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Cetacean Interactions with Trawls: A Preliminary Review

by

D. Fertl[1] and S. Leatherwood[2]

[1] Marine Mammal Research Program, Texas A&M University
4700 Avenue U, Galveston, TX 77551, USA
current address: Minerals Management Service, 1201 Elmwood Park Blvd
New Orleans, LA 70123, USA

[2] IUCN/SSC Cetacean Specialist Group, c/o Ocean Park Conservation Foundation
Ocean Park, Aberdeen, Hong Kong
University of Rhode Island Graduate School of Oceanography
Narragansett, RI 02882, USA

Abstract:

The interactions of cetaceans with trawls occur to an undetermined magnitude. A preliminary review indicates that individuals of 26 cetacean species (3 mysticete, 23 odontocete) have been documented to have died in working trawls or discarded trawling gear. Cetacean interactions with trawls are complex, partially because fishermen and cetaceans are drawn to areas of high prey density. Further, within these areas, cetaceans are probably attracted to trawling activities because the trawlers' operations make it easier for the animals to exploit a concentrated food source. Individuals of 11 odontocete species, and possibly one mysticete species, have been reported to feed in association with trawls. Animals follow working nets (feeding on stirred-up organisms or fish gilled in mesh) and also feed on discarded bycatch. Damage to gear as a result of feeding interactions or entanglement has been reported. This results in: (1) harm to the animals, (2) fishermen's negative opinions of cetaceans (regardless of whether a cetacean or a shark is responsible for the damage in question), and (3) loss of time and money for repair or replacement of gear. The relationship of cetaceans with trawls needs to be further studied to determine what impacts the trawl fisheries have on the ecology and population levels of the whales and dolphins involved.

Interactions between various cetacean species and fisheries are geographically widespread and consist of many different types (see reviews in Northridge, 1984, 1991; Currey *et al.*, 1990, 1991). Interactions are potentially harmful for cetaceans (*depletion of* fish stocks, direct kills in fisheries, and incidental entanglement in fishing gear) and for humans (gear damage and depletion of commercially valuable fish stocks) (Beddington *et al.*, 1985). Incidental entanglements of cetaceans in nets, especially purse seines, gill nets, and drift nets have caused great concern (Bjoerge *et al.*, 1991; Perrin *et al.*, 1994). In light of the extensive kills of cetaceans in gill nets, mortality in trawls has been less reported and all but ignored, even though many of the causes are similiar to causes of gillnet captures.

Many fisheries in the world use trawl nets (Nedelec & Prado, 1990). Trawls are used to take various species of fishes, squid, and crustaceans around the world. Incidental takes of cetaceans exist in most areas where trawling occurs, for example, the North Sea, Bering Sea, Indian Ocean, Gulf of Mexico, Gulf of California, off Australia and New Zealand, and the Mediterranean Sea (Appendix 1). Extensive foreign trawl fisheries in the Bering Sea for squid and small pelagic fishes from the mid-1960's to the mid-1970's likely killed marine mammals, but at unknown rates (Perez & Loughlin, 1991). Information on the numbers of animals caught and causes of entanglement in trawls is not readily accessible, this paper compiles and summarizes existing information. Much of the information about cetacean catches in trawls is embedded in the gillnet literature

Cetacean catch and composition

Three mysticete species, twenty-three odontocete species, and several unidentified cetaceans, including unidentified beaked whales, have been documented to be incidentally caught in trawls (Appendices 1 and 2). As is the case for purse seines (Coe *et al.*, 1984), animals could be either entangled in trawl mesh or entrapped by folds of webbing. Reports of captures in trawls are not as specific to indicate the difference, so the term entanglement will be used. The condition of entangled animals is variable. It has been suggested that cetaceans found in nets are rarely alive when caught, and that dead or dying animals are scooped up as the nets pass (T. Loughlin, Natl. Mar. Mamm. Lab., NMFS, 7600 Sand Point Way NE, Seattle, WA 98115, pers. comm., 1991). There are a number of reports of dead and decomposed bodies of cetaceans being caught up in trawls (Scheffer & Slipp, 1948; Testaverde, 1978; Perez & Loughlin, 1991), as well as just skulls (Anonymous, 1979; Smith *et al.*, 1989). Some feel that healthy cetaceans should be able to easily avoid trawl nets, since the vessels move forward quite slowly (van Utrecht, 1978; Niazi, 1990; T. Loughlin, Natl. Mar. Mamm. Lab., NMFS, pers. comm., 1991). This is clearly not the case for pinniped species that interact with trawls. Many of these animals are caught live and perish in trawls, such as Steller sea lions (*Eumetopias jubatus*) (Alverson, 1992), Cape fur seals (*Arctocephalus pusillus*) (Shaughnessy & Payne, 1979), Hooker's sea lions (*Phocarctos hookeri*) (MAF Fisheries, 1991), northern fur seals (*Callorhinus ursinus*) (Perez & Loughlin, 1991), and New Zealand fur seals (*Arctocephalus forsteri*) (MAF Fisheries, 1991). Miller *et al.* (1982) report that while a small number of California sea lions (*Zalophus californianus*) are entangled entering trawl nets (versus other fishery interactions), most had been drowned, but some survived and were released. A similar situation occurs for some cetaceans (see Appendix 1). Other cetaceans are fortunate when caught, and can be released alive (see Appendix 1). One incident involved a minke whale (*Balaenoptera acutorostrata*) harpooned in Newfoundland that was found with trawl mesh web grown into its snout (D.E. Sergeant, , 325 Main Road, Hudson Quebec, JOP1HO, Canada, pers. comm., 1992). It was thought that this whale had been cut out of a trawl net at some point in its life.

These catches raise the question of why cetaceans become caught in trawls. Most of the possible causes for cetacean entanglement in gillnets (IWC, 1994) are applicable to cetacean catches in trawls. A variety of biological factors can influence entanglement of marine mammals: species distribution, various behavioral traits, sensory capacities, and attention and searching images. Behavior of an individual causes interactions with a number of gear characteristics.

Feeding Behavior

Marine mammals frequently exploit fisheries for food (O'Hara *et al.*, 1986). California sea lions, bottlenose dolphins (*Tursiops truncatus*), and boto (*Inia geoffrensis*) are known to remove fish from nearshore gillnets (Everitt *et al.*, 1981; Cato and Prochaska, 1976; S. Leatherwood, unpubl. data, respectively); bottlenose dolphins (Cato and Prochaska, 1976; Iversen, 1975), rough-toothed dolphins (*Steno bredanensis*) (Iversen, 1975), false killer whales (*Pseudorca crassidens*) (Leatherwood et al., 1984), and killer whales (*Orcinus orca*) (Sivasubramanian, 1964; Dahlheim, 1988) steal hooked fish. It appears that some cetacean species are attracted to trawl nets because of the easy food source they represent. This is usually the case for pinnipeds (e.g., Shaughnessy & Payne, 1979; Beddington *et al.*, 1985).

Eleven cetacean species (eleven odontocete and possibly one mysticete) have been documented to feed in association with trawling (Table 1, Appendix 3). Such associations appear to occur in all areas of the world. Individuals exploit food concentrated by trawl operations. This is best illustrated by the long-standing relationship between bottlenose dolphins and shrimp trawlers, in which the dolphins show readiness to make use of a variety of easily-procured food items (e.g., Leatherwood, 1975; Gruber, 1981; Corkeron *et al.*, 1990; Fertl, 1994).

Animals tend to be attracted to food which is clumped or patchy in distribution (Krebs, 1978). A trawler might well be considered to be a mobile patch. By remaining with this moving patch, in which available food is being frequently concentrated, dolphins presumably can reduce the proportion of time spent foraging (searching for and consuming food) and possibly increase the quantity and quality of what they do consume. Additionally, the less time that is spent foraging, the less energy is used. In this way, trawling may provide a large quantity of food in a small area and permit the animals to select food of higher-than-usual caloric value.

Trawling operations probably also open up a food niche not otherwise available to some cetaceans. This is certainly what is happening for killer whales in the sable fish *Anoplopoma fimbria*) fishery (Dahlheim, 1988; Yano & Dahlheim, 1995. Killer whales are often observed taking from long lines, the sablefish which otherwise live too deep for them to catch themselves (Matkin and Saulitis, 1994). There are two reports of humpback whales feeding behind trawl nets (von Ziegesar, 1984; D.E. Sergeant, pers. comm., 1992). It has been suggested that since the humpback whales (*Megaptera noveangliae*) do not usually dive very deeply, the additional food supply brought up by trawl nets gives the whales a broader feeding resource (D.E. Sergeant, 325 Main Road, Hudson Quebec, JOP1HO, Canada, pers. comm., 1992). It is questionable, however, based on the diet of humpback whales, whether these whales really are associating with trawl fisheries in this manner.

There is considerable overlap of prey species occurring in the stomachs of cetaceans that have been feeding opportunistically around trawlers and target species of the commercial fishery. Analyses of stomach contents of bottlenose dolphins from the Gulf of Mexico (Barros and Odell, 1990) indicate prey composition similar to non-shrimp catches of shrimp boats (Bryan, 1980; Pellegrin, 1982). Pellegrin (1982) calculated an overall fish/shrimp ratio in bycatches of the Gulf of Mexico shrimp fishery as 9.1 : 1. Stomach contents of pilot whales (*Globicephala* spp.) caught in the North Atlantic mackerel (*Scomber scombrus*) fishery suggested that mackerel may be a major component of the pilot whales' diet, though feeding on Atlantic mackerel may well be an opportunistic phenomenon related only to the fishery (Waring *et al.*, 1990). The above observations do not necessarily indicate the cetaceans are scavenging from trawls, but they do show they are exploiting the same species targeted by the fisheries. Cetaceans could be feeding on fish that are ancillary to the catch (as is the case for bottlenose dolphins feeding in association with the shrimp fishery) or feeding on the directed catch of the fishery (such as the association of pilot whales with the Atlantic mackerel fishery in the northeastern United States) (see Appendix 3 for sources). A cetacean could be attracted to nets because of prey caught in the trawl nets, and also to scavengers feeding on fish caught by the nets. One dramatic example of the latter was reported for the Bering Sea, where killer whales pursued Steller sea lions that were waiting to feed on discarded bycatch from a trawler (Branson, 1971).

The bottlenose dolphin is the most often documented species to feed in association with trawls. Leatherwood (1975) describes three feeding patterns bottlenose dolphins use when associating with shrimp boats: (1) foraging behind working boats, (2) feeding on trash fish discarded or fallen from the net, and (3) feeding on fish attracted to non-working shrimpers. The vast majority of episodes of cetaceans feeding around trawls involves feeding behind working trawlers (Appendix 3). In such instances, the animals typically follow a vessel and feed on organisms stirred-up by the trawl, pick out fish entangled in the net's mesh, or possibly, feed on fish which pass through the mesh. It is reasonable to assume that in all three of these circumstances the prey are dead, injured, or disoriented and therefore easier for the dolphins to catch than organisms that are healthy and and actively avoiding capture. Bottlenose dolphins and pilot whales have been observed feeding around the mouth of nets (Fertl, pers. obs.; Leatherwood, pers. obs., Waring *et al.*, 1990, respectively), presumably on fish escaping the net's pathway. In interviews, many Gulf of Mexico shrimpers told one of us (D.F.) that they had witnessed bottlenose dolphins entering the nets to feed.

Opportunistic feeding by cetaceans in association with fisheries is perhaps best exemplified by cetaceans feeding on discarded bycatch. This behavior has been described for killer whales in the Bering Sea (Teshima & Ohsumi, 1983) and bottlenose dolphins in the Gulf of Mexico (e.g., Caldwell & Caldwell 1972; Leatherwood, 1975; Gruber, 1981), southeastern United States (Davis, 1988), and Moreton Bay, Australia (e.g., Corkeron *et al.*, 1990; Wassenberg and Hill, 1990). Typically the animals have been seen to wait alongside the vessel for by-catch to be discarded. Wassenberg and Hill (1990) calculated that dolphins scavenging behind a trawler can eat about 86% of fish discarded from a single trawl. In observations of feeding on trash fish, bottlenose dolphins have been found to show preferences for some species over other (Shane, 1977; Corkeron *et al.*, 1990; Wassenberg and Hill, 1990).

Leatherwood (1975) suggested that bottlenose dolphins have learned the advantages of following and feeding in conjunction with shrimp boats. Females with calves, in particular, have been observed following shrimp boats, and it has been speculated that the calves learn this foraging behavior by observation and participation (Shane *et al.* 1986). Studies of other marine mammals, such as sea otters (*Enhydra lutris*) and killer whales, have suggested that youngsters develop feeding skills through imitation of the mother's feeding behaviors (Riedman *et al.*, 1989 and Guinet, 1991, respectively. It is reasonable to speculate that females with calves may be taking advantage of the concentrated food resource provided by shrimp boats to meet increased energetic needs due to lactation (Fertl, 1994). Lactating mammals have greater energetic needs, and may need to eat greater quantities of food or to change to a diet richer in nutrients (Bernard & Hohn, 1989). Caloric consumption of captive, lactating bottlenose dolphins in the six months following parturition increases from 129% to 204% over that of resting (Ridgway *et al.*, 1992). The association of cetaceans with trawls may well be a strategy to increase the rate of feeding, while decreasing the energy expenditure associated with foraging.

The association of cetaceans with trawls indicates the behavioral flexibility of some cetaceans to capitalize on human activities. This feeding pattern may be beneficial in that it reduces time required to forage, provides the animals with an easier way to obtain food which is outside their usual foraging depths or otherwise too energetically costly to them to exploit.

Gear Damage During Feeding

Many trawl fishermen blame dolphins for holes in their nets (Gunter, 1942, 1944, 1951, 1954; Cadenat, 1957; Ravel, 1963; Reynolds, 1985; Northridge, 1984, 1991; dos Santos & Lacerda, 1987; Bearzi & Notarbartolo di Sciara, 1992; Consiglio *et al.*, 1992; Silvani *et al.*, 1992; Fertl, 1994); perhaps these are from dolphins attempting to pull fish out of the net, or even sharks tearing at the nets (as reported in Shane, 1977; Gruber, 1981; Delgado-Estrella, 1991; Fertl, 1994). Problem areas seem to be the Mediterranean and Gulf of Mexico regions, with bottlenose dolphins being the species blamed (when species was designated). Gulf of Mexico shrimpers felt that dolphins were "attacking" the nets in response to low fish productivity in the area (Fertl, 1994).

Attempts to reduce damage to trawl nets on the Gulf Coast of the United States and the Mediterranean have included firecrackers detonated near the animals and bullets fired into the water nearby (Gunter, 1944; Cadenat, 1957; Reynolds, 1985; Bearzi & Notarbartolo di Sciara, 1992; Consiglio *et al.*, 1992; Silvani *et al.*, 1992; Fertl, 1994). Acoustical deterrents appear to only be successful for a very short time period (Consiglio *et al.*, 1992). Non-acoustical methods used by trawl fishermen include tying ribbons to nets and putting an extra skirt on the net to frighten dolphins away; this method has met with mixed results. On the coast of the Adriatic and Tyrrhenian Seas, there is a story of fishermen putting a fake dolphin in the net - like a scarecrow - to scare dolphins away. The results were apparently good for a few days, but then the dolphins "saw the cheating" and tore the nets with their teeth (L. Marini, pers. comm., 1993).

Holes in nets, and incidental capture can result in loss of time while disentangling carcasses or live animals, and money for fixing or replacing damaged gear. Dolphins sometimes blunder into a tow or handling line and do minor damage while struggling to get free (Leatherwood & Reeves, 1982; Fertl, 1994). As stated earlier, a net was cut to release a bottlenose dolphin caught in a groundfish trawl (C. Pharr, National Marine Fisheries Service, per. comm., 1991). Another incident, involved a stranded bottlenose dolphin from Mississippi found lodged in a complete, small trawl net (Stranding record SE3983, Southeast U.S. Stranding Network Region). Northridge (1988) reported an incident of a pilot whale which became lodged in a trawl, drowned, and then the net was lost.

Distribution of Entanglements

It is not surprising that cetaceans and humans exploiting similar food resources would have overlapping ranges. If seasonal habits of a cetacean and the target of a commercial fishery bring the two into close proximity at certain times, the situation may create a significant interaction, or at least the perception of it and a resulting conflict of interest. Frequency with which a species is caught is a funciton of the abundance of that species in a fishing area. The abundance of a cetacean species in a fishing area sometimes may be related to the frequency with which it is caught. For abundant species in heavily fished areas, it would be surprising is some animals were not taken in fishing nets, for example, high catch rates in the Northwest Atlantic may be related to the distribution of fishing effort in particular areas of high pilot whale (*Globicephala* sp.) density (Northridge, 1991). Harbor porpoises (*Phocoena phocoena*), generally found near shore, may be particularly susceptible to entrapment because inshore areas are often heavily fished (Nelson, 1990). Movements and distribution of a species will be reflected in seasonal and geographic differences in net catches. Some species' abundance, however, may have no connection to entanglement rates. For example, the size of the animal and net size could determine the possibility of the animal being caught.

Gear Characteristics

More cetacean species are caught in mid-water trawls than in bottom trawls. Northridge (1988) discussed several reasons why mid-water gear is more likely to catch cetaceans. First, mid-water nets are generally targeted on small pelagic fish species, which are often the same species preyed upon by marine mammals. Second, mid-water gear is generally towed at higher speeds. Finally mid-water trawls are generally much larger than most demersal trawls. Niazi (1990) felt that the smaller size and openings of bottom trawls in Pakistan were harmless to the finless porpoise (*Neophocoena phocaenoides*). Whether the author felt the trawl openings were small enough to deter animals from entering the nets is not clear. In New Zealand's waters, pair trawlers, because of their ability to tow nets with higher headlines and greater overall dimensions faster than single trawlers and account for about 50% of all cetacean catches, with gillnets and single trawlers making up the remainder (Anonymous, 1981).

Some sources (Northridge, 1988; Waring *et al.*, 1990) have speculated that the large and widespread openings in the trawl nets provide enough room for an animal to get caught. It is generally thought that some individuals enter the trawl and become trapped when the boat stops hauling and the trawl entrance collapses ("haulback") (Clausen & Andersen, 1988; Northridge, 1988; Waring *et al.*, 1990) or when the net is being shot (put out into the water) (Moreno, 1993). This is the time when many pinnipeds appear to become entangled (e.g., MAF Fisheries, 1991). It is highly probable that many animals are alive when caught, but die because the nets are kept in the water for long periods of time before being checked. Bottlenose dolphins in the Gulf of Mexico have been reported with their rostrums caught in the net's mesh, perhaps when pulling fish scraps from the nets (Leatherwood & Reeves 1982; R. Ford, National Marine Fisheries Service, pers. comm., 1991); one bottlenose dolphin in the Gulf of Mexico was caught by its teeth in the net, but was released alive (Fertl, 1994). Ironically, there are two separate reports of bottlenose dolphin entanglement in turtle excluder devices (to allow turtles to escape from shrimp trawls if caught) (Burn & Scott, 1988; Fertl, 1994).

Behavior and social structure

Cetacean social structure may play a significant role in entanglement potential. Entanglements of pilot whales, a very social cetacean, often involve multiple animals (G. Waring, Natl. Mar. Fish. Serv., Woods Hole, MA 02543, pers. comm. 1991). Coastal cetaceans that forage in dense groups, such as common dolphins (*Delphinus* sp.) and pilot whales, often become victims to trawls (Waring *et al.*, 1990). One also needs to consider at what point in the water column the animals feed. Much feeding occurs at mid-water depths, which may account for the large number of animals caught in mid-water trawls.

It appears that a potentially disproportionate number of young animals are caught (records provided by Teshima & Ohsumi, 1983; Corkeron et al., 1990; Niazi, 1990; Vidal, 1990; V. Cockcroft, Port Elizabeth Museum, P.O. Box 13147, Humewood 6013, South Africa, pers. comm., 1992). Most of the common dolphins killed in squid (*Loligo*) and Atlantic mackerel fisheries are likely sexually immature (Waring *et al.*, 1990). Vidal (1990) suggested that because vaquita (*Phocoena sinus*) calves move too slowly they come entrapped in trawls. It is more probable that young cetaceans may be caught because of their inexperience with fishing gear (Nelson, 1990). Young animals may learn safe movements around nets by watching conspecifics. Phocoenids have a shorter dependency period than delphinids (Gaskin, 1984; Perrin & Reilly, 1984), and thus, have less opportunity to learn from their mothers or conspecifics. Tyack (1986) reviews the importance of a long period of parental care as it relates to the importance of social learning in odontocetes. It is also probable that younger animals are not as attentive as adults to the dangers that nets pose, accidentally get caught, panic, and are unable to free themselves. Young cetaceans may also be greater 'risk takers' than (Nelson, 1990), as is true in most animal species (Fagen, 1981).

Lack of attention (also dicussed in IWC, 1994 for gillnet captures) may be another reason for incidental entanglement. Mature cetaceans, as well as young and inexperienced individuals, could be caught due to "carelessness" around nets. Attention to social activity, such as play, may distract individuals. This behavioral cause fits with suggestions from trawl fishermen that dolphins do not get caught in their nets because they are too fast and too smart (Davis, 1988; Moreno, 1993; Fertl, 1994). Bottlenose dolphins are sometimes caught around the tail stock in the hanging line of the trawl and end up drowning (Fertl, 1994). Several episodes of bottlenose dolphins playing with lines while nets were being pulled in have been witnessed (Fertl, pers. obs; Leatherwood, pers. obs.).

Additional considerations

Discarded or lost gear

Entanglement in discarded gear is an often overlooked, but important, problem. Trawl fisheries are major activities in the North Pacific Ocean, with 5,500 km of nets in use (Uchida, 1985). Proportions of litter were studied on southeastern Alaska beaches, and 76-85% of all litter, by weight, consisted of trawl-web fragments (Low *et al.*, 1985). There are many reports of marine mammals becoming entangled in trawl webbing (O'Hara *et al.*, 1986), but few data on the numbers of entangled animals that die. Fowler (1982) has shown that entanglement in trawl net fragments could account for about a 5% mortality rate of seals a year. These fragments may act as ghost nets, not unlike fragments of monofilament gill net. It is probable that some of these fragments may have food organisms in them which attract cetaceans. One sperm whale (*Physeter macrocephalus*) stranded in Oregon was reported to have approximately one liter of tightly packed trawl nets in its stomach (Mate, 1985). Despite the circumstantial nature of the link between frequency of entanglement and resultant death, there seems little doubt that this, and perhaps other kinds of operational interaction arising from the increased trawling in the Bering Sea, is a major factor in determining the otherwise inexplicable decline of the Pribilof fur seal population (Beverton, 1985).

Ecological/Resource Depletion

There has been some concern that trawling may break up and alter distributional features of prey species for some cetaceans. The Steller sea lion has already seen a collapse in its population, reputably from the vast over-fishing in its habitat (Alverson 1992). It has been suggested that the current health of these sea lions is in danger because of a nutritional deficiency resulting from the absence of fatty fishes in their diet (Alverson 1992). This type of impact may result in grave situations for cetaceans in heavily trawl-fished areas, such as the Bering Sea, Mediterranean Sea, and Gulf of Mexico. While trawling may open up a niche on one hand (to provide easier captured food) it probably detroys other niches on the other hand. Fishermen in many parts of the Mediterranean and Gulf of Mexico complain about low catches in over-fished areas. This is bound to exasperate the human-cetacean conflict.

There has also been discussion about the effect that trawls have on the marine habitat, particularly directed at bottom trawls. It appears that bottom trawls on a sandy/muddy bottom caused little, if any, degradation of the infaunal communities of a

South Carolina sound (van Dolah *et al.*, 1991). However, biomass of epifaunal organisms has dropped dramatically because of trawling and changed the dominant species of fish caught in the North West Shelf, Australia (Sainsbury, 1988 referenced in Hutchings, 1990). The frequency of previous trawling in the area and type of gear used may severely modify the impact of trawling (Hutchings, 1990).

In polluted areas that are trawl-fished, pollutants can be recirculated back into the water column. Lipophilic contaminants can accumulate in the blubber and may be released at high concentrations when the energy reserves are mobilized (UNEP, 1991). Contaminants (including polychlorinated biphenyls may affect the animals' immune and reproductive systems (UNEP, 1991).

Concluding thoughts

Intensive trawling occurs in many areas of the world, with resulting incidental cetacean catches. Since the late 1950's, large numbers of dolphins, perhaps as many as seven million have been killed incidental to purse seine fishing operations for yellowfin (*Thunnus albacares*) tuna in the eastern tropical Pacific (Bjoerge *et al.*, 1991). Incidental entanglements in gillnets are occuring at alarming numbers. For example, calculations have suggested that 25,000 to as many as 45,000 small cetaceans may have been landed at Sri Lankan fish-landing sites annually in 1985-1986, after dying in gillnets or being harpooned (Leatherwood & Reeves, 1991). Considering the intensive trawl fisheries that exist in some areas, it appears that comparatively, small numbers of animals are caught.

Distribution, social structure, and behavior are important biological factors that interact with characteristics of trawl nets to induce entanglements. It appears that food may be an important correlate in many of the cases. In fact, common dolphins in New Zealand (Anonymous, 1982) and bottlenose dolphins in the Gulf of Mexico (Leatherwood, 1975) and eastern tropical Pacific (Awbrey *et al.*, 1975) feed on fish attracted to non-working trwalers, when boats are anchored at night, their lights often attract fish and other animals to feed. Trawlers may make it easier for individuals, especially juveniles, seniors, or mothers with calves to capture food that is difficult (in volume) for them to catch.

As also reported by IWC (1994), entanglements may occur where: the target species are prey or potential prey for cetaceans; the fish caught are not prey species but cetaceans are attracted to the nets because other potential prey are associated with the net; the target and incidental species are seeking similar prey; or the cetaceans and fisheries occur in the same vicinity for reasons related to physiography and biological productivity.

In general, the behavior of cetaceans near nets is poorly understood. There are several additional suggested causes for entanglement related to behavior of an individual including inattention by or inexperience of individuals, and social patterns.

In order to assess the impact on cetacean populations, it is recommended that accurate information on current takes of cetaceans must be collected; mortality should be monitored continuously, through on-board observer programs. As is the case for gillnet bycatches, the official numbers of cetaceans recorded as caught by the trawl fisheries are certainly underestimated. This occurs mostly because on the majority of trawlers, there are no observers on board to monitor accidental catches. Also, fishermen fail to report any cetaceans caught in their nets, because they fear legal sanctions from the authorities. Therefore, most marine mammals caught are simply thrown back into the sea. Studies also must be developed for those species most affected by trawls. These studies need to include identification of stocks, assessment of abundance, seasonal distribution, population size, and current trends.

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Dall's porpoise (*Phocoenoides dalli*)	E
Harbor porpoise (*Phocoena phocoena*)	E,F
Vaquita (*Phocoena sinus*)	E
Sperm whale (*Physeter macrocephalus*)	E
Commerson's dolphin (*Cephalorhynchus commersonii*)	E
Heaviside's dolphin (*Cephalorhynchus heavisidii*)	E
Hector's dolphin (*Cephalorhynchus hectori*)	E,F
Common dolphin (*Delphinus* sp.)	E,F
Short-finned pilot whale (*Globicephala macrorhynchus*)	E
Long-finned pilot whale (*Globicephala melas*)	E,F^
Risso's dolphin (*Grampus griseus*)	E
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	E,F
White-beaked dolphin (*Lagenorhynchus albirostris*)	E
Peale's dolphin (*Lagenorhynchus australis*)	E
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	E
Dusky dolphin (*Lagenorhynchus obscurus*)	E
Killer whale (*Orcinus orca*)	E,F
Tucuxi (*Sotalia fluviatilis*)	F*
Indo-Pacific hump-backed dolphin (*Sousa chinensis*)	F
Striped dolphin (*Stenella coeruleoalba*)	E
Atlantic spotted dolphin (*Stenella frontalis*)	E,F
Spinner dolphin (*Stenella longirostris*)	E,F
Bottlenose dolphin (*Tursiops truncatus*)	E,F
Franciscana (*Pontoporia blainvillei*)	E

E = reports of entanglement
F = reports of feeding association
* possible record
^ marked as unidentified pilot whale; this species is most likely

Figure 1. Cetaceans that have interactions (feeding or entanglement) with trawl nets world-wide.

Appendix 1. Bycatch of cetaceans in trawl nets, reported by geographic location.

Record	Species	Time Period	# Entangled	# Released Alive	Source(s)
			BERING SEA AND ALEUTIAN ISLANDS		
1	Minke whale	1973-88	2(decomp.)	0	Perez & Loughlin (1991)
2	Minke whale	1989	1	N/A	NMFS (1995)
3	Harbor porpoise	1973-88	4(3 dead,1 decomp.)	0	Perez & Loughlin (1991)
4	Dall's porpoise	1973-88	13(11 dead,2 decomp.)	0	Perez & Loughlin (1991)
5	Dall's porpoise	1989	1	N/A	NMFS (1995)
6	Dall's porpoise	1990	6	N/A	NMFS (1995)
7	Dall's porpoise	1991	1	N/A	NMFS (1995)
8	Dall's porpoise	1992	5	N/A	NMFS (1995)
9	Dall's porpoise	1993	4	N/A	NMFS (1995)
10	Risso's dolphin	1973-88	1(decomp.)	0	Perez & Loughlin (1991)
11	Killer whale	1982	1 calf	1 calf	Teshima & Ohsumi (1983)
12	Killer whale	1973-1988	4(1 dead,1 alive,2 decomp.)	N/A	Perez & Loughlin (1991)
13	Killer whale	1991	1	0	NMFS (1995); Matkin & Saulitis (1994)
14	Killer whale	1992	1	N/A	NMFS (1995)
15	Killer whale	1993	1	N/A	NMFS (1995)
16	Unid. species	1973-88	25(7 dead,18 decomp.)	0	Perez & Loughlin (1991)
17	Unid. cetacean	1990	1	N/A	NMFS (1995)
18	Unid. cetacean	1991	1	N/A	NMFS (1995)
19	Unid. cetacean	1992	1	N/A	NMFS (1995)
20	Unid. cetacean	1993	1	N/A	NMFS (1995)
			BRITISH COLUMBIA		
21	Dall's porpoise	1990	1	O	Baird et al. (1991)
			GULF OF ALASKA		
22	Dall's porpoise	1973-88	2(1 dead,1 alive)	N/A	Perez & Loughlin (1991)
23	Dall's porpoise	1993	1	N/A	NMFS (1995)
24	Killer whale	1973-88	1 dead	0	Perez & Loughlin (1991)
25	Unid. cetacean	1973-88	2 dead	0	Perez & Loughlin (1991)
			ALASKA		
26	Harbor porpoise	1941	1 (dredged by trawler)	0	Scheffer & Slipp (1948)
27	Harbor porpoise	1986-88	3	N/A	Barlow et al. (1994)
28	Dall's porpoise	1986-88	20	N/A	Barlow et al. (1994)
29	Dall's porpoise	1989	1	N/A	Barlow et al. (1994)

30	Pacific white-sided dolphin	N/A	3	N/A	Barlow et al. (1994)
31	Killer whale	1986-88	2	N/A	Barlow et al. (1994)
32	Unid. cetacean	N/A	18	N/A	Barlow et al. (1994)
			WEST COAST OF UNITED STATES		
33	Dall's porpoise	1973-88	9(8 dead,1 alive)	N/A	Perez & Loughlin (1991)
34	Dall's porpoise	1989	1	N/A	NMFS (1995)
35	Dall's porpoise	1990	3	N/A	NMFS (1995)
36	Dall's porpoise	1992	1	N/A	NMFS (1995)
37	Harbor porpoise	N/A	# not given	N/A	Leatherwood & Reeves (1986)
38	Pacific white-sided dolphin	1973-88	3(dead)	0	Perez & Loughlin (1991)
39	Pacific white-sided dolphin	1990	8	N/A	NMFS (1995)
40	Unid. cetacean	1973-88	10(9 dead,1 alive)	N/A	Perez & Loughlin (1991)
41	Unid. cetacean	1990	2	N/A	NMFS (1995)
			GULF OF CALIFORNIA		
42	Vaquita	1961	1	N/A	Norris & Prescott (1961)
43	Vaquita	1984	# not given	N/A	Vidal (1990)
44	Vaquita	1985	2	N/A	Vidal (1990)
45	Vaquita	1990	2	N/A	Vidal (1990)
46	Vaquita	N/A	1	1	G. Silber, pers. comm. (1993)
			GULF OF MEXICO		
47	Short-finned pilot whale	N/A	# not given	N/A	NMFS (1995)
48	Risso's dolphin	N/A	# not given	N/A	NMFS (1995)
49	Atlantic spotted dolphin	1985	2	N/A	R. Ford, pers. comm. (1991)
50	Atlantic spotted dolphin	1988	2	N/A	R. Ford, pers. comm. (1991)
51	Bottlenose dolphin	N/A	small numbers	N/A	Gunter (1942)
52	Bottlenose dolphin	1976	1	N/A	Prescott et al. (1980)
53	Bottlenose dolphin	1988	2	N/A	Burn & Scott (1988)
54	Bottlenose dolphin	N/A	# not given	N/A	Reynolds (1985)
55	Bottlenose dolphin	1978-79	1	1	Gruber (1981)
56	Bottlenose dolphin	N/A	small numbers	N/A	Leatherwood & Reeves (1982)
57	Bottlenose dolphin	1987	1	1	C. Pharr, pers. comm. (1991)
58	Bottlenose dolphin	N/A	small numbers	3	Fertl (1994)

SOUTHEASTERN UNITED STATES

59	Bottlenose dolphin	N/A	1	N/A	Wang et al. (1994)
60	Bottlenose dolphin	N/A	small numbers	N/A	Reynolds (1985)
			NORTHEASTERN UNITED STATES/ATLANTIC OCEAN		
61	Northern right whale	1977-83	1	N/A	Waring et al. (1990)
62	Humpback whale	1986	2(1 alive,1 dead)	N/A	O'Hara et al. (1986)
63	Harbor porpoise	1977	1 (decomp.)	0	Testaverde (1978)
64	Harbor porpoise	1982	1	N/A	O'Hara et al. (1986)
65	Common dolphin	1977-83	8	N/A	Waring et al. (1990)
66	Common dolphin	1983	1 (alive)	N/A	O'Hara et al. (1986)
67	Common dolphin	1984	3	N/A	Waring et al. (1990)
68	Common dolphin	1985	66	N/A	Waring et al. (1990)
69	Common dolphin	1986	76	N/A	Waring et al. (1990)
70	Common dolphin	1987	19	N/A	Waring et al. (1990)
71	Common dolphin	1988	31	N/A	Waring et al. (1990)
72	Common dolphin	1990	11	N/A	NMFS (1995)
73	Common dolphin	1991	2	N/A	NMFS (1995)
74	Common dolphin	1992	3	N/A	NMFS (1995)
75	Common dolphin	1993	6	N/A	NMFS (1995)
76	Pilot whale	1977-83	35	N/A	Waring et al. (1990)
77	Pilot whale	1984	2	N/A	Waring et al. (1990)
78	Pilot whale	1985	47	N/A	Waring et al. (1990)
79	Pilot whale	1986	20	2	Waring et al. (1990)
80	Pilot whale	1987	26	1	Waring et al. (1990)
81	Pilot whale	1988	142	3	Waring et al. (1990)
82	Pilot whale	1990	1	N/A	NMFS (1995)
83	Pilot whale	1990	107	N/A	Young et al. (1993)
84	Pilot whale	1991	13	N/A	Young et al. (1993)
85	Pilot whale	1992	12	N/A	NMFS (1995)
86	Risso's dolphin	1985	1	N/A	Waring et al. (1990)
87	Risso's dolphin	1986	1	N/A	Waring et al. (1990)
88	Risso's dolphin	1987	1	N/A	Waring et al. (1990)
89	Risso's dolphin	1992	1	N/A	NMFS (1995)
90	Atlantic white-sided dolphin	1990	4	N/A	Young et al. (1993)
91	Atlantic white-sided dolphin	1990	10	N/A	NMFS (1995)

92	Atlantic white-sided dolphin	1991	1	N/A	Young et al. (1993)
93	Atlantic white-sided dolphin	1991	7	N/A	NMFS (1995)
94	Striped dolphin	1991	2	N/A	NMFS (1995)
95	Bottlenose dolphin	1977-83	2	N/A	Waring et al. (1990)
96	Bottlenose dolphin	1984	1	N/A	Waring et al. (1990)
97	Bottlenose dolphin	1985	3	N/A	Waring et al. (1990)
98	Bottlenose dolphin	1988	2	N/A	Waring et al. (1990)
99	Bottlenose dolphin	1991	1	N/A	NMFS (1995)
100	Bottlenose dolphin	1992	4	N/A	NMFS (1995)
101	Bottlenose dolphin	1993	17	N/A	NMFS (1995)
102	Unid. dolphin	1977-83	3	N/A	Waring et al. (1990)
103	Unid. dolphin	1985	1	N/A	Waring et al. (1990)
104	Unid. dolphin	1988	1	N/A	Waring et al. (1990)
105	Unid. baleen whale	1977-83	1	N/A	Waring et al. (1990)
			NORTHWEST ATLANTIC		
106	Northern right whale	N/A	1	N/A	O'Hara et al. (1986)
107	Risso's dolphin	N/A	a few captures	N/A	O'Hara et al. (1986)
108	Atlantic white-sided dolphin	1978-85	3	N/A	O'Hara et al. (1986)
			ARGENTINEAN WATERS		
109	Commerson's dolphin	N/A	tens of individ/yr	N/A	Scialabba (1989)
110	Commerson's dolphin	N/A	# not given	N/A	Crespo & Corcuera (1990)
111	Commerson's dolphin	N/A	2	N/A	Goodall et al. (1988)
112	Commerson's dolphin	N/A	# not given	N/A	Goodall et al. (1990)
113	Common dolphin	N/A	# not given	N/A	Crespo & Corcuera (1990)
114	Long-finned pilot whale	N/A	1	N/A	Goodall et al. (1988)
115	Peale's dolphin	N/A	# not given	N/A	Crespo & Corcuera (1990); Goodall et al. (1990)
116	Dusky dolphin	N/A	3	N/A	Scialabba (1989)
117	Dusky dolphin	N/A	# not given	N/A	Crespo & Corcuera (1990)
118	Dusky dolphin	1989	1	N/A	Crespo et al. (1994)
119	*Franciscana*	N/A	2	N/A	Goodall et al. (1988)
120	Franciscana	N/A	rare event	N/A	Crespo & Corcuera (1990)
121	Franciscana	N/A	# not given	N/A	Perez Macri & Crespo (1989)
122	Bottlenose dolphin	N/A	1	N/A	Goodall et al. (1988)
123	Unid. dolphin	N/A	5 in one trawl	N/A	Crespo & Corcuera (1990);

			NORTHEAST ATLANTIC		
124	Harbor porpoise	1980-81	28	N/A	Andersen & Clausen (1983)
125	Harbor porpoise	---------	3	N/A	Anonymous (1988b)
126	Harbor porpoise	1973-87	21	N/A	Lindstedt & Lindstedt (1989)
127	Harbor porpoise	1986-1989	4	N/A	Kinze (1994)
128	Common dolphin	1971-81	15	N/A	Duguy & Hussenot (1982)
129	Common dolphin	1971-76	1	N/A	Duguy (1977)
130	Long-finned pilot whale	1971-76	1	N/A	Duguy (1977)
131	Long-finned pilot whale	1971-81	3	N/A	Duguy & Hussenot (1982)
132	Long-finned pilot whale	----------	possible 1 record	N/A	Northridge (1988)
133	Risso's dolphin	----------	occasionally caught	N/A	Northridge (1984)
134	Striped dolphin	----------	occasionally caught	N/A	Northridge (1984)
135	Striped dolphin	1971-76	1	N/A	Duguy (1977)
136	Bottlenose dolphin	1971-76	2	N/A	Duguy (1977)
137	Bottlenose dolphin	1977-81	3	N/A	Duguy & Hussenot (1982)
138	Bottlenose dolphin	---------	1	N/A	Anonymous (1988b)
			BALTIC SEA		
139	Harbor porpoise	1952	1	N/A	Ropelewski (1957)
140	Harbor porpoise	N/A	2	N/A	Skora et al. (1988)
141	Harbor porpoise	1987/90	1	N/A	Benke et al. (1991)
			NORTH SEA		
142	Harbor porpoise	-----	several tens/yr	N/A	Currey et al. (1990)
143	Harbor porpoise	1963-82	18	N/A	Gaskin (1984)
144	Harbor porpoise	1987-88	7	N/A	Anonymous (1989a)
145	Harbor porpoise	------	few	N/A	Mitchell (1975)
146	Harbor porpoise	1992	137	N/A	Moreno (1993)
147	Harbor porpoise	------	regularly caught	N/A	Reijnders & Lankester (1990)
148	Common dolphin	------	regularly caught	N/A	Reijnders & Lankester (1990)
149	Pilot whale	------	regularly caught	N/A	Reijnders & Lankester (1990)
150	Pilot whale	1994	3(dead) in 1 haul	0	Lowry, pers. comm. (1994)
151	Risso's dolphin	-----	not given	N/A	Reijnders & Lankester (1990)
152	White-beaked dolphin	-----	few	N/A	Leatherwood & Reeves (1983)
153	White-beaked dolphin	1958	1	N/A	van Bree & Nijssen (1964)

154	Bottlenose dolphin	------	# not given	N/A	Currey et al. (1990)
155	Bottlenose dolphin	------	few	N/A	Mitchell (1975)
			MID-ATLANTIC BIGHT		
156	Bottlenose dolphin	N/A	3 in 8 years	N/A	Northridge (1991)
			SCOTLAND		
157	Harbor porpoise	1988-89	20+	N/A	Northridge (1991)
			BRITAIN		
158	Harbor porpoise	N/A	# not given	N/A	Northridge (1991)
159	Harbor porpoise	N/A	1	N/A	Northridge (1988)
160	Harbor porpoise	1989	2	N/A	Anonymous (1990c)
161	Common dolphin	1982	5 (3 alive,2 dead)	3	Pascoe (1986)
162	Common dolphin	N/A	# not given	N/A	Couperus (1994)
163	Pilot whale	1986	towed in trawl	N/A	Northridge (1988)
164	Long-finned pilot whale	N/A	# not given	N/A	Couperus (1994)
165	Atlantic white-sided dolphin	N/A	# not given	N/A	Couperus (1994)
166	White-beaked dolphin	1986,1987	# not given	N/A	Northridge (1988)
167	White-beaked dolphin	N/A	# not given	N/A	Couperus (1994)
168	Unid. porpoise	N/A	entangle at least 6, one drowned in net	N/A	Northridge (1988)
169	Unid. porpoise	N/A	3	N/A	Northridge (1988)
170	Unid. whale	1986	1	N/A	Northridge (1988)
			EASTERN CENTRAL ATLANTIC		
171	Common dolphin	N/A	# not given	N/A	Scialabba (1989)
172	Bottlenose dolphin	N/A	# not given	N/A	Scialabba (1989)
			MEDITERRANEAN		
173	Common dolphin	N/A	1	N/A	Di Natale (1983)
174	Common dolphin	N/A	not given	N/A	Di Natale (1989)
175	Striped dolphin	N/A	not given	N/A	Di Natale (1989)
176	Bottlenose dolphin	N/A	3	N/A	Duguy & Hussenot (1982)
177	Bottlenose dolphin	N/A	incidental catches said to be high, although some dolphins reported to be freed	N/A	Currey et al. (1990)
178	Bottlenose dolphin	N/A	not given	N/A	Di Natale (1989)
179	Bottlenose dolphin	N/A	1	N/A	Silvani et al. (1992)
180	Sperm whale	N/A	3	N/A	Di Natale & Mangano (1983)

181	Sperm whale	N/A	1	N/A	Di Natale (1989)
			PORTUGAL		
182	Harbor porpoise	1977-91	1	N/A	Sequeira & Ferreira (1994)
183	Common dolphin	1977-91	18	N/A	Sequeira & Ferreira (1994)
			CENTRAL CANTABRIAN SEA		
184	Harbor porpoise	1977-91	1	N/A	Nores et al. (1992)
185	Common dolphin	1977-91	1	N/A	Nores et al. (1992)
186	Long-finned pilot whale	1977-91	1	N/A	Nores et al. (1992)
			NORTHWEST AFRICA		
187	Common dolphin	N/A	# not given	N/A	Northridge (1984)
188	Common dolphin	N/A	large numbers	N/A	Currey et al. (1990)
189	Common dolphin	1980	'6-22' dolphins per haul at night for one trawler. 12 trawlers in area also caught dolphins, exact number unknown. An estimated minimum of 500-1,000 common dolphins and *Stenella* spp. are caught per year.	N/A	Maigret (1994)
			SOUTH & SOUTHWEST AFRICA		
190	Heaviside's dolphin	1978-79	2	N/A	Anonymous (1979)
191	Heaviside's dolphin	1978-79	small numbers	N/A	Northridge (1984)
192	Heaviside's dolphin	1977	1	N/A	P.Best, pers. comm. (1992)
193	Heaviside's dolphin	1990	1	N/A	P.Best, pers. comm. (1992)
194	Common dolphin	N/A	small numbers	N/A	Northridge (1984)
195	Common dolphin	1983	5	N/A	P.Best, pers. comm. (1992)
196	Common dolphin	N/A	2 young	N/A	V. Cockcroft, pers. comm. (1992)
197	Risso's dolphin	1986	1	N/A	P. Best, pers. comm. (1992)
198	Dusky dolphin	N/A	small numbers	N/A	Northridge (1984)
199	Dusky dolphin	1988	4	N/A	P. Best, pers. comm. (1992)
200	Dusky dolphin	1989	6	N/A	P. Best, pers. comm. (1992)
201	Dusky dolphin	1990	1	N/A	P. Best, pers. comm. (1992)
			EAST AFRICA		
202	Unid. dolphin	N/A	large number	N/A	Currey et al. (1991)
			PAKISTAN		
203	Finless porpoise	1989	2 young	N/A	Niazi (1990)
			INDIA (GULF OF MANNAR)		
204	Bottlenose dolphin	1980-82	3	0	Pillai & Kasinathan (1987)
			THAILAND		
205	Spinner dolphin	1970-71	10	N/A	Perrin et al. (1989)

			NEW ZEALAND		
206	Hector's dolphin	1970's	7	N/A	Baker (1978)
207	Hector's dolphin	N/A	occasionally	N/A	Anonymous (1981); Scialabba (1989); Slooten & Dawson (1988)
208	Hector's dolphin	1988	5	N/A	Anonymous (1990b)
209	Common dolphin	N/A	a few	N/A	Mitchell (1975)
210	Common dolphin	1978	10	4	Anonymous (1981)
211	Common dolphin	1979	23	2	Anonymous (1981)
212	Common dolphin	N/A	occasionally	N/A	Slooten & Dawson (1988)
213	Common dolphin	1980	1	N/A	Anonymous (1982)
214	Common dolphin	since April 1986	2	N/A	Anonymous (1988a)
215	Common dolphin	1987	1	N/A	Anonymous (1989b)
216	Common dolphin	1988	1	N/A	Anonymous (1990b)
217	Common dolphin	1989	2 (adult+calf)	N/A	Anonymous (1990b)
218	Common dolphin	1989-90,1993-94	69	N/A	Baird (1995)
219	Common dolphin	1990	34-35	N/A	Anonymous (1991b)
220	Common dolphin	1995	21	N/A	R. Mattlin, pers. comm. (1995)
221	Pilot whale	N/A	1	N/A	R. Mattlin, pers. comm. (1995)
222	Dusky dolphin	1986-1988	2	N/A	Anonymous (1988)
223	Dusky dolphin	1988	1	N/A	Anonymous (1988a)
224	Dusky dolphin	N/A	occasionally	N/A	Slooten & Dawon (1988)
225	Killer whale	1979	1	N/A	Anonymous (1981)
226	Bottlenose dolphin	N/A	100's	N/A	Mitchell (1975)
227	Bottlenose dolphin	N/A	1	N/A	R. Mattlin, pers. comm. (1995)
228	Unid. dolphin	N/A	low numbers	N/A	R. Mattlin, pers. comm. (1995)
229	Unid. beaked whale	1979	1	N/A	Anonymous (1981)
			AUSTRALIA		
230	Bottlenose dolphin	N/A	2 juveniles	N/A	Corkeron et al. (1990)
231	Bottlenose dolphin	1989	1	N/A	Anonymous (1991a)
232	Unid. dolphin	1988	3	N/A	Anonymous (1990a)
233	Unid. dolphin	1990	1	N/A	Anonymous (1991a)

Appendix 2. Species for which there are reports of bycatches in trawl nets (Record numbers correspond to entries in Appendix 1.

Species	Record Number(s)
Northern right whale (*Eubalaena glacialis*)	61,106
Minke whale (*Balaenoptera acutorostrata*)	1,2
Humpback whale (*Megaptera novaeangliae*)	62
Finless porpoise (*Neophocaena phocaenoides*)	203
Dall's porpoise (*Phocoenoides dalli*)	4-9,21-23,28-29, 33-36
Harbor porpoise (*Phocoena phocoena*)	3,26-27,37,63-64, 124-127,139-147, 157-160,182,184
Vaquita (*Phocoena sinus*)	42-46
Sperm whale (*Physeter macrocephalus*)	180-181
Commerson's dolphin (*Cephalorhynchus commersonii*)	109-112
Heaviside's dolphin (*Cephalorhynchus heavisidii*)	190-193
Hector's dolphin (*Cephalorhynchus hectori*)	206-208
Common dolphin (*Delphinus* sp.)	65-75,113,128-129,148, 161-162,170,173-174, 183,185,187-189, 194-196,209-220
Short-finned pilot whale (*Globicephala macrorhynchus*)	47
Long-finned pilot whale (*Globicephala melas*)	114,130-132,164,186
Unid. pilot whale species (*Globicephala* sp.)	76-85,149-150,163,221
Risso's dolphin (*Grampus griseus*)	10,48,86-89,107,133,151,197
Atlantic white-sided dolphin (*Lagenorhynchus acutus*)	90-93,108,165
White-beaked dolphin (*Lagenorhynchus albirostris*)	152-153,166-167
Peale's dolphin (*Lagenorhynchus australis*)	115
Pacific white-sided dolphin (*Lagenorhynchus obliquidens*)	30,38-39
Dusky dolphin (*Lagenorhynchus obscurus*)	116-118,198-201,222-224
Killer whale (*Orcinus orca*)	11-15,24,31,225
Striped dolphin (*Stenella coeruleoalba*)	94,134-135,175
Atlantic spotted dolphin (*Stenella frontalis*)	49-50
Spinner dolphin (*Stenella longirostris*)	205
Bottlenose dolphin (*Tursiops truncatus*)	51-60,95-101,122, 136-138,154-156, 172,176,179,204, 226-227,230-231

Franciscana (*Pontoporia blainvillei*)	119-121
Unid. cetacean species	16-20,25,32,40-41
Unid. baleen whale	105
Unid. dolphin species	102-104,123,202,228, 231-232
Unid. beaked whale	229
Unid. porpoise	168-169
Unid. whale	170

Appendix 3. Accounts of cetaceans feeding in association with trawls, reported by geographic location.

Species	Interaction	Source(s)
	BERING SEA	
Killer whale	Seen following nets when trawling began.	Teshima & Ohsumi (1983)
Killer whale	Seemed attracted to winching sounds. Positioned themselves along the sides of trawlers to feed on trash fish, and offal. Jostled for positions while feeding was also noted.	J. Heimlich-Boran, Cambridge Univ, Cambridge, U.K., pers. comm.(1991)
	WEST COAST OF UNITED STATES	
Common dolphin	Feed on specimens that had escaped from the net. The fish were disabled and floating belly up.	Edwards (1960)
	GULF OF CALIFORNIA	
Bottlenose dolphin	Seen associated with shrimpers. Observed to feed on trash fish. Dolphins attracted to engines shutting down, signifying culling.	Norris & Prescott (1961)
Bottlenose dolphin	Observed feeding in mudboil behind shrimpers.	Leatherwood (1975)
Bottlenose dolphin	Habitually followed trawlers with net down (19% of sightings).	Wells et al. (1981)
	GULF OF MEXICO	
Bottlenose dolphin	Observed following trawlers. Shrimp found in stomach. Believed to damage nets.	Gunter (1942)
Bottlenose dolphin	Reported to damage nets. Could be made to move with rifle shots.	Gunter (1944)
Bottlenose dolphin	Second-hand report from E.A. McIlhnenny of whole shrimp in stomachs.	Gunter (1951)
Bottlenose dolphin	Reported to distinguish changes of boat operation.	Gunter (1954)
Bottlenose dolphin	Observed to feed on trash fish off northeast coast of Florida, and to feed on catfish while operating shrimp boats were nearby.	Caldwell & Caldwell (1972)
Bottlenose dolphin	Seen following trawling boats; spent more tim socializing near boats than eating discarded fish..	Hogan (1975)
Bottlenose dolphin	Categorized behaviors related to shrimp boats as: foraging behind working shrimp boats, feeding on trash fish, and feeding on fish attracted to nonworking shrimpers	Leatherwood (1975)
Bottlenose dolphin	Observed feeding behind shrimp boats that had moved from sounds to marsh in Mississippi.	Leatherwood & Platter (1975)
Bottlenose dolphin	Dolphins' activities completely dominated by shrimp boats.	Shane (1977)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats. Mother/calf pairs fed behind shrimp boats; feeding as early as 0545 and continued past 2200; following boat seemed preferable to eating trash fish. Late spring to early fall, most dolphins observed feeding in association with shrimp boats.	Gruber (1981)
Bottlenose dolphin	Fed in association with shrimp boats in Mobile Bay, Alabama.	Goodwin (1985)
Bottlenose dolphin	Associated with shrimp boats in Galveston Bay, TX.	Henningsen (1991)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats in	Delgado-Estrella (1991)

	Campeche Bay. Dolphins responded to motor changes associated with changes in boat operation. Observed feeding almost exclusively on bycatch. Observations of feeding at night near working shrimp boats..	
Bottlenose dolphin	Group of 7 young dolphins followed groundfish trawl in Gulf of Mexico.	C. Pharr, NMFS, pers. comm. (1991)
Bottlenose dolphin	Detailed accounts of dolphin behaviors around shrimp boats. Movements of dolphins did not appear to be linked to changes in shrimp boat stages. Speculated that females with calves may be taking advantage of concentrated food resource provided by shrimp boats to meet increased energetic needs due to lactation.	Fertl (1994)
Atlantic spotted dolphin	Observed feeding in association with shrimp boats.	Delgado-Estrella (1991)
Atlantic spotted dolphin	Followed large otter trawl to surface as it was hauled in in. Dolphins milled around the filled cod-end of the net until it was actually brought on board.	Caldwell (1955)
Atlantic spotted dolphin	Mixed herd with bottlenose dolphins "biting the bag of the trawl" and were seen in front of the bag.	C. Rogers, NMFS, pers. comm. (1991)
	BELIZE	
Bottlenose dolphin	Observed feeding in association with trawls.	K. Dudzinski, Texas A&M Univ., pers. comm. (1992)
	BRAZIL	
Tucuxi	On at least 4 occasions, groups of up to five individuals were observed close to shrimp boats. No information is available on apparent association	Barros & Teixeira (1994)
	ARGENTINA	
Unidentifed dolphins	Observed coming into and out of the mouth of the net catching fish.	Crespo & Corcuera (1990)
	SOUTHEASTERN UNITED STATES (NORTH CAROLINA)	
Bottlenose dolphin	Observed feeding on discarded bycatch.	Davis (1988)
Bottlenose dolphin	Observed following working trawlers.	G. Rountree, pers. comm. (1993)
	NORTHEAST UNITED STATES	
Pilot whale	Active pursuit and opportunistic feeding in and around mouth of net during haulback.	Waring et al. (1990)
	NORTH SEA	
Harbor porpoise	Observed following the trawls, catching fish squeezed out through the meshes.	Clausen & Andersen (1988)
	BRITISH ISLES (IRELAND)	
Atlantic white-sided dolphin	Scavenged on catch pumped on board.	A.J. Couperus, pers. comm. (1994)
Pilot whale	Scavenged on catch pumped on board.	A.J. Couperus, pers. comm. (1994)
Killer whale	Feeding on fish that slipped through the meshes or fell overboard, when hauling or shooting the net.	Couperus (1994)
Bottlenose dolphin	30-40 dolphins scavenging behind a freezer trawler during hauling.	A.Couperus, pers. comm. (1995)
	MEDITERRANEAN REGION	

	MEDITERRANEAN REGION	
Bottlenose dolphin	Suspected to feed on fish in trawl.	Di Natale (1989)
Bottlenose dolphin	Associated with shrimp boats.	Bearzi & Notarbartolo di Sciara (1992)
Bottlenose dolphin	Reported to harrass trawlers.	Northridge (1984)
	WEST AFRICA	
Unidentifed dolphin	Feeding at night on fish attracted to non-working trawler.	Fulton (1976)
	SOUTH AFRICA	
Common dolphin	Suspected to feed in association with trawls	V.Cockcroft, pers. comm. 1991
	WESTERN SRI LANKA	
Bottlenose dolphin	Fed in mudline behind trawler.	Leatherwood et al. (1984)
	SOUTHEAST MALAYSIA	
Bottlenose dolphin	Fed around trawl net when it was reeled in in the evening. Fed on fish dropping from the nets or discarded over the side, and occasionally rammed their rostrums into the net, causing the net contents to spill.	Abel & Leatherwood (1985)
Spinner dolphin	Fed around trawl net when it was reeled in in the evening;	Abel & Leatherwood (1985)
	INDIA (GULF OF MANNAR)	
Bottlenose dolphin	Reported following cod-end of net.	Pillai & Kasinathan (1987)
	NEW ZEALAND	
Common dolphin	Seen feeding on "meatballing clupeids" beneath the hulls of trawlers and along the trawl warps.	Anonymous (1982)
	Attracted to vessels and may take advantage of herding effect of a trawl net on fish, specifically, fish swimming ahead of the trawl mouth.	S.J.Baird (1994)
Hector's dolphin	Occasionally followed trawlers, possibly feeding on fish stirred up, but not caught by trawl gear.	Slooten & Dawson (1988)
	AUSTRALIA (MORETON BAY)	
Bottlenose dolphin	Reported feeding behind trawlers; feeding intensively on trash fish. Fish preferences observed. Refused floating fish. Dominance hierarchies inter- and intra-species observed. Fed in mixed groups with humpbacked dolphins.	Corkeron et al. (1990)
Bottlenose dolphin	Fed on discarded bycatch. Dolphins estimated to eat about 86% of fish discarded from single trawl. Dolphins scavenged only fish and cephalopods, and not crustaceans or echinoderms. Large floating fish (25-65 g) were eaten by dolphins.	Wassenberg & Hill (1990)
Bottlenose dolphin	Attempted to establish a feeding station by feeding dolphins with discards while on stationary trawler. Leading the animals with the trawler was not successful for a variety of speculated reasons.	Green & Corkeron (1991)
Humpbacked dolphin	Reported to feed in mixed groups with bottlenose dolphins behind trawlers. Would generally remain further from stern of trawler. Did not gain access to preferred food items.	Corkeron (1990)