	TBD	TBD
1.5	PROVIDE ADEQUATE NUTRITION.								
1.51	Monitor levels of prey abundance.	2	NMFS/RFMC	5	120	100	100	100	100
1.52	Identify and evaluate fisheries competition.	2	NMFS/RFMC	5	15	15	15	15	15
1.53	Prevent initiation of new large-scale fisheries for primary prey of humpback whales.	2	NMFS/RFMC	5	N	N	N	N	N
1.54	Improve cooperation with commercial fishermen.	2	NMFS/RFMC	5	30	30	15	15	15
1.6	DEVELOP FEDERAL-STATE-LOCAL GOVERNMENT PARTNERSHIPS FOR PROTECTING HUMPBACK WHALE HABITATS								
1.61	Encourage government entities at all levels to correct existing impacts on habitat of humpback whales.	2	NMFS/SEA GRANT	5	N	N	N	N	N
1.621	Convene workshop on habitat protection of humpback whale winter ranges in waters under U.S. jurisdiction.	2	NMFS/HAWAII,GUAM, SAMOA,PTO.RICO,USVI	1	100				

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
1.622	Convene workshop on protecting humpback whale habitats in Alaska.		NMFS/ALASKA,SEA GRANT,NPS	1	60				
1.623	Convene workshop on central Pacific stock.	2	NMFS/NPS, CALIFORNIA, MEXICO	1	75				
1.624	Convene workshop on protecting habitats for Gulf of Maine feeding aggregation.	2	NMFS/NORTHEASTERN U.S., EASTERN CANADA	1	75				
1.7	ENCOURAGE MULTINATIONAL COOPERATION TO PROTECT HUMPBACK WHALE HABITATS								
1.71	Distribute U.S. Humpback Whale Recovery Plan to other countries and provide follow-up communication as appropriate.	2	NMFS/DOS	1	10	N	N	N	N
1.72	Integrate plan recommendations with goals of the International Whaling Commission (IWC).	3	NMFS/IWC	5	N	N	N	N	N
1.73	Encourage habitat and environmental protection for humpback whales by other nations.	3	NMFS/ICES,DOS	5	N	N	N	N	N
1.74	Encourage other nations to develop recovery plans for conservation and management of humpback whales.	2	DOS/NMFS,IWC,DOS	5	N	N	N	N	N
1.75	Negotiate bilateral or multilateral agreements to protect humpback whale habitats.	2	NMFS/DOS	5	10	10	10	10	10
2.	IDENTIFY AND REDUCE DIRECT HUMAN-RELATED INJURY AND MORTALITY								
2.1	Continue prohibition on commercial hunting of humpback whales.	2	NMFS/IWC, DOS	5	N	N	N	N	N
2.2	CONTINUE TO IDENTIFY SOURCES AND RATES OF HUMAN-CAUSED INJURY AND MORTALITY AND USE INFORMATION TO REDUCE THOSE FACTORS								
2.21	REDUCE MORTALITY AND INJURY FROM ENTANGLEMENT IN FISHERY GEAR OR OTHER OBSTACLES								

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
2.211	Improve reporting of entangled whales and rescue animals when possible.	3	NMFS/REGIONAL STRANDING NETWORKS	5	20	20	5	5	5
2.212	Use standardized forms for entanglement reports.	3	NMFS/REGIONAL STRANDING NETWORKS	1	N	N	N	N	N
2.213	Investigate and modify fishing gear to prevent entrapment or entanglement.	2	NMFS	3	50	50	50		
2.214	Identify and implement seasonal and/or geographic regulations for fishing gear that may kill or injure humpback whales.	2	NMFS	3	5	10	15		
2.215	Require fishing gear to be removed when fishery ends.	2	NMFS	5	N	N	N	N	N
2.22	Evaluate impact on humpback whales from collisions with ships or boats.	2	NMFS/REGIONAL STRANDING NETWORKS	5	15	10	5	5	5
3.	MEASURE AND MONITOR KEY POPULATION PARAMETERS.								
3.1	Estimate and re-evaluate historic population sizes.	3	NMFS/IWC	3	30	30	30		
3.2	Estimate current population estimates by evaluating and re-analyzing existing data with improved techniques.	2	NMFS	2	20	10			
3.21	Workshop to develop capture-recapture estimate of humpback whale abundance in the North Pacific using existing photos.	2	NMFS	2	30	30			
3.3	Systematize sampling methods for estimating present population size.	2	NMFS	2	30	30			
3.4	MAINTAIN AND DEVELOP FACILITIES FOR OBTAINING, ARCHIVING AND ANALYZING DATA ON HUMPBACK WHALES								
3.41	Archive existing data.	3	NMFS	5	10	10	10	10	10

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
3.411	Maintain centers for comparative analysis of identification photographs.	2	NMFS	5	150	100	100	100	100
3.412	Identify, accumulate and archive existing sightings survey data.	2	NMFS	5	30	30	15	7	7
3.42	Dedicate research vessels to study humpback whales and other endangered cetaceans.	2	NMFS/NFS,MMS,ONR,EPA	5	200	5000	250	250	250
3.421	Charter research vessels.	2	NMFS/NSF,MMS,EPA	5	1600	1600	1600	1600	1600
3.5	PERFORM NEW FIELD STUDIES ON POPULATION DYNAMICS								
3.51	EXAMINE RATES OF BIRTH, SURVIVORSHIP AND MORTALITY								
3.511	Convene workshop to estimate survivorship of calves based on existing individual-identification photographs.	2	NMFS	2	30	30			
3.513	Identify and quantify sources of natural mortality in juvenile and adult humpback whales.	3	NMFS/EPA,MMS,USCG, FDA,CDC,NIH,RSN	5	60	50	40	40	40
3.52	DEFINE GEOGRAPHIC SUBDIVISIONS OF POPULATION								
3.521	Anlyze and evaluate existing information on population subdivisions.	2	NMFS	2	40	40			
3.522	Implement immediately initial surveys of selected regions.	2	NMFS	5	60	60	60	60	60
3.523	DESCRIBE MIGRATION ROUTES AND TRANSIT TIMES.								
3.5231	Employ long-term radio tags.	2	NMFS/MMS,ONR,DOD	5	200	240	240	240	240
3.5232	Employ underwater listening stations.	2	NMFS/DOD,ONR	3	50	50	50		
3.5233	Utilize genetic techniques.	2	NMFS/NSF,NCI	3	60	60	100		

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
3.53	ESTIMATE ABUNDANCE OF HUMPBACK WHALE POPULATIONS.								
3.531	Perform new census surveys.	2	NMFS/MMS	5	TBD	TBD	TBD	TBD	TBD
3.532	Encourage and participate in international sightings surveys.	2	NMFSS/IWC,ICES	5	N	N	N	N	N
3.533	Implement improved sampling program for capture-recapture estimation of population abundance.	2	NMFS	5	40	40	TBD	TBD	TBD
3.6	Continue long-term photo ID studies.	2	NMFS/MMS,NSF	5	200	200	200	200	200
3.7	Assess population status and trends.	2	NMFS	3	20	20	20		
4.	IMPROVE ADMINISTRATION AND COORDINATION OF RECOVERY PROGRAM FOR HUMPBACK WHALES								
4.1	Select Director and implement recovery Plan.	2	NMFS/MMC	5	100	100	100	100	100
4.2	Improve governmental coordination.	3	NMFS/MMC	5	N	N	N	N	N
4.3	Improve coordination with non-governmental agencies.	3	NMFS	5	10	10	10	10	10
4.4	Expand or reconstitute a Recovery Implementation Team, update the Recovery Plan and prepare Comprehensive Work Plans.	2	NMFS/MMC	1	30				
4.5	Collect and archive available information on humpback whales, including translations of foreign literature.	3	NMFS	5	35	15	10	10	10
4.6	Improve process for obtaining permits to do research on marine mammals and make appropriate changes.	3	NMFS/FWS		N	N	N	N	N
4.7	Maintain coordination with other recovery programs.	3	NMFS/FWS	5	N	N	N	N	N

APPENDIX A. IMPLEMENTATION SCHEDULE AND COSTS

NO.	TASK NAME	PRIORITY	LEAD/COOPERATORS	DURATION	YEAR1	YEAR2	YEAR3	YEAR4	YEAR5
4.8	Reassess as appropriate political goals for population recovery.	2	NMFS	5	N	N	N	N	N
4.81	Change listings in Endangered Species Act (ESA) and Marine Mammal Protection Act (MMPA) as appropriate.	3	NMFS/MMC	5	N	N	N	N	N
4.9	DEVELOP EDUCATIONAL MATERIALS IN SUPPORT OF RECOVERY PLAN OBJECTIVES.								
4.91	Produce and distribute educational materials.	3	NMFS	3	30	30	20		
4.92	Improve cooperation with the whalewatching industry.	3	NMFS	5	20	20	15	15	15

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APPENDIX D. List of abbreviations used in text.

AAAS	American Association for the Advancement of Science
ACOE	Army Corps of Engineers
APHIS	Animal Plant and Health Inspection Service
CDC	Center for Disease Control
CETAP	Cetacean and Turtle Assessment Program, University of Rhode Island, Narragansett, RI
CZMA	Federal Coastal Zone Management Act of 1972
CZM	Coastal Zone Management
COSEWIC	Committee for Studying Endangered Wildlife in Canada
DOD	Department of Defense
DOS	Department of State
EPA	Environmental Protection Agency (U.S.)
ESA	Endangered Species Act of 1973 (U.S.)
FDA	Food and Drug Administration
FWS	Fish and Wildlife Service (U.S.)
ICES	International Council for Exploration of the Sea
IOCARIBE	Intergovernmental Oceanographic Commission Association for the Caribbean and Adjacent Regions
IWC	International Whaling Commission
MARMAP	Marine Resources Mapping and Assessment Program (NOAA)
MEXUS	Mexico/United States Gulf of Mexico Cooperative Program
MMC	Marine Mammal Commission (U.S.)
MMEP	Marine Mammal Event Program (Smithsonian Institution)
MMPA	Marine Mammal Protection Act of 1972 (U.S.)
MMS	Minerals Management Service (U.S.)
NCI	National Cancer Institute (U.S.)
NMFS	National Marine Fisheries Service (U.S., NOAA)
NMML	National Marine Mammal Laboratory (U.S., NOAA)
NOAA	National Oceanic and Atmospheric Administration (U.S.)
NOAA/OAD	NOAA Ocean Assessment Division (U.S.)
NOAA/NOS	NOAA National Ocean Service (U.S.)
NIST	National Institute of Standards and Technology
NTIS	National Technical Information Service, Springfield, VA
OCS	Outer Continental Shelf
OCSEAP	Outer Continental Shelf Environmental Assessment Program (U.S.)
ONR	Office of Naval Research (U.S.)
RFMC	Regional Fisheries Management Council
RSN	Regional Stranding Networks
SEAMAP	Southeast Atlantic Marine Assessment Program
WATS	Western Atlantic Turtle Symposium

APPENDIX E. Existing treaties, acts and regulations protecting humpback whales.

International Whaling Convention

The International Whaling Convention provided for the formation of the International Whaling Commission, formed in 1946. Member nations meet annually to review scientific and management-related information on all kinds of whales and dolphins. Starting in July 1966, the IWC prohibited all commercial hunting for humpback whales. This protection remains in effect. Compliance with any regulations enacted by the IWC is voluntary. Current information on most cetacean species, including humpback whales, is summarized in the Report of the International Whaling Commission, which is published annually.

Convention on International Trade in Endangered Species (CITES)

Humpback whales are listed in Appendix I of this treaty. This level of listing prohibits all international trade in this species except for scientific research. Obtaining a research permit requires a four-part permit process involving both the Scientific Authority and Management Authorities of the exporting and importing countries. All Appendix I permits are reviewed by the CITES Secretariat and made available to all signatory nations for procedural review.

International Indian Ocean Sanctuary for Whales

In 1979, the International Whaling Commission adopted a proposal introduced by the Seychelles Islands designating the entire Indian Ocean north of 55° S as a sanctuary for all cetaceans. All commercial hunting was prohibited for 10 years. The Indian Ocean Sanctuary was reauthorized by the IWC at its meeting in June 1989.

U.S. Marine Mammal Protection Act of 1972 (as amended 1988)

Protects all species of marine mammals. Establishes moratorium on taking of marine mammals, goal for achieving "optimum sustainable populations" of species and stocks of marine mammals, and protects species that are endangered, threatened or below their optimum sustainable population (OSP). Regulates incidental take of marine mammals by fisheries.

U.S. Endangered Species Act of 1973

Provides for designation and protection of endangered and threatened species and populations. Significant provisions of the Act includes Section 7(a)(2) which requires all Federal agencies to "ensure that any action authorized, funded, or carried out by such agency ... is not likely to jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat ... critical" to their survival. All Federal agencies must consult with the National Marine Fisheries Service for any actions that may adversely effect such species, including humpback whales. Section 9 prohibits the "taking" of any endangered species of fish and wildlife in the United States, the territorial sea of the United States, or by U.S. citizens on the high seas. "Take" is defined as meaning to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, collect, or to attempt to engage in any such conduct. Knowing violations are punishable with civil penalties up to $10,000. Civil penalties of up to $500 may be assessed for violations other than knowing violations. Criminal violations are punishable by fines of up to $20,000, or imprisonment for up to a year, or both.

U.S. Fishery Conservation and Management Act of 1976 (FCMA)

Establishes regional fishery management councils with authority to develop programs for the conservation and management of all fishery resources within the Fishery Conservation Zone (FCZ), out to 200 miles from the territorial sea. The councils establish fishery management plans for specific fisheries in the FCZ. These plans can be useful in limiting or mitigating any fishery-related activities, commercial or recreational, that adversely affect humpback whales, for example. Amendments to the FCMA, notably the Packwood-Magnuson and Pelly Amendments, permit economic sanctions against any country whose fisheries operate contrary to accepted conservation procedures.

U.S. Marine Protection, Research and Sanctuaries Act of 1972

Title III of this act authorizes the designation of ocean areas as marine sanctuaries for the purpose of preserving or restoring their conservation, recreational, ecological or aesthetic values. Once an area is designated as a national marine sanctuary, comprehensive management programs are established to (1) promote and coordinate research to expand scientific knowledge and improve management decision making; (2) provide interpretive and recreational programs to enhance public awareness, understanding, and wise use of the marine environment; and (3) provide for optimum compatible public and private use of marine areas. Three national marine sanctuaries, affecting humpback whales and all in California, have been designated--Channel Islands (1980), Gulf of the Farallones (1981), and Cordell Bank (1989). The Gulf of the Farallones is an important feeding range for humpback whales. Cordell Bank, offshore from San Francisco and contiguous to the existing Gulf of the Farallones National Marine. Sanctuary, is used for feeding by humpback whales. A proposal to establish certain waters offshore from Maui, Hawaii, as a national marine sanctuary was rejected by Hawaii in 1984 owing to concern that it would impose undue restrictions on fishermen and boaters. However, in 1990, Congress directed NOAA to conduct a study of the feasibility of establishing a national marine sanctuary in the marine environment adjacent to Kahoolawe Island, Hawaii. In conducting the study, NOAA was instructed to give special consideration to the effects of such a sanctuary on the humpback whale populations that inhabit the waters off Kahoolawe. The feasibility study, along with NOAA's recommendation for further action, is to be transmitted to Congress by December 1, 1991.

Three areas are currently being evaluated for designation as national marine sanctuaries: (1) Stellwagen Bank in Massachusetts Bay is one of the most important feeding sites from mid-April to November; (2) Monterey Bay provides habitats to a diverse array of ocean species including humpback whales; and (3) Western Washington Outer Coast, offshore from the State of Washington, was historically inhabited by humpback whales.

Regulations of Glacier Bay National Park, National Park Service (NPS) Department of the Interior

NPS regulations were established May 15, 1980, and modified into permanent regulations May 31, 1985, to protect humpback whales at the Glacier Bay National Park and Preserve. These regulations establish a system for limiting entry into Glacier Bay and restricting the operation of these vessels, including limiting speed, maneuvering and approach distance towards whales. They also prohibited the harvest of certain species of fish and crustaceans which are prey species of humpback whales.

Hawaii Humpback Whale Regulations

The Department of Commerce (NOAA) established interim regulations on December 23, 1987, to protect humpback whales in Hawaiian waters. These regulations prohibit aircraft from approaching closer than 1,000 feet, and prohibit vessels or people from approaching closer than 100 yards to a whale. The approach limit is extended to 300 yards in cow/calf areas.

State of Hawaii

In 1978, Hawaii designated the humpback whale to be its official state marine mammal. The Department of Land and Natural Resources (DLNR) establishes programs for ensuring the "continued perpetuation of indigenous wildlife and plants for their habitats for human enjoyment, for scientific purposes, and as members of ecosystems ...". The Division of Aquatic Resources within DLNR is responsible for marine endangered species management. To date, no comprehensive conservation program has been established for humpback whales in Hawaii. The Legislature of the State of Hawaii has passed HB 2994 to regulate the operation of thrill craft, parasailing vessels and high-speed motorized vessels in Hawaiian waters. Among other provisions, this act prohibits operation of such vessels on the west and south coasts of Maui between December 15 and May 15, the period when humpback whales are normally present. This act is awaiting signature by the Governor of Hawaii. State permits are required for performing research on humpback whales; possession of a Federal research permit is necessary for issuance of a state permit.

Silver Bank Sanctuary for Humpback Whales

During winter, Silver Bank, along with nearby Navidad and Mouchoir Banks, is inhabited by the largest concentration of humpbacks whales in the world, approximately 85% of the population of the entire western North Atlantic Ocean. Most of the whales are found on Silver Bank, a shallow, limestone plateau, located about 80 miles off the north coast of the Dominican Republic. Silver Bank was designated as a sanctuary for humpback whales in October 1986, by decree of the President of the Dominican Republic. No activities are permitted that would threaten humpback whales. Since this sanctuary was established by Presidential Decree, its future during the tenure of another Dominican President is not automatically assured.

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