

A Review of Interactions Between Hawaii's Fisheries and Protected Species

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Introduction

Interactions involving commercial fisheries and small odontocetes protected by Federal statutes have occurred in Hawaii since 1948 (Schlais, 1984, 1985), and reports from fishermen about small cetaceans stealing catch and bait continue to surface periodically throughout the Hawaiian Islands. Several species of sea turtles and whales are also involved in fisheries through entanglement or accidental hooking. The threatened and endan-

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ABSTRACT—Several fisheries in Hawaii are known to have interactions with protected cetaceans, seabirds, marine turtles, or seals. Handline fisheries for bottomfish, tuna, and mackerel scad lose bait and catch to bottlenose dolphins, rough-toothed dolphins, and Hawaiian monk seals. Troll fisheries for billfish lose live bait to bottlenose dolphins, rough-toothed dolphins, albatrosses, and boobies; these fisheries may also lose catch to false killer whales. A longline fishery for tuna and billfish has burgeoned in Hawaii since 1987, resulting in interactions with protected species; marine turtles, seabirds, and monk seals take bait and are known to become hooked, and false killer whales may take catch. Research on deterrents or alternative fishing methods has been limited, and interactions have been reduced primarily through management and regulatory actions. These include area closures and gear requirements. An observer program has also been established for the bottomfish and longline fisheries.

gered species involved in fishery interactions are the Hawaiian monk seal, *Monachus schauinslandi*; humpback whale, *Megaptera novaeangliae*; leatherback turtle, *Dermochelys coriacea*; olive ridley turtle, *Lepidochelys olivacea*; loggerhead turtle, *Caretta caretta*; hawksbill turtle, *Eretmochelys imbricata*; and green sea turtle, *Chelonia mydas*. Nonendangered marine mammals identified as interacting with commercial fisheries in Hawaiian waters include bottlenose dolphins, *Tursiops truncatus*; false killer whales, *Pseudorca crassidens*; rough-toothed dolphins, *Steno bredanensis*; and spinner dolphins, *Stenella longirostris*. Among seabirds, which are protected by the Migratory Bird Treaty Act of 1918, albatrosses, *Diomedea* sp.; and boobies, *Sula* sp., are reported involved in fishery interactions.

This paper describes protected species interactions with Hawaiian commercial fisheries on a fishery by fishery basis. Hawaiian commercial fisheries will include the areas fished by the distant water fleets originating from Hawaii even if outside of the 200-mile Exclusive Economic Zone (EEZ) surrounding the Hawaiian Archipelago. Efforts to document and resolve protected species/fishery interactions will also be described.

Biology and Status of Protected Species

Small Cetaceans

Four species of small cetaceans interact with fisheries in Hawaii, but three (bottlenose dolphin, rough-toothed dolphin, and false killer whale) occur pelagically as well as within the Ar-

chipelago. Animals which are sighted inshore and interact with fisheries may mix with their pelagic conspecifics, but the extent of such movement is not known.

The bottlenose dolphin is found throughout the Hawaiian Archipelago, usually within five miles of emergent land or shallow banks (Shallenberger, 1981). School sizes range from single or small groups of 3–10 animals to aggregations of more than 100 (Tomich, 1986). A combined aerial and vessel survey of inshore waters adjacent to Oahu, Molokai, Lanai, Maui, and Hawaii documented a minimum of 430 individuals¹.

The rough-toothed dolphin is found near all major islands within the Archipelago (Tomich, 1986), and at least as far north as French Frigate Shoals (JRH, personal observ.). No estimates of abundance exist. At least 23 were collected from Hawaiian waters for oceanaria in 1963–81 (Shallenberger, 1981).

The false killer whale is found near all the main islands, but its occurrence and distribution in the Northwestern Hawaiian Islands (NWHI) is unknown. An aerial survey of the lee areas of Oahu, Lanai, and Hawaii documented a minimum of 470 individuals, all of which were sighted along the northwestern coast of Hawaii².

Spinner dolphins occur in relatively discrete schools frequenting inshore bays and lagoons within the Archi-

¹Naval Ocean Systems Center, Kaneohe Marine Corps Air Station, Kaneohe, HI. 1987. Unpubl. aerial survey data.

²S. Leatherwood and R. R. Reeves. Aerial survey for false killer whales off Hawaii, June 1989. 2146 Fort Stockton Dr., San Diego, CA 92103. Unpubl. rep., 13 p.

pelago, from the island of Hawaii to Kure Atoll. The largest school (200 – 250 animals) occurs along the west coast of Hawaii from Honokohau Harbor to Kiholo Bay (Norris and Dohl, 1980). Schools disperse to deep water at night to feed and return inshore to rest during the day. Some mixing of animals between schools may occur during feeding forays.

Humpback Whale

Humpback whales that winter in Hawaii are part of the North Pacific population, estimated at 1,200 – 2,000 animals (Johnson and Wolman, 1984; Darling and Morowitz, 1986; Baker and Herman, 1987). The Hawaiian stock is estimated at $1,407 \pm 294$ (95% confidence limits) whales (Baker and Herman, 1987). These whales begin arriving from North Pacific summer feeding grounds in December. The number of whales peaks in late January through February. In April, they begin migrating out of Hawaiian waters, and by late May or early June the last whales usually have departed. A few animals have been sighted in the NWHI³.

Hawaiian Monk Seal

The only seal native to the Hawaiian Islands, the Hawaiian monk seal, is found around all of the NWHI and is occasionally seen in the main islands. The major pupping islands are in the NWHI. The total population for the five major breeding locations plus Necker Island in 1987 was estimated to be 1,718 seals⁴ including 202 pups of the year (Gilmartin⁵). Significant declines in pupping and juvenile survival, particularly at French Frigate Shoals since 1989, are cause for concern for this endangered species.

³M. Craig, Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822–2396. Personal commun. 1993.

⁴This estimate utilizes counts of adult males at Lisianski made during the late summer molting season, which confounds the total estimate somewhat because beach counts at the other islands were conducted in the spring.

⁵W. G. Gilmartin. 1988. The Hawaiian monk seal: Population status and current research activities. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-88-17, 14 p.

Sea Turtles

Five species of sea turtle interact with fisheries in Hawaii, but only one, the green sea turtle, nests in large numbers in the Archipelago and represents a distinct population. There are isolated nesting sites for hawksbill turtles in the main Hawaiian Islands, primarily on the islands of Hawaii and Molokai. The remaining three species nest elsewhere in the Pacific Basin.

Leatherback turtles are commonly seen by fishermen in Hawaiian offshore waters, generally beyond the 100 – fathom contour but within sight of land. Sightings often occur off the north coast of Oahu and the west coast of Hawaii. The pelagic zone surrounding the Hawaiian Islands likely constitutes foraging habitat and migratory pathways for this species. A high-seas aggregation of leatherbacks is known to occur north of the Hawaiian Islands at lat. 35°–45°N, long. 175°–180°W (Balazs et al.⁶; Skillman and Balazs, 1992). The nesting habitat and origin of these turtles are not known.

Available information suggests that the olive ridley turtle regularly uses the Hawaiian pelagic region for foraging and/or developmental migrations. Olive ridleys in reasonably good health have been found entangled in scraps of net or other floating synthetic debris. Small crabs, barnacles, and other marine life often reside on the debris and likely serve as food attractant to turtles. Juvenile and subadult olive ridleys are among the life stages known to be present in Hawaiian waters. Olive ridleys found in Hawaiian waters are probably derived from the eastern Pacific breeding aggregation of Mexico (Balazs et al.⁶).

The loggerhead turtle is a cosmopolitan species found in temperate and subtropical waters. Nearly all nesting occurs north of 25°N or south of 25° S. Adult loggerheads undertake long reproductive migrations between their

⁶G. H. Balazs, H. F. Hirth, P. Y. Kawamoto, E. T. Nitta, L. H. Ogren, R. C. Wass, and J. A. Wetherall. 1992. Interim recovery plan for Hawaiian sea turtles. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-92-01, 76 p.

nesting sites and foraging areas. However, their dispersal patterns in foraging areas are not well known for any population. In the North Pacific the only major nesting beaches are in the southern part of Japan (Dodd, 1988). Although reliable counts are not available, as many as 2,000 – 3,000 loggerheads may nest annually on beaches throughout Japan. Immature loggerheads encountered during driftnet fishing in the North Pacific may originate from nesting beaches in Japan, being transported to the north and east by the Kuroshio Current and its extension (Wetherall et al., In press). Loggerheads reported taken in the Hawaiian longline broadbill swordfish fishery may be of the same origin.

The green sea turtle is found throughout the Hawaiian Archipelago. Its distribution, however, has been reduced in recent historical times; breeding aggregations have been eliminated, and certain foraging areas are no longer used in the main Hawaiian Islands (Balazs, 1980; Balazs, et al., 1987). More than 90 percent of the breeding and nesting activity of Hawaiian green turtles occurs at French Frigate Shoals, in the NWHI. The number of females nesting there fluctuates annually. An annual mean as high as 300 was recorded during 1973–1982. The total mature female population at French Frigate Shoals is estimated to be approximately 750 animals (Balazs et al.⁶).

Seabirds

All five species of seabirds known to interact with fisheries nest on remote islands throughout the Archipelago. Recent estimates of abundance in Hawaii are 683,500 breeding pairs for the two albatross species⁷, and 6,590–7,950 breeding pairs for the three species of booby (Harrison et al., 1984).

Fishery Interactions

Interactions between cetaceans and fisheries have been documented in Hawaii since at least the late 1940's and

⁷E. Flint, U.S. Fish and Wildlife Service, Pacific/Remote Islands NWR Complex, P.O. Box 50167, Honolulu, HI 96850. Personal commun. 1993.

were exacerbated by installation in 1979 of a deep-water buoy as part of the Ocean Thermal Energy Conversion (OTEC) project west of the island of Hawaii (Schlais, 1984, 1985). This buoy proved very productive as a fish aggregating device, was popular with fisherman from Kona, and became well known for schools of dolphins stealing bait and catch. Interactions further increased in the early 1980's with the deployment of fish aggregation devices (FAD's) by the Hawaii Division of Aquatic Resources throughout state waters. Specific fisheries and the species involved have been documented by Mate (1980), Shallenberger (1981), and Kuljis⁸.

Interactions may be divided into two basic types in this region. One involves the loss of catch or bait with little or no impact to the individual animals from the fishing gear or technique, short of aversive action taken by the fishermen. The other is the hooking or entanglement of animals in gear whether or not catch or bait is the primary stimulus for interactions. While documenting these two types of interactions is relatively straightforward, investigating how these take place, assessing the impact on fisheries and protected species, and developing solutions to incidental take and loss of catch are much more difficult.

Loss of catch is documented through observer reports, interviews with fishermen, and reports directly from fishermen through fish catch/interaction logs. Entanglements and hookings are reported in the same manner.

Handline Fishery for Bottomfish

Boats in this fishery use 3–6 lines, each with 6–15 hooks, usually baited with squid. Hooks are spaced in approximately 0.5 m intervals and are fished at depths of 120–250 m. A chum bag containing chopped fish or squid may be suspended above the highest

of these hooks. The gear is pulled after several fish are hooked. Locations for this fishery include the main islands as well as banks in the NWHI.

Both bait and catch have been reported lost to bottlenose dolphins, and schools of dolphins have been reported following fishing boats, particularly in the NWHI. Danger to fishermen results when a dolphin jerks a fish from a hook; the dolphin may pull 10–15 m of line from the fisherman's hands, exposing the fisherman to the risk of open hooks. Interactions with dolphins have been reported off the island of Hawaii, Kaula Island, and several banks in the NWHI. Dolphins may be attracted by undersized fish or unmarketable species (e.g., kahala, *Seriola dumerili*) which are discarded during fishing operations. In some cases after consuming a few fish the dolphins will continue to remove fish from the lines and "play" with them.

Interactions between Hawaiian monk seals and the bottomfish fishery have occurred in the main Hawaiian Islands and the NWHI. A female Hawaiian monk seal was observed with an "uluu" hook in its mouth on Kauai in October 1989. The hook was removed from the seal with no apparent serious aftereffects⁹. A Hawaiian monk seal was photographed at French Frigate Shoals with a bottomfish hook in its mouth in 1982. The seal was later observed alive without the hook (Henderson, 1985). Like dolphins, monk seals may be attracted by discarded bycatch (Fig. 1).

Reports of monk seals and bottlenose dolphins taking bottomfish off fishing lines from around Necker Island and Kaula Island were received from commercial fishermen in 1983–1987¹⁰. In 1991 and 1992 observer trip reports from the bottomfish fishery documented monk seals and bottlenose dolphins taking fish off of lines in the NWHI. A rate of one interaction event/

34.4 hours of fishing was calculated for monk seals and a rate of one interaction event/24.3 hours for bottlenose dolphins based on observer reports through July 1992¹¹.

Day Handline Fishery (Palu-ahi) for Tuna

Boats in this fishery use 3–5 lines, each with a single hook, baited with mackerel, mackerel scad, or squid, and fished at a depth of up to 150 m. The fishery targets both skipjack and yellowfin tuna. The location for this fishery is primarily off the southeast and west coasts of the island of Hawaii, often in association with FAD's in other areas of the main Hawaiian Islands as well. Bottlenose dolphin and rough-toothed dolphin take both bait and catch.

Night Handline Fishery (Ika-shibi) for Tuna

Bigeye tuna and yellowfin tuna are taken in this night handline fishery at the edge of the island shelf near the 1,000 fathom contour from 2 to 20 km from shore. This fishery occurs predominantly south of the island of Hawaii from Hilo to around Captain Cook, but also occurs around FAD's throughout the main islands. The boats use 20–30 watt bulbs underwater or over the surface to attract squid, *Stenoteuthis oualeniensis* which is caught for bait or market. Other baits include frozen mackerel or squid. The bait is typically fished at 30 m depth. Loss of catch and bait as well as poor catch rates have been attributed to bottlenose dolphins. Poor catch has also been attributed to sharks.

Handline Fishery for Mackerel Scad

This fishery takes place at night, primarily off the west shores of Oahu and the island of Hawaii. Lights are used to illuminate an area around the boat, and a line with several hooks, either

⁹W. Gilmartin. Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822-2396. Personal commun. 1993.

¹⁰E. W. Shallenberger. 1983. 1440 Woodland Ave., Anacortes, WA 98221. Unpublished report to the Marine Mammal Commission and personal commun. 1991.

¹¹J. K. Hale and C. W. Coon. 1993. Summary report - Bottomfish observer trips in the Northwestern Hawaiian Islands, October 1990 to June 1992. Pacific Area Office, Southwest Region, 2570 Dole St., Honolulu, HI 96822-2396. Unpubl. rep.

⁸B. A. Kuljis. 1983. Porpoise/fisheries interactions within the Hawaiian Islands. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-88-19C, 16 p.

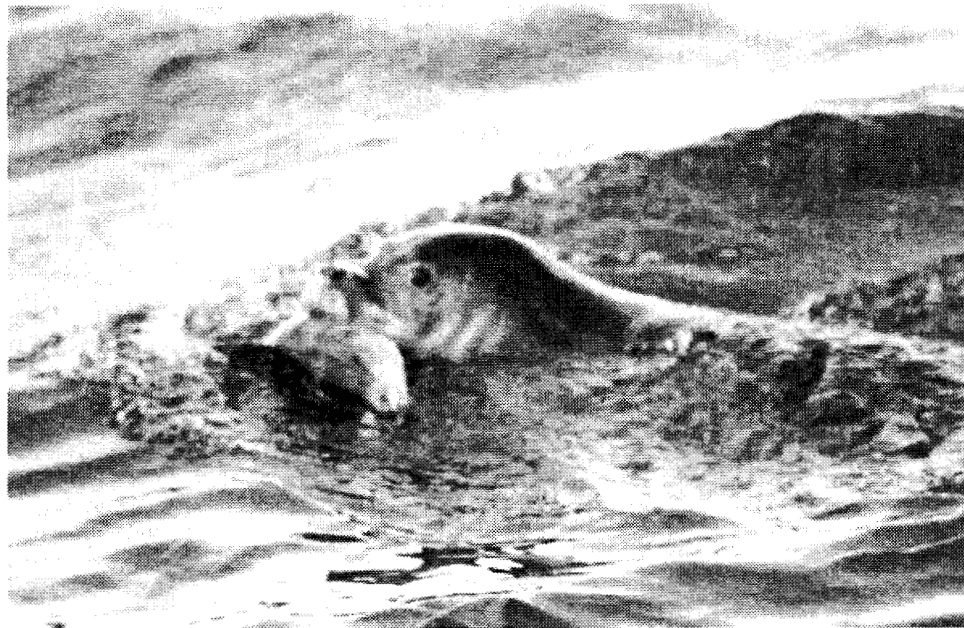
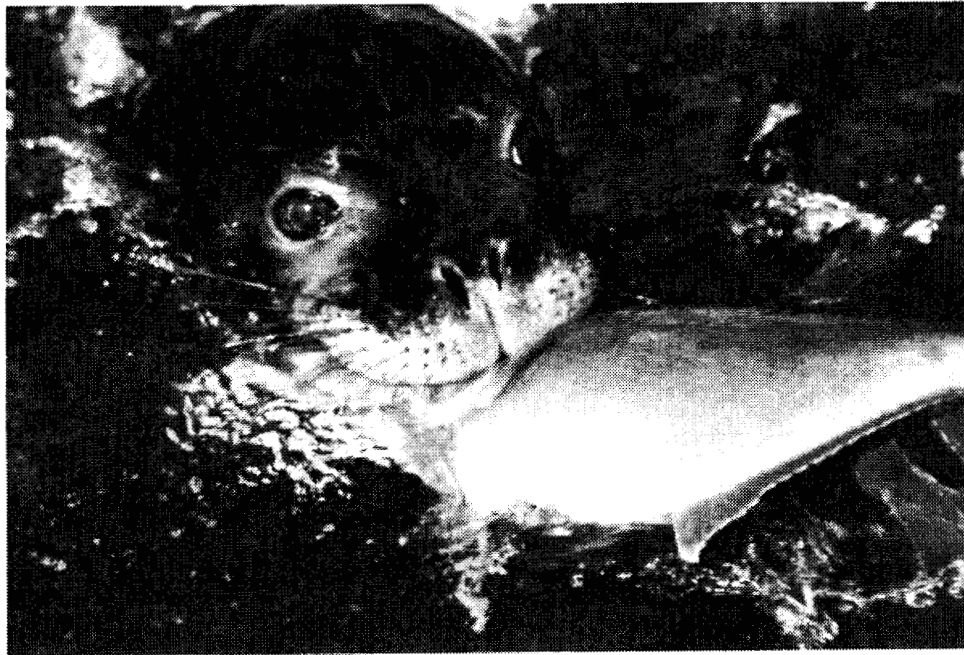


Figure 1.—Hawaiian monk seal consuming a discarded kahala (photo by Frank LaSorte, NMFS).

baited or with feathered jigs, is fished at 15–25 m. Bottlenose dolphin have been observed taking catch, but not bait or lures. Fishermen may be snagged by open hooks when dolphins take the catch and run with it.

Trolling for Billfish and Tuna

This fishery is a sport and commercial fishery located in waters near Honolulu and along the Kona (west) coast of the Island of Hawaii. Gear involves trolling lures or live bait near the surface. Catches of both billfish (marlin and spearfish) and tuna have been reported taken by false killer whales (Zimmerman, 1983). One fisherman reported a false killer whale surfacing immediately astern of his boat holding the catch (a marlin) crosswise in its jaws (Zimmerman, 1983). Catch may either be damaged or removed from the hook entirely. Rough-toothed dolphins, bottlenose dolphins, albatrosses, and boobies have also been observed taking live bait.

Longline Fishing for Tuna and Billfish

The Hawaiian longline fishery for broadbill swordfish has developed rapidly since 1987 when fewer than 40 vessels were in the fleet, landing less than 30,000 pounds of broadbill swordfish, a bycatch product of the tuna longline fishery. As of September 1992, the Hawaiian longline fishing fleet comprised about 165 vessels with permits, of which approximately 100 were active. Up to 40 of these vessels have been recorded as targeting broadbill swordfish in the NWHI.

The major fishing grounds for broadbills in the central Pacific region, traditionally exploited by foreign longliners, lie approximately 1,000 miles north of the Hawaiian Islands (25°–40°N.). Local longliners have fished closer to the islands, especially off the NWHI around “66 Fathom Bank” near French Frigate Shoals, St. Rogatien and Brooks Banks, and Gardner Pinnacles. A typical set consists of 16–48 km of monofilament line having as many as 700–1,000 branch (leader) lines and an equal number of

hooks. The leader line is relatively short, 9–18 m long, to which is attached a “night lightstick” (a luminescent lure) about 76 cm above a broad, flat hook (8/0–9/0 Mustad). Whole squid is the preferred bait for catching broadbills. The longline is set in the evening and retrieved early the next morning.

Midwater longlines are used to catch bigeye and yellowfin tuna in the tuna longline fishery. A main line is suspended from buoys, and dropper lines are attached to the main line. Hooks are baited with whole fish of several species. Lines are usually deployed from vessels larger than 15 m. Main lines are frequently more than 32 km long with 1,000–1,400 hooks. Although yellowfin and bigeye tuna are the targeted species, swordfish, albacore, sailfish, marlin, shortbill spearfish, and sharks are often caught.

Until recently, interactions between monk seals and the longline fishery were not believed to constitute a problem in the NWHI. Events in 1990 and 1991 indicated that monk seal interactions were occurring at a level and in a manner not previously considered. Seven injured seals were observed during a survey of monk seals and turtles at French Frigate Shoals in May 1990¹². All had head injuries ranging from abrasions to gaping wounds which could not be attributed to shark attack or harassment by adult male seals. In early 1991 nine monk seals with evidence of injury as a result of interaction with the longline fleet were reported or observed.

Sea turtle interactions with the longline fishery in the NWHI were also reported for this period. During the NMFS field surveys conducted in May 1990, a green turtle was found on Trig Island at French Frigate Shoals with monofilament line similar to longline leader protruding from its mouth.¹³ Olive ridley, loggerhead, and green turtles have been reported taken on baited hooks and snagged on longline hooks in the NWHI¹⁴, but there is some

¹²NMFS field survey report. May 18, 1990. Southwest Fish. Sci. Cent., Honolulu Lab., 2570 Dole St., Honolulu, HI 96822–2396.

¹³See footnote 12.

¹⁴NMFS longline logbook reports, 1991. Pacific Area Office, Southwest Region, 2570 Dole St., Honolulu, HI 96822–2396.

question regarding identification of the species involved. Regardless, preliminary analysis of logbook data from the Hawaii longline fishery indicates a significant take of sea turtles. For 1991, 61 total takes with 3 mortalities were reported. Leatherback turtles constituted the largest percentage of turtles taken (61%, 38 individuals) and green turtles were reported as the second highest (31%, 19 individuals)¹⁵.

Based on logbook reports false killer whales are identified as taking catch in all pelagic longline fisheries as has been reported in other longline fisheries in the Pacific. A 1990 observer report described catch loss to a solitary killer whale, *Orcinus orca*, on one set in mid-Pacific waters (Dollar¹⁶). In 1991 a humpback whale was observed entangled in longline gear in the EEZ off the NWHI (Dollar^{16, 17}) and a second was reported entangled in longline gear off Lanai.

From January through September 1992, longline logbook data indicated up to 68 albatrosses killed or injured over 947 reported trips. There is no distinction made in the logbooks between species of albatrosses.

Other Fisheries

Inshore Monofilament Gillnets

Small-mesh (about 5 cm stretched mesh) gillnets are commonly set on the shallow reefs around all the main islands and allowed to soak overnight, usually in water less than 10 m depth. In 1992–93 the State of Hawaii received 288 applications for permits that listed nets as the primary gear. Gill net was specified in 161 additional applications for permits. This fishery targets inshore reef fish.

Interactions with protected species have been reported. One bottlenose dolphin calf was recovered from a gill net off Maui in 1991¹⁸, but bottlenose

¹⁵See footnote 14.

¹⁶R. A. Dollar. 1991. Summary of swordfish longline observations in Hawaii, July 1990–March 1991. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-91-09, 13 p.

¹⁷See also footnote 11.

¹⁸Stranding Report ETN 91–03, Hawaii Marine Mammal Stranding Network. Pacific Area Office, Southwest Region, 2570 Dole St., Honolulu, HI 96822–2396.

dolphins are rarely reported entangled or raiding set gill nets in Hawaii; this is somewhat surprising, since they readily remove akule, opelu, bottomfish, and small tunas from handlines and trolling lines.

There are records of spinner dolphins being taken in nets or net fragments in Hawaiian waters (Rizzuto, 1988, 1989), and there is an eyewitness account of a spinner dolphin removed from an inshore gillnet on Oahu and buried on the beach in 1990¹⁹. One confirmed interaction between Hawaiian monk seals and inshore monofilament gill nets has been reported from the main Hawaiian Islands. A Hawaiian monk seal was reported drowned in a gill net near Poipu, Kauai, in 1976²⁰. Green turtles are periodically caught in inshore monofilament gill nets set around the main Hawaiian Islands. At least 43 (25%) and possibly as many as 86 (50%) of the 171 dead green turtles stranded in Hawaii in 1991 were likely entangled in these gill nets²¹. A hawksbill turtle was recovered from a monofilament gill net in Kaneohe Bay, Oahu, in 1977 (Balazs, 1978).

Lobster Fishery

The commercial spiny lobster fishery around the main Hawaiian Islands represents a small percentage of Hawaii's total fishery. The primary commercial fishing grounds are found in the NWHI, and the fishery is governed by a Federal fishery management plan. Consistent commercial-scale operations began in the NWHI in 1976, with most vessels processing frozen lobster tails on-board and a few vessels delivering live lobster to a specialized market.

Gear used initially in the NWHI fishery was a version of the California two-chambered trap or the wooden-lath Florida pot, deployed on a main

line and spaced at intervals of 2 to 10 m. Each main line had 75 to 150 traps, and vessels carried an average of 300 traps. Traps were set each day before sunset between 55 and 90 m depth, fished overnight, and retrieved the next morning. By 1985 virtually the entire fleet of 16 active vessels (compared with 4 active vessels in 1983) had converted to the black plastic crab pot which is used in the Alaska crab fisheries. This dome shaped pot is single chambered, has two entrance funnels, and can be folded in half to increase a vessel's trap carrying capacity. Between 1983 and 1985, during the conversion from the two-chambered California pot and Florida pot to the black plastic trap, the number of active vessels increased from 4 to 16 and the total trap carrying capacity of the active fleet increased from 1,200 to 12,250. From 1983 to 1990 the average trap carrying capacity of the lobster vessels in the NWHI fleet increased from 300 to over 1,000, with the number of active vessels fluctuating between 4 and 16 (Dollar and Landgraf²²). The black plastic pots are fished in the same manner as the old traps.

A monk seal was entangled and drowned in the trap bridle and main lines of a string of lobster traps in the vicinity of Necker Island in 1986²³. This is the only reported mortality of a Hawaiian monk seal associated with the spiny lobster fishery in the NWHI since the Crustaceans Fishery Management Plan (FMP) went into effect in 1983. In 1980 an adult leatherback turtle was entangled in a mainline of a string of lobster traps near Kure Atoll. The turtle was released alive (Humphreys²⁴).

Miscellaneous and Unidentified Gear

Reports between 1986 and 1992 of at least three incidents of humpback whales dragging unidentified pieces of netting around Kauai and Maui appear to demonstrate that some interaction between whales and fisheries occurs. The disposition of these animals is unknown, as are the sites where entanglements occurred. In 1992 a humpback whale mother and calf were found entangled off the east coast of the island of Hawaii in gear similar to longline deployed from shore. The animals were subsequently disentangled and released alive by the U.S. Coast Guard (ETN, personal observ.).

Green turtles have been reported hooked and entangled in the flippers and body and taken on baited hooks from shoreline pole-and-line fishermen around the main Hawaiian Islands²⁵. Protected species, especially Hawaiian monk seals and often green sea turtles, are susceptible to entanglement in lost and discarded fishing equipment, including lines, nets, and other plastic flotsam. These entanglements represent secondary interactions, i.e., interactions with gear no longer actively being used, and as such are beyond the scope of this paper. However, it is often difficult to determine whether an entanglement occurred during active fishing or after the gear had been lost.

Research

The first reports of attempts, such as shooting, to deter bottlenose dolphins from taking catch were received by the NMFS in the early 1970's. Although many methods were tried to deter predation by dolphins, none proved successful. Methods included rigging live baits with wire, hooks, or foil to confound the animals' sonar (Schlais, 1985), injecting citric acid into the baits to develop a taste aversion for certain species of fish²⁶, and using various

¹⁹M. Hoffines. University of Hawaii, Kewalo Basin Marine Mammal Laboratory, 1129 Ala Moana Blvd., Honolulu, HI 96814. Personal commun. 1992.

²⁰Internal NMFS stranding report, March 16, 1976. Pacific Area Office, Southwest Region, NMFS, Honolulu, HI 96822-2396.

²¹G. Balazs. Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822-2396. Personal commun. 1991.

²²R. A. Dollar and K. C. Landgraf. 1992. Annual report of the 1991 western Pacific lobster fishery. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Sci. Cent., Honolulu Lab., Southwest Fish. Sci. Cent. Admin. Rep. H-92-10, 26 p.

²³NMFS lobster logbook report, November 1986. Pacific Area Office, Southwest Region, NMFS, 2570 Dole St., Honolulu, HI 96822-2396.

²⁴R. L. Humphreys, Jr. 1981. Hawaiian monk seals and sea turtle — sightings and direct interactions with fishing operations in the Northwestern Hawaiian Islands. U.S. Dep. Commer., NOAA, Natl. Mar. Fish. Serv., Southwest Fish. Cent., Honolulu Lab., Southwest Fish. Cent. Admin. Rep. H-81-6, 18 p.

²⁵G. Balazs. Southwest Fisheries Science Center, Honolulu Laboratory, 2570 Dole St., Honolulu, HI 96822-2396. Personal commun. 1992.

²⁶J. J. Naughton. 1981. Trip report on porpoise-fisheries interaction, Kona, Hawaii, November 2-4, 1981. Pacific Area Office, Southwest Region, Natl. Mar. Fish. Serv., Honolulu, HI 96822-2396. Unpubl. rep. 4 p.

noisemakers including explosive, mechanical, and electronic devices. The unconfirmed use of poisons in bait was also reported during this time. Food aversion was investigated by the NMFS in 1980²⁷ as a potential method of deterring cetaceans. The results proved inconclusive. Complaints to NMFS from fishermen continue and appear to peak in cycles of 3 to 5 years, covering all fisheries from longline and live bait troll fisheries for pelagic species to handlining for bottomfish and mackerel scad.

Sound generators were tested on pinnipeds in California and Oregon with mixed results. In some cases the acoustic harassment was successful in initially deterring pinniped predation on various species of fish. However, the animals either habituated to the sounds or ignored them (Mate and Harvey, 1987). Masking or confusing sounds proved ineffective.

Any future investigations of aversive techniques for small cetaceans will have to consider stimuli strong enough to be physically painful but not injurious, particularly under the current regulatory regime. This is particularly difficult because of the behavior and adaptability of bottlenose dolphins and perhaps other species such as false killer whales to new stimuli. The attraction for food is secondary, and the challenge or stimulus of taking fish may be the primary motivating factor for some individual animals. The use of aversive techniques may provide greater motivation for these animals to solve the "problem" or "play the game."

Other avenues of research which could be considered are the use of conspecific social sounds that indicate threat or alarm which might serve to confuse some of the more socially oriented small cetaceans and the use of pheromones as distractors.

There has been no directed investigation of alternative fishing methods or other means of reducing the poten-

tial for incidental take in Hawaii. Most of the effort to reduce incidental take of sea turtles results from regulatory actions that limit fishing effort through closed areas and limited entry and restrictions on the level of allowable incidental take. Altered fishing methods may serve to diminish seabird interactions in the longline fishery (Brothers, 1991). Setting and retrieving gear during the night, a voluntary measure taken by longline fishermen, appears to have reduced the incidental take of seabirds in this fishery.

Management and Regulation

Statutory and Regulatory Implications

Since 1972 various regulatory regimes have been implemented in response to fishery interactions. The Endangered Species Act of 1973 (ESA) and the Marine Mammal Protection Act of 1972 (MMPA) are the two primary Federal statutes that protect marine mammals and threatened and endangered species in Hawaiian waters, and the Migratory Bird Treaty Act of 1918 protects seabirds. The Magnuson Fishery Conservation and Management Act of 1976 (MFCMA) also provides management authority to protect these species in fisheries governed by FMP's.

The ESA prohibits the taking of endangered species except under limited circumstances. These include, but are not limited to, scientific research under permit, actions taken by personnel authorized by the NMFS or USFWS to salvage or rescue a stranded or distressed endangered animal, and an allowable level of take (except for certain marine mammals) set forth during consultation for a specific Federal activity under Section 7 of the ESA. Incidental take of listed sea turtles may be authorized, but no take can be authorized for Hawaiian monk seals or humpback whales.

The MMPA allows the incidental take of marine mammals during commercial fishing operations under certain conditions. Depleted marine mammal species, including Hawaiian monk seals, cannot be intentionally lethally taken. Under the 1988 amendments to the MMPA, some levels of mortalities of nonendangered and

nondepleted marine mammals have been determined for specific fisheries. Nonlisted cetaceans may be taken incidentally or harassed, but not intentionally killed or injured, again for specific fisheries.

Historic Context

Prior to 1988 the MMPA allowed the NMFS to issue general incidental take permits to commercial fishermen operating within the U.S. EEZ. This exception to the general moratorium on the taking of marine mammals was permitted provided that the marine mammal stocks involved were within OSP²⁸ levels, that the takings would not disadvantage the stocks, and that the issuance of the permits were consistent with the purposes and policies of the MMPA.

From 1981 to 1988 commercial fishermen operating in Hawaiian waters who participated in fisheries affected by small cetaceans were covered under a general permit which allowed harassment of these animals without injury or mortality. Reports of harassment were required under the permit, but few were actually received. Complaints of catch loss far exceeded reports of harassment. The high point of participation occurred in 1982 when 77 certificates of inclusion were issued to commercial fishermen allowing them to operate under the general permit. Since 1988 there have been few written reports of interactions from non-FMP regulated fisheries in Hawaii. An estimate of economic loss to the various fisheries has not been made but may be substantial in relation to the size of the fisheries.

A district court ruling in 1987 invalidated a permit issued to a Japanese fishing cooperative for the incidental taking of Dall's porpoise because species for which permits could not be

²⁷B. A. Kuljis, C. S. Baker, and W. G. Gilmartin. 1981. Effects of lithium chloride on a Pacific bottlenose dolphin (*Tursiops gilli*). Presented abstract, Fourth Biennial Conference on the Biology of Marine Mammals, December 14-18, 1981, San Francisco, Calif.

²⁸OSP (optimum sustainable population) as defined in the MMPA means, "... with respect to any population stock, the number which will result in the maximum productivity of the population or the species, keeping in mind the carrying capacity of the habitat and the health of the ecosystem of which they form a constituent element." Marine Mammal Protection Act of 1972, 86 Stat. 1027, 16 U.S.C. 1361-1407, P. L. 92-522.

issued would also be taken during fishing operations. Under this judicial interpretation NMFS could issue permits for only a few species of marine mammals for which OSP levels were known (none in Hawaii). In order to provide a temporary means of obtaining reliable information about marine mammal/fisheries interactions, while allowing commercial fishing to continue, Congress passed the 1988 Amendments to the MMPA which established the Interim Exemption for Commercial Fisheries (Interim Exemption). Under the Interim Exemption fisheries were categorized according to the likelihood of incidentally taking marine mammals. Observer programs to monitor marine mammal interactions and reporting requirements were also established by the Interim Exemption.

All domestic Hawaiian fisheries have been classified by NMFS as Category III, with incidental takings of marine mammals unknown and/or considered extremely unlikely. This does not mean that no interactions occur, only that marine mammals would not normally be hooked, snagged, injured, or killed during fishing operations. Interactions as well as accidental lethal takes are to be reported to the NMFS.

The Interim Exemption expired 1 October 1993. The NMFS was required to develop a regime to govern the incidental taking of marine mammals associated with commercial fishing operations after 1 October 1993.

Fishery Management Plans

Four FMP's are in effect in the U.S. EEZ around Hawaii—Precious Corals, Crustaceans, Bottomfish, and Pelagics. Protective measures for marine mammals and threatened and endangered species are generally incorporated into FMP's as they are developed. Because of concerns regarding interactions between Hawaiian monk seals and the spiny lobster fishery in the NWHI, specific conservation measures were incorporated into the Crustaceans FMP as it was being developed. These measures included closed areas within 10 fathoms of the islands in the NWHI, a 20-mile fishing refugium around Laysan Island, a trap opening size re-

striction of 6.5 inches, NMFS authority to place observers on lobster vessels upon request, and a protocol by which the NMFS could institute emergency protection for monk seals if a problem involving the fishery arose. Only the fishery for precious corals has not reported an interaction with marine mammals, sea turtles, or sea birds in fisheries governed by the four existing FMP's.

Section 7 consultations under the ESA for the Crustaceans, Bottomfish, and Pelagics FMP's concluded that these fisheries would not likely jeopardize the continued existence of the Hawaiian monk seal if certain gear and reporting requirements were included in the implementing regulations for these fisheries. Because of recent developments in the broadbill swordfish fishery, the Pelagics FMP is now being monitored based on Section 7 requirements. The longline fishery and bottomfish fishery are discussed together in this section because the management issues are tied to the geographic area of the NWHI and involve interactions with Hawaiian monk seals.

Allegations of Hawaiian monk seal interactions with the longline broadbill swordfish fishery in the NWHI surfaced in April 1990. NMFS field surveys in May 1990 found seven injured Hawaiian monk seals in the NWHI with possible evidence of interactions with the longline fishery. Subsequent interviews by NMFS special agents with captains and crews of 28 vessels returning from the NWHI did not generate sufficient information for enforcement action. However, there was enough consistency in reports to indicate that measures were needed to obtain definitive information on possible impacts on protected species from the longline and bottomfish fisheries.

In June 1990 the Western Pacific Fishery Management Council (Council) considered this issue. The Council proposed that NMFS implement the following: 1) A permit and logbook reporting system for the pelagic longline fishery and 2) a program to place observers on selected longline and bottomfish vessels operating in the NWHI. Although not required by regu-

lation, observers were placed aboard one bottomfish and six longline vessels on a voluntary basis between July and October 1990 and reported interactions with sea birds, sea turtles, whales, dolphins, and monk seals. Emergency regulations were subsequently implemented by the NMFS in November 1990 restricting longline and bottomfishing operations within 50 n.mi. of selected islands in the NWHI (protected species zone). This was intended to provide a "safe zone" where Hawaiian monk seals were most likely to occur. These restrictions were waived on a trip by trip basis however, provided the operator of the vessel allowed NMFS the opportunity to place an observer aboard to document and describe interactions with protected species.

Concerns increased after further reports, in January 1991, of monk seals observed with hooks (long pieces of monofilament line attached) imbedded in their bodies and with severe injuries that appeared to be the result of interactions with fishing operations. As a result the protected species zone was expanded to include all NWHI and was closed to longline fishing in April 1991, through emergency regulation.

Amendments were subsequently implemented to both the Bottomfish FMP and the Pelagic FMP making these emergency regulations permanent. Specifically, Amendment 4 to the Bottomfish FMP restricted bottomfishing in the protected species zone which includes the area within 50 n.mi. of the islands and atolls in the NWHI from Nihoa Island to Kure Atoll. These restrictions can be waived on a trip by trip basis however, provided the operator of the vessel allows NMFS the opportunity to place an observer aboard. Amendment 3 to the Pelagics FMP prohibited fishing in the protected species zone which includes the 100 n.mi. wide corridors between islands in the NWHI where the zones are not contiguous. Logbook reporting of interactions is also required of longline vessels in order to obtain information regarding interactions outside the protected species zone.

Observer coverage became mandatory in November 1990 for bottomfish

vessels because of the proximity of their fishing operations to the banks and islands of the NWHI, and the evidence of interactions between protected species and the fisheries in this area. The area from Nihoa Island to Necker Island comprises the Mau Zone. The Ho'omalulu Zone is a limited entry fishing zone and comprises the area from French Frigate Shoals to Kure Island (Fig. 2). All vessels which bottomfish in either the Mau or Ho'omalulu Zones are required to place onboard observer selected by NMFS. Target observer coverage is currently set at 30 percent annually.

Future Prospects

The probable trends in protected species/fishery interactions in Hawaii are difficult to assess, but interactions will likely increase. Fishing effort is also likely to grow and place the various fish stocks under greater pressure, as an increasing human population demands more food resources. With the protection afforded by the ESA and MMPA, certain species, such as the

humpback whale, will probably continue to recover from the low levels to which they were reduced by exploitation, and such increases may result in more interactions. Finally, continued environmental awareness, together with increased fishing pressure, will likely result in greater scrutiny of fisheries, resulting in more restrictions, regulations, and reporting requirements. Regardless of the difficulties in predicting trends and developing solutions for protected species/fisheries interaction problems, at the minimum, the variables that need to be monitored include population levels of the different species involved, fishing effort, and rates of interaction.

The following research and management tasks address both long- and short-term needs for the conservation and protection of marine mammals and other protected species in Hawaiian waters.

- 1) Accurate, timely, and consistent documentation of interactions;
- 2) Elimination of inshore gillnets and set nets;

3) Assessment of the status of stocks of all protected species which interact with fisheries;

4) Development of alternative fishing methods which reduce or eliminate interactions with small cetaceans; and

5) Where interactions cannot be eliminated or mitigated by other means, development of management schemes which allow for incidental take of selected species of marine mammals in Hawaiian waters provided that the stocks of marine mammals are not adversely affected.

Many of the tasks identified above rely upon the cooperation of a number of agencies and will be affected by the restrictions and requirements of the applicable Federal and state statutes. Given the biology of the protected species involved in fishery interactions, the current and likely future regulatory regimes, and the nature and locations of the Hawaiian fisheries, the interaction problems identified ultimately may have no legal or practical solutions.

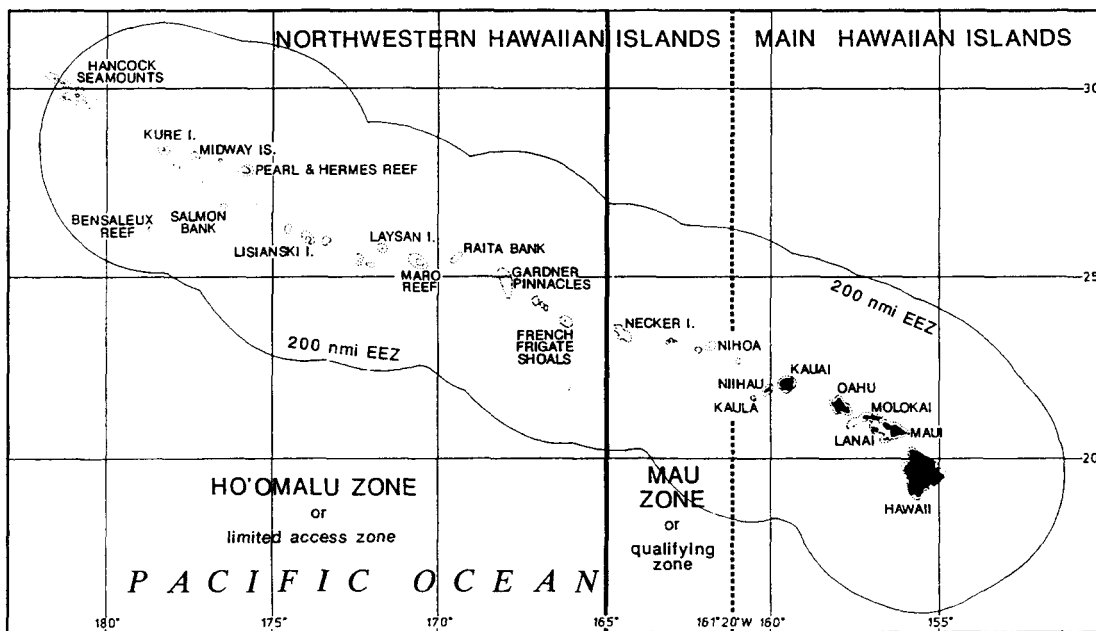


Figure 2.—Northwestern Hawaiian Islands bottomfish management areas.

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