Biological Conservation **67** (1994) 167–183

A GLOBAL REVIEW OF PORPOISE (*CETACEA: PHOCOENIDAE*) MORTALITY IN GILLNETS

Thomas A. Jefferson & Barbara E. Curry

Marine Mammal Research Program, c/o Department of Wildlife and Fisheries Sciences, Room 210, Nagle Hall, Texas A&M University, College Station, Texas 77843, USA

(Received 1 June 1992; revised version received 30 December 1992; accepted 11 March 1993)

Abstract

A global review of mortality of porpoises in gillnet fisheries indicates that individuals of all six species become entangled and die in gillnets. Harbor porpoises Phocoena phocoena *are taken throughout their range and several populations are in decline, at least partly as a result of gillnet entanglement. The vaquita* P. sinus *is the most endangered cetacean species, and gillnet fisheries in the northern Gulf of California, Mexico, threaten the single population with extinction. Burmeister's porpoises* P. spinipinnis *are taken in several gillnet fisheries in South America; populations in Peru appear to be most severely affected. In southern South America, spectacled porpoises* Australophocaena dioptrica *are known to be caught in gillnets, but the effects of these takes are unknown. Primarily in the western North Pacific, Dall's porpoises* Phocoenoides dalli *are entangled in driftnet fisheries in large numbers, but so far major impacts have not been apparent. Although taken in gillnets in many areas throughout the Indo-Pacific region, only those finless porpoise* Neophocaena phocaenoides *populations in China are considered to be threatened by gillnet catches. In most circumstances, existing information is insufficient to evaluate the effects of gillnets on porpoise populations, but where it is possible impacts often prove to be severe. Gillnets represent the single most important threat to porpoises as a group, and this may be an example of a 'no technical solution problem'. We conclude that better documentation of catches and new approaches to dealing with porpoise/gillnet interaction problems are needed in order to prevent the loss of several species and populations.*

Keywords: porpoise, Phocoenidae, gillnet, entanglement, mortality.

INTRODUCTION

Gillnets are passive fishing devices that entangle or ensnare animals in the net's mesh (see Nedelec & Prado, 1990). (In this paper, the term gillnet is used loosely, to refer to a variety of entangling nets that are generally used passively in vertical orientation (see von Brandt, 1984). This includes setnets, driftnets and trammel nets.) All six species of porpoises have substantial problems with gillnet fisheries. For most of the species, this may be largely due to their nearshore habitats, which often have high concentrations of human activities, including gillnet fishing. However, high-seas driftnets are now in use in almost all major oceans, and thus represent a threat to the more pelagic porpoises (such as Dall's porpoise *Phocoenoides dalli*, and to a lesser extent the spectacled porpoise *Australophocaena dioptrica*) as well as to other oceanic small cetaceans (most dolphins Delphinidae, and beaked whales Ziphiidae).

In October 1990, participants in a conference on Mortality of Cetaceans in Passive Nets and Traps, sponsored by the International Whaling Commission (IWC) and several other organizations, accumulated information on gillnet catches and effects on populations of porpoises and other cetaceans worldwide (IWC, in press). With the exception of the spectacled porpoise, for which there is almost no information, this conference showed that all species of porpoises are impacted by encounters with gillnets. In fact, one species, the vaquita *Phocoena sinus*, is in immediate danger of extinction due to catches in gillnets (see Silber, 1990*a*; Vidal, in press).

In this paper, we present a more detailed and comprehensive documentation of porpoise takes in gillnets and the available information on the effects of this mortality on the populations involved (we use the terms 'take' and 'catch' synonymously). With the exception of some of the information from fisheries affecting Dall's, harbor *Phocoena phocoena*, and Burmeister's *Phocoena spinipinnis* porpoises, the data were collected opportunistically, and are thus incomplete and underrepresentative of the true takes. Sources of information consisted of published and unpublished literature, as well as unpublished records of many colleagues working on porpoises (see Acknowledgements).

By reviewing and synthesizing information on porpoise takes in gillnets, we hope to encourage increased reporting of such takes in the future, and to stimulate work on the effects of gillnet fisheries on small cetacean stocks and on the reduction or elimination of such impacts.

HARBOR PORPOISE *Phocoena phocoena*

Distribution and abundance

Harbor porpoises are widely distributed in cold temperate and subpolar waters of the Northern Hemisphere (Gaskin, 1984; Klinowska, 1991). They are found primarily in shallow waters, mostly nearshore. In the North Pacific, the range extends from southern California to the Bering Strait. There are a few records as far north as the southern Beaufort and Chukchi Seas. In the western Pacific, harbor porpoises are found as far south as southern Honshu, Japan. In the North Atlantic, this species occurs from the south-central United States north to central Baffin Island. They are found around southern Greenland, Iceland, and the Faroe Islands. On the eastern side of the Atlantic, the range extends from northern West Africa, north and then east to the Barents–White Sea area; the range includes the Black, Azov, Baltic, and North Seas. The continued existence of harbor porpoises in the western Mediterranean is uncertain.

The stock structure of the harbor porpoise is poorly known. Gaskin (1984) delineated three major populations in the North Pacific, North Atlantic, and Black Sea/Sea of Azov, as well as three subpopulations in the North Pacific and 14 in the North Atlantic. There is little question that the major populations represent truly separate stocks, but the subpopulations (which were based largely on ecological and geographic factors, rather than direct evidence of reproductive isolation) have not all been accepted by the IWC (1991).

There is evidence from pollutant loads, for separate regional populations along the west coast of North America (Calambokidis & Barlow, 1991). There is good evidence from skull morphology for separation of eastern and western North Atlantic stocks (Yurick & Gaskin, 1987). The four subpopulations suggested by Gaskin (1984) in the western North Atlantic (West Greenland, Newfoundland/Labrador, Gulf of St Lawrence and Bay of Fundy/Gulf of Maine) have been tentatively accepted by the IWC (1991). Stock structure in the eastern North Atlantic is very poorly known, but there is evidence for the existence of several stocks, with at least separate Baltic and North Sea populations (Gaskin, 1984; Kinze, 1985; IWC, 1991).

There are no reliable estimates of worldwide abundance for the harbor porpoise and only a few regional estimates are available. Populations on the west coast of the United States from California to Washington have been estimated at 45 710 individuals with 1670 of these in central California (Barlow, 1988). Prince William Sound, Alaska contained an estimated 590–946 individuals in the 1970s (Hall, 1981). There were previously thought to be only about 8000–15 300 harbor porpoises in the Bay of Fundy and Gulf of Maine (Read & Gaskin, 1990*a*); however, recent improved surveys in the Gulf of Maine suggest that there are 45,000–66,000 in that area alone (Smith *et al.*, 1991). There are estimated to be about 93,600 animals in Norwegian waters (Bjørge & Øien, 1990). An estimate of over 200 000 harbor porpoises in the Black Sea by Celikkale *et al.* (1989) is considered by the IWC Small Cetacean Subcommittee to be unsupportable and not useful for management (IWC, 1991).

Mortality in gillnets

Harbor porpoises are known to be taken in gillnets throughout most of their range (Table 1). The Black Sea and Sea of Azov area is the only major region in which there are no known incidental takes in gillnets, although Gaskin (1984) stated that harbor porpoises may still be taken there. Recent large direct catches in the Black Sea are discussed below.

In the North Pacific, about 200–300 have been taken in most recent years in halibut setnets in central California (see Barlow & Hanan, in press, for review). A significant take is known in the Makah Indian setnet fishery for salmon on the northern Washington coast (Gearin *et al.*, 1990) and takes in various setnet and driftnet fisheries throughout Alaska, though poorly documented, are probably substantial (Matkin & Fay, 1980; Barlow *et al.*, in press).

In the western North Atlantic, the largest numbers have been taken in foreign and domestic driftnet fisheries for salmon around Greenland. Up to 2500 may have been taken in 1972 (Kapel, 1977, 1984; Lear & Christensen, 1975). The foreign fishery was phased-out in the mid-1970s, so current catches by local fishermen are likely to be much smaller.

High numbers of harbor porpoises are also taken in gillnets in eastern Canada, especially off Newfoundland and Labrador (Piatt & Nettleship, 1987; Lien *et al.*, 1989) and in the St Lawrence (Fontaine *et al.*, 1990). Catches in the Bay of Fundy and Gulf of Maine have been particularly well-studied. Annual catches for this region are estimated to be greater than 1,350 per year (Read & Gaskin, 1990*a*; Smith *et al.*, 1991).

In the eastern North Atlantic area, substantial gillnet catches occur in most areas, with the highest known takes in Norway (Bjørge & Øien, 1990), Sweden (Lindstedt, 1990), and Denmark (Clausen & Andersen, 1988; Kinze, 1990). Although accurate data from fisheries observer programs are generally not available, high gillnet takes throughout the rest of the Baltic and North Seas seem likely. The United Kingdom, in particular, has substantial takes of harbor porpoises in gillnets, as well as in other fisheries (see Kayes, 1985; Northridge, 1988).

Status of affected populations

Along the west coast of North America, harbor porpoise populations in Puget Sound, Washington, and around Vancouver Island, British Columbia, appear to be reduced in relation to their numbers several decades ago (see Flaherty & Stark, 1982; Gaskin, 1984; Cowan, 1988). Gillnet catches have probably been a factor, but pollution and boat disturbance are also possible factors (Flaherty & Stark, 1982). Past direct exploitation in Puget Sound included a fishery by coastal Indians (Scheffer & Slipp, 1948).

Table 1. Records of harbor porpoise catches in gillnets

Area	Fishery type[a]	Known take	Estimated take	Source
Central California	I—halibut, shark flounder setnet	15 (1980)	41–402/year (1969/70–1982/83)	Miller *et al.*, 1983; Diamond & Hanan, 1986; Hanan *et al.*, 1986, 1987; Hanan & Diamond, 1989; Lennert *et al.*, 1991; Jefferson *et al.*, in press; Barlow *et al.*, in press; Barlow & Hanan, in press
		14 (1983/84)	303	
		19 (1984/85)	226	
		33 (1985/86)	226	
		16 (1986/87)	197	
		53 (1989)	No estimate	
		3 (1990)	44	
	I—white croaker gillnet	1 (1985/86)	No estimate	Hanan *et al.*, 1987
	I—seabass gillnet	10 (1958)	No estimate	Norris & Prescott, 1961
Northern California to British Columbia	I—Canadian experimental squid driftnet[b]	2 (1983)	No estimate	Jamieson & Heritage, 1988
		1 (1987)	No estimate	
Washington/Oregon	I—thresher shark driftnet[b]	1 (1987)	No estimate	Stick & Hreha, 1989
		6 (1988)	No estimate	
Washington	I—gillnet	1 (1943)	No estimate	Scheffer & Slipp, 1948; K.C. Balcomb, III in Gaskin, 1984
		6 (1939–1945)[c]	No estimate	
	I—Makah Indian salmon setnet	102 (1988)	No estimate	Gearin *et al.*, 1990
		23 (1989)	No estimate	
		13 (1990)	No estimate	
Greater Puget Sound, Washington	I—gillnet	1 (1979)	No estimate	Everitt *et al.*, 1980; Flaherty & Stark, 1982; Baird & Guenther, in press
		2 (1991)[d]	No estimate	
British Columbia	I—gillnet	1 (1962)	No estimate	Pike & MacAskie, 1969; Baird & Guenther, in press
		1 (1970)	No estimate	
		1 (1988)	No estimate	
	I—salmon research driftnet	1 (1989)	No estimate	Langelier *et al.*, 1990; Baird *et al.*, 1991; Baird & Guenther, in press
		1 (1990)	No estimate	
		2 (1991)	No estimate	
Copper River, Alaska	I—salmon driftnet	7 (1978)	102	Matkin & Fay, 1980; Wynne, 1990; Barlow *et al.*, in press
		1 (1988)	No estimate	
		3 (1990)	No estimate	
Bering Sea	I—herring gillnet	1 (1982)	No estimate	S. Leatherwood in Gaskin, 1984
Bering Strait	I—salmon gillnet	—	No estimate	Frost & Lowry, 1988
Pt Barrow, Alaska	I—gillnet[c]	—	No estimate	Hall & Bee, 1954
Northern Alaska	I—gillnet	7 (1981–87)	No estimate	Barlow *et al.*, in press
		3 (1989/90)	No estimate	
Chukchi Sea	I—salmon gillnet	—	No estimate	Frost *et al.*, 1983
Northwestern North Pacific and Bering Sea	I—Japanese salmon mothership driftnet	1 (1965)	No estimate	Mizue *et al.*, 1966; Jones, 1984 Jones *et al.*, 1987
		1 (1978)	No estimate	
		4 (1979)	No estimate	
		4 (1980)	No estimate	
		2 (1981)	No estimate	
		2 (1983)	No estimate	
		3 (1986)	No estimate	
Northwestern North Pacific	I—Japanese salmon research driftnet	1 (1962–1971)	No estimate	Ohsumi, 1975; INPFC, 1989; Northridge, 1991*a*
		1 (1988)	No estimate	
		1 (1979–84)	No estimate	
		1 (1985)	No estimate	
		2 (1986)	No estimate	
Northern Japan	I—gillnet	55 (1976–81)	10/year	Miyazaki, 1980, 1983; S. Ohsumi in Gaskin, 1984; Miyazaki *et al.*, 1987
		1 (1986)	No estimate	

(continued)

Table 1.—*contd*

Area	Fishery type[a]	Known take	Estimated take	Source
West Africa	I—gillnet	2 (1949) —	No estimate >30/year	Cadenat, 1949; IWC, in press
Morocco	I—lobster setnet	—	Approx. 10/year	Maigret, in press
Portugal	I—coastal gillnet	—	No estimate	Sequeira & Ferreira, in press
France	I—gillnet	6 (1971–1981)	No estimate	Duguy & Hussenot, 1982
Scotland	I—cod, salmon, and whitefish gillnets	40 (1959–1965) 24 (1965–1970) 86 (1973–1988) 24 (1989–1990)	No estimate	Rae, 1965, 1973; Evans, 1980; Northridge, 1988; P. G. H. Evans, pers. comm.
Northeast England	I—salmon driftnets and inshore setnets	1–6/year/boat	No estimate	Northridge, 1988
Ireland	I—salmon setnets and whitefish gillnets	—	No estimate	Greenpeace, 1989; P. G. H. Evans, pers. comm.
West German Baltic Sea	I—gillnet	83 (1987–1990)[e]	No estimate	Kremer & Schultze, 1990; Benke *et al.*, 1991
Poland	I—salmon and herring nets[e]	597 (1922–35) 7 (1945–55) 10 (1970–87)	No estimate No estimate No estimate	Ropelewski, 1957; Skora *et al.*, 1988; Skora, 1991
Sweden	I—cod, flatfish, pollack, lumpfish, dogfish gillnet	128 (1973–87) 116 (1988–90)	No estimate No estimate	Lindstedt & Lindstedt, 1989; Lindstedt, 1990, 1991; IWC, 1991
	I—salmon driftnet	50 (1960–1961)[e] 2 (1988–1990)	No estimate No estimate	Lindroth, 1962; Otterlind, 1976; Kinze, in press
Denmark	I—cod, turbot, plaice, lumpsucker gillnet	111 (1980/81) 147 (1986–89)	3000/year[f] >750/year	Andersen, 1974; Andersen & Clausen, 1984; Clausen & Andersen, 1988; Kinze, 1990
Norway	I—salmon driftnet[b]	96 (1988) 33 (1989) 49 (1961)	No estimate No estimate No estimate	Bjørge & Øien, 1990
White Sea	I—beluga whale gillnet	—	No estimate	Yablokov & Belkovich, 1968
Faroe Islands	I—herring nets (presumably gillnets)	—	No estimate	Larsen, 1990
Iceland	I—lumpsucker gillnet	63 (1982/83)	No estimate	Iceland, 1984
Greenland	I—domestic (mostly salmon driftnet)	4 (1987)	500–1000/year (1950s–1970s)	Kapel, 1977, 1984; Heide-Jørgensen & Leatherwood, 1987
	I—foreign salmon driftnet[b]	573 (1972)	1401	Lear & Christensen, 1975; Christensen & Lear, 1977
West Greenland to Newfoundland	I—gillnet (mostly salmon)	15 (1967–72)	No estimate	Mercer, 1973
	I—salmon tagging driftnet	—	No estimate	Stenson & Reddin, 1990
Labrador	I—salmon gillnet and cod traps	4 (1982)	No estimate	Alling & Whitehead, 1987
	I—gillnets	111 (1982)	160–317/year	Lien, 1987
Newfoundland and Labrador	I—gillnet	243 (1980)	1800	Lien *et al.*, 1989

Table 1.—*contd*

Area	Fishery type[a]	Known take	Estimated take	Source
Newfoundland	I—cod and salmon gillnet	40 (1981–84)	530	Piatt & Nettleship, 1987
Gulf and Estuary of St Lawrence	I—cod, herring, groundfish, and salmon gillnet	5–6 (1973) 4 (1974) 2 (1975) 623 (1988) 148 (1989)	No estimate No estimate No estimate No estimate 1500/year	Laurin, 1976; Fontaine *et al.*, 1990; IWC, in press
Nova Scotia	I—herring gillnet	—	No estimate	Read, in press
Bay of Fundy	I—groundfish setnet	4 (1976) 4 (1981) 2 (1982) 11 (1983) 46 (1985) 56 (1986) 73 (1987) 67 (1988) 56 (1989) 33 (1990)	No estimate No estimate No estimate No estimate No estimate 105 129 80 91 No estimate	Prescott & Fiorelli, 1980; Gaskin *et al.*, 1985, Read & Gaskin, 1988, 1990*a*; A. J. Read pers. comm.
Gulf of Maine	I—groundfish setnet	2 (1975) 2 (1978) 4 (1979) 7 (1981/82) 30 (1984) 107 (1985) >12 (1986) 5 (1989) 18 (1990) 11 (1991) —	No estimate No estimate No estimate 801 300 506 No estimate 1250/year 1250/year 1250/year 635/year	Prescott & Fiorelli, 1980; Gilbert & Wynne, 1987; Read & Gaskin, 1990*a*; Payne *et al.*, 1990; Kraus, 1990; Smith *et al.*, 1991
	I—mackerel gillnet	—	No estimate	Polacheck, 1989
Virginia	I—shad gillnet	1 (year unknown)	No estimate	Polacheck & Wenzel, 1990

[a] Fishery type: I, incidental catch; D, direct catch. (Notation also applies to Tables 2–6.)
[b] Fishery has been discontinued.
[c] Possibly from gillnets or other types of gear.
[d] These animals were found at the US/Canada border. They were considered to have been taken in a US gillnet fishery because there are no gillnet fisheries in BC at that time of year (R. W. Baird, pers. comm.).
[e] Includes gillnet and other types of fishing gear.
[f] Very rough estimate — treat with caution.

Porpoises have virtually disappeared from San Francisco Bay, California, possibly due to increased pollution and vessel traffic (Brownell, 1964; Szczepaniak & Webber, 1985). In central California, harbor porpoise population(s) have been depleted by past levels of gillnet mortality, but their status relative to carrying capacity (K) is unknown (Barlow & Hanan, in press). Active restriction of gillnetting by the state has somewhat lessened the mortality, and it is hoped that populations will soon recover under this new protection. However, if there are several small localized populations along the coast, as is suggested by the work of Calambokidis and Barlow (1991), they may still be at risk from periods of unusually high mortality caused by changes in porpoise distribution or fishing effort (Jefferson *et al.*, in press).

There are extremely large catches of harbor porpoises in gillnets and a large direct catch (Kapel, 1977) around southwest Greenland. There is reason to fear that these takes threaten the population(s) there, but too little information on population status or trends exists to confirm or deny this. The same is true for populations off Newfoundland and Labrador, and in the Gulf and Estuary of St Lawrence. Additional kills in cod traps and a small direct hunt for meat in the St Lawrence add to the problem there (Laurin, 1976).

In the Bay of Fundy and Gulf of Maine, long-term research has given us a better data base from which to make conclusions. Besides gillnet catches, threats include a past direct hunt by Indians (Prescott & Fiorelli, 1980), and small takes in herring weirs (Smith *et al.*, 1983). A single stock is thought to inhabit this area, and there is evidence that it is depleted (see Read & Gaskin, 1990*a,b*). Changes in life history parameters and summer distribution patterns provide the most compelling of such evidence (Read & Gaskin, 1990*b*);

however, there are alternative explanations. Present estimates of bycatch range from 1–5% of the population (Smith *et al.*, 1991), and Woodley and Read (1991) suggested that harbor porpoises have a limited capacity for increase and cannot sustain even moderate annual losses, as low as 4%. In Canada, the harbor porpoise is listed as Threatened (Gaskin, 1992), and a petition is pending that would classify this stock as Threatened under the US Endangered Species Act (Read, *et al.*, 1993).

The population status of northern European harbor porpoises is not known, but populations throughout the Baltic and North Seas have been in serious decline for several decades (Ropelewski, 1957; Otterlind, 1976; Verway & Wolff, 1982; Andersen & Clausen, 1984; Kayes, 1985; Smeenk, 1987; Skora *et al.*, 1988; Evans & Scanlan, 1989; Berggren & Pettersson, 1990; Northridge & Lankester, 1990). Harbor porpoises in Danish waters show changes in reproductive parameters that are probably the result of overexploitation (Clausen & Andersen, 1988). In addition to catches in gillnets, harbor porpoises in this area are also taken in pond nets, trawl nets, and other types of fishing gear (Andersen, 1974; Kayes, 1985; Clausen & Andersen, 1988; Lindstedt & Lindstedt, 1989; Benke *et al.*, 1991). For several hundred years, ending in 1944 there was an extensive drive fishery for harbor porpoises that took animals as they migrated from the Baltic (Møhl-Hansen, 1954; Andersen, 1982). Increases in pollution (especially organochlorines), competition with fisheries (especially depletion of herring stocks by fisheries), and disturbance by increases in ship traffic have all been proposed as additional possible reasons for the decline (see reviews in Kayes, 1985; Smeenk, 1987). It is probable that all of these factors played a role, probably differently in different areas, but only fisheries bycatches and the drive fishery can be unequivocally shown to have caused the death of large numbers of porpoises.

The isolated population of harbor porpoises in the Black Sea and Sea of Azov has been drastically reduced, mostly as a result of a large-scale directed fishery conducted by the Soviet states, Turkey, Romania, and Bulgaria (reviews in Smith, 1982; IWC, 1992). This fishery was thought to have ceased in 1983, but has been recently revived (IWC, 1992).

The World Conservation Union's (IUCN) Cetacean Specialist Group considered the harbor porpoise, as a species, to be Threatened, but not enough information existed to classify it either as Endangered or Vulnerable (Perrin, 1989). It was classified as Insufficiently Known by IUCN in the Red Data Book (Klinowska, 1991).

VAQUITA *Phocoena sinus*

Distribution and abundance

The known range of the vaquita is in the northern Gulf of California, Mexico, although it may possibly include waters further south in the Gulf as well (Silber, 1990*b*; Vidal, in press). This is apparently the most limited range of any marine cetacean; it is improbable that there is more than one stock.

There are no statistically defendable estimates of the abundance of this species. Silber (1990*a*) suggested the population to number 200–500 individuals, but this is a rough estimate not based on survey analyses, and the true population size may be closer to the lower number (Vidal, in press).

Mortality in gillnets

The large mesh gillnet fishery for totoaba (a large sciaenid fish) is the greatest cause of incidental mortality for the vaquita (Table 2). The fishery began in the early 1940s (Brownell, 1982) and continues illegally today. Vidal (in press) reviewed this fishery and its effects on the vaquita population. Smaller mesh gillnets set for other fish species and shrimp trawls may account for a small number of mortalities. A planned large-mesh fishery for sharks would ensure that the threat will continue. An estimated 30–40 vaquitas are killed per year in commercial fishing operations (IWC, 1991).

Status of affected populations

In addition to incidental catches, habitat degradation —in the form of pollution, reduced habitat productivity, and depletion of food resources from commercial fishing—represents a potential threat to the continued existence of the vaquita (Barlow, 1986). The vaquita is considered to be one of the two most endangered cetacean species today (the other is the bajii *Lipotes vexillifer*, now restricted to a portion of the Yangtze

Table 2. Records of vaquita catches in gillnets

Area	Fishery type	Known take	Estimated take	Sources
Northern Gulf of California, Mexico	I—totoaba and shark gillnet	10 (1 day, 1970s) 2 (1972) 1 (1980) 1 (1984) 27 (1985) 5 (1985/86) 1 (1986/87) 2 (1986) 5 (1987) 7 (1988) 12 (1989) 21 (1990)	10s–100s (early 1970s) No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate	Norris & Prescott, 1961; W. E. Evans in Brownell, 1982; Brownell *et al.*, 1987; Robles *et al.*, 1987; Boyer & Silber, 1990; Vidal, in press

River in China). The vaquita has been listed as Endangered by IUCN and by the US Fish and Wildlife Service (FWS), and is listed in Appendix I of CITES (Brownell, 1988; Klinowska, 1991). If the estimates of abundance and mortality summarized above are even approximately accurate, there is no question that the vaquita population is decreasing towards extinction.

BURMEISTER'S PORPOISE *Phocoena spinipinnis*

Distribution and abundance

Burmeister's porpoise is found in coastal waters of South America, from northern Peru, south to Tierra del Fuego, and north to southern Brazil (Brownell & Praderi, 1984; Pinedo, 1989).

There are no estimates of abundance. This species is not commonly sighted at sea; however, this may be more a reflection of its low visibility than of real rarity (see Van Waerebeek & Reyes, in press). Strandings and fisheries catches indicate that it is not uncommon. Burmeister's porpoises appear to be more abundant off the Pacific coast of South America than the Atlantic coast (Brownell & Praderi, 1982) or the Chilean and Argentinean fjords (S. Leatherwood, pers. comm.).

Mortality in gillnets

Catches in gillnets occur throughout the range of this species (Table 3). By far, the best information is for central Peru, where fisheries taking small cetaceans have been monitored at several ports since 1985 (Read *et al.*, 1988; Van Waerebeek & Reyes, 1990, in press). The 1988 take of this species for all of Peru was roughly estimated at about 1500–2500 porpoises (Van Waerebeek & Reyes, in press). The catch is primarily incidental to surface driftnet fishing for sharks and other species, and demersal setnet fishing for a variety of fish species, but sometimes the nets are set intentionally for small cetaceans (mostly dusky dolphins *Lagenorhynchus obscurus* and bottlenose dolphins *Tursiops truncatus*) (Read *et al.*, 1988; Van Waerebeek & Reyes, 1990).

Status of affected populations

Central Peruvian Burmeister's porpoises are taken primarily in demersal gillnets and driftnets, but also occasionally in purse seines (Read *et al.*, 1988). In Chile, they are shot and harpooned in small numbers for bait and for human consumption (Torres *et al.*, 1979; Van Waerebeek & Guerra, 1987).

Because there are no population estimates available, it is not possible to evaluate the status of any Burmeister's porpoise stock. However, the very large kills off Peru strongly suggest that the population(s) there are declining (Perrin, 1989).

Table 3. Records of Burmeister's porpoise catches in gillnets

Area	Fishery type	Known take	Estimated take	Sources
Brazil	I — presumably gillnet	—	No estimate	IWC, 1991
Uruguay	I — shark gillnet	4 (1·5 years) 10 (1970–1989)	No estimate No estimate	Pilleri & Gihr, 1972*a*, 1974; Brownell & Praderi, 1976, 1982; Praderi, 1990
Northern Argentina	I — shark gillnet	—	18/year	Crespo & Corcuera, in press; Corcuera *et al.*, 1990
Tierra del Fuego (Argentina and Chile)	I — *centolla, róbalo*, hake, trout, and silverfish gillnet[a]	16 (1965–1988)	No estimate	Goodall, 1978; Torres *et al.*, 1979; Goodall & Cameron, 1980; Goodall *et al.*, in press
Chile	D/I — surface gillnet	—	No estimate	Goodall & Cameron, 1980; Mitchell, 1975; Van Waerebeek & Guerra, 1987
	I — ratfish and sciaenid setnet	62 (1988) 57 (1989) 40 (1990)	180–400/year[b] No estimate No estimate	Reyes & Oporto, in press
	I — swordfish driftnet	—	No estimate	Northridge, 1991*a*
Peru	D/I — presumably gillnet	—	1500–2500/year	Brownell & Praderi, 1976 1982; Clarke, 1962; Clarke *et al.*, 1978; Van Waerebeek & Reyes, in press
Central Peru	D/I — driftnet and demersal gillnet	26 (1985) 20 (1986) 71 (1987) 259 (1988) 175 (1989)	47 24 83 383 331	Read *et al.*, 1988; Van Waerebeek & Reyes, 1990, in press; K. Van Waerebeek, pers. comm.

[a] Nets are no longer used for *centolla* (Goodall *et al.*, 1988).
[b] Mostly Burmeister's porpoises.

SPECTACLED PORPOISE *Australophocaena dioptrica*

Distribution and abundance

This poorly known species is distributed off South America, from Uruguay to the Beagle Channel and Strait of Magellen in Tierra del Fuego, around the Falkland Islands and South Georgia (South Atlantic), the Kerguelen Islands and Heard Island (southern Indian Ocean), Macquarie Island (Australia), and the Aukland Islands (New Zealand) (Brownell *et al.*, 1989; Goodall, in press). It is unclear whether this is primarily a coastal or an offshore species, although recent evidence suggests that it may be more common offshore (see IWC, 1991).

There are no published estimates of abundance for the spectacled porpoise. Sighting records are rare, but strandings are not uncommon, at least in Tierra del Fuego (Goodall, in press).

Mortality in gillnets

Spectacled porpoises are known to be taken in gillnets off Argentine and Chilean Tierra del Fuego, and off Santa Cruz, Argentina; however, there are no estimates of the number of animals taken annually (Table 4).

Status of affected populations

Goodall (in press) summarized the little that is known about the biology of the spectacled porpoise. Besides being taken in gillnet fisheries, they are known to have been taken deliberately off parts of South America, and may be taken for crab bait in southern Chile. If the spectacled porpoise is indeed an offshore species, it may not be as rare as sighting records suggest.

DALL'S PORPOISE *Phocoenoides dalli*

Distribution and abundance

Dall's porpoises are found in the North Pacific Ocean and adjacent seas (Bering and Okhotsk Seas, and Sea of Japan) (see Jefferson, 1988; Houck & Jefferson, in press). In the eastern North Pacific, they are common to as far south as 32°N, with some records as far south as 28°N. In the western Pacific, they occur from about 35°N to the northern Sea of Okhotsk. The distributional limit is at about 39°N in the central Pacific, and most sightings are south of 62°N in the Bering Sea. There are two commonly-occurring color types of Dall's porpoise, which differ primarily in the extent of the white flank patch. These are called *dalli*-type and *truei*-type (see Kasuya, 1982; Jefferson, 1988 for discussion).

The IWC currently recognizes eight stocks of Dall's porpoise, with calving grounds in the following areas: (1) central Bering Sea (*dalli*-type); (2) south of the Kamchatka Peninsula (*dalli*-type); (3) south of the Aleutian Islands (*dalli*-type); (4) central Gulf of Alaska (*dalli*-type); (5) northern Okhotsk Sea (*dalli*-type); (6) central Okhotsk Sea (*truei*-type); (7) southern Okhotsk Sea (*dalli*-type); and (8) eastern North Pacific (*dalli*-type) (see IWC, 1992).

Jones *et al.* (1987) estimated the abundance of Dall's porpoise for the entire range of the species, excluding the Sea of Japan and Okhotsk Sea, at 1·4–2·8 million individuals. Miyashita and Kasuya (1988) provided a minimum estimate of 104,000 animals for the waters around Japan (including the Sea of Japan and southern Okhotsk Sea), and Miyashita (1991) estimated the three Okhotsk Sea stocks to be around 554,000 porpoises.

Mortality in gillnets

Although only small numbers of Dall's porpoises are known to be taken in gillnets in the eastern North Pacific, stocks in the western and central North Pacific suffer large takes in pelagic driftnets (Table 5). Incidental catches in the Japanese salmon mothership and land-based fisheries have declined dramatically with the decreases in effort of these fisheries in recent years (directed takes have increased, however, in part to make up for restrictions of Japanese coastal whaling).

Catches by the Japanese squid driftnet fishery have only recently been explored in detail (INPFC, 1990, 1991). Estimated takes of over 3000 Dall's porpoises per year in the Japanese fishery have been extrapolated to the Korean and Taiwanese fisheries by Northridge (1991*a*) to obtain an estimate of about 6000 porpoises/year taken by the combined squid fisheries, although the IWC (1992) pointed out that this estimate might be too high. In addition, there may also be some takes of Dall's porpoises in the large mesh driftnet fisheries for tuna and billfish, which operate further south than the squid and salmon fisheries.

Status of affected populations

The effects of these large driftnet catches on Dall's porpoise populations are largely unknown. Some stocks have been subjected to large catches since at least the mid-1950s, when catches of the mothership fishery were possibly as high as 10,000–20,000/year

Table 4. Records of spectacled porpoise catches in gillnets

Area	Fishery type	Known take	Estimated take	Sources
Santa Cruz, Argentina	I — *róbalo* gillnet	—	No estimate	Crespo & Corcuera, in press
Tierra del Fuego (Argentina and Chile)	I — *róbalo* hake, and trout gillnet	35 (1975–1990)[a]	No estimate	Goodall, 1978; Goodall & Cameron, 1980; Goodall *et al.*, 1988, in press

[a] Only five of these 35 are known definitely to have been caught in nets; the others probably were (R. N. P. Goodall, pers. comm.).

Table 5. Records of Dall's porpoise catches in gillnets

Area	Fishery type	Known take	Estimated take	Sources
California	I—swordfish and shark driftnet	1 (1990)	23	Lennert *et al.*, 1991
Northern California to British Columbia	I—Canadian experimental squid driftnet[a]	3 (1983) 1 (1985) 33 (1986) 58 (1987)	3 1 33 58	Jamieson & Heritage, 1988
Washington/Oregon	I—experimental thresher shark driftnet[a]	1 (1987) 5 (1988)	No estimate No estimate	Stick & Hreha, 1989
Washington State	I—salmon gillnet[b]	2 (1978)	No estimate	Everitt *et al.*, 1979, 1980
British Columbia, Canada	I—gillnet	2–5 (1978) 1 (1983) 1 (1984)	No estimate No estimate No estimate	Bigg, 1984; Gaskin, 1984; Jefferson, 1987; Stacey *et al.*, 1990
Prince William Sound, Alaska	I—Coghill salmon gillnet	51 (1978)	No estimate	Matkin & Fay, 1980
Kodiak/Alaska Peninsula/S Unimak, Alaska	1—salmon gillnet	1 (1990)	No estimate	Barlow *et al.*, in press
Central North Pacific	I—Japanese, Taiwanese, and Korean squid driftnet	2500 (1982)[c] 2502 (1983)[c] 2515 (1984)[c] 2483 (1985)[c] 17 (1986/87)[c,d] 57 (1988)[c] 141 (1989)[c] 318 (1990)[c]	No estimate No estimate No estimate No estimate No estimate No estimate 3110–3397[c] 3342[c]	Jones *et al.*, 1987; Tsunoda, 1989; INPFC, 1990, 1991; Anon., 1991; Yatsu *et al.*, in press
Northwestern North Pacific and Bering Sea	I—Japanese salmon mothership driftnet	148 (1964, 1965) 499 (1978) 683 (1979) 999 (1980) 1354 (1981) 3189 (1982) 2986 (1983) 2670 (1984) 2747 (1985) 1857 (1986) 801 (1987) 222 (1988) — (1989) — (1990)	10,000–20,000/year (1960s) No estimate No estimate 8970 2862 5903 4280 3355 3239 1719 1011 No estimate 36 54	Mizue & Yoshida, 1965; Mizue *et al.*, 1966; Jones, 1984; Jones *et al.*, 1987; INPFC, 1989; Anon., 1991
	I—Japanese salmon research driftnet	>518 (1962–1971) 27 (1978) 20 (1979) 56 (1980) 25 (1981) 50 (1982) 60 (1983–84) 39 (1985) 24 (1986) 16 (1987) 14 (1988)	No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate No estimate	Ohsumi, 1975; Jones, 1984; INPFC, 1989; Northridge, 1991

(continued)

Table 5.—*contd.*

Area	Fishery type	Known take	Estimated take	Sources
Western Pacific	I—Japanese salmon land-based driftnet	303 (1978) 127 (1979) 139 (1980) 696 (1981) 1691 (1982) 1291 (1983) 813 (1984) 781 (1985) 404 (1986) 458 (1987) 319 (1988) — (1989) — (1990)	No estimate No estimate No estimate 2936 6010 4429 3356 2979 1392 1229 No estimate 282 134	Jones, 1984, 1990; Jones *et al.*, 1987, in press; INPFC, 1989; Anon., 1991
Japan	I—gillnet	554 (1976–1981)	No estimate	Miyazaki, 1983

[a] Fishery has been discontinued.
[b] Everitt *et al.* (1979) indicated that these animals were caught in seines.
[c] Japanese fleet only.
[d] Includes both commercial and research squid vessels.

(Mizue & Yoshida, 1965; Mizue *et al.*, 1966). Uncertainties in the accuracy of abundance estimates (see Bouchet, 1981) and problems in definition of stock boundaries make interpretation of these catches difficult.

In 1987, both Dall's porpoise stocks affected by the salmon mothership fishery (Bering Sea and south of the Aleutians stocks) were thought to be above maximum net productivity level (MNPL), defined as 60% of pre-exploitation population size (Jones *et al.*, 1987). There has been little evidence of major population declines in the area of operation of the mothership salmon fishery and, in most areas of their range, Dall's porpoises appear to be abundant. Current census techniques, however, have little power to detect small to moderate changes in abundance (see Holt *et al.*, 1987). The IUCN Cetacean Specialist Group considered the populations affected by the salmon driftnet fisheries to be at risk (Perrin, 1989). Porpoises off Japan are affected not only by incidental catches in gillnet fisheries, but also by large direct catches in an extensive harpoon fishery (see Kasuya, 1982; IWC, 1992). Catches of 21 800–40 300/year in the harpoon fishery in 1987–1990 were definitely unsustainable (IWC, 1991), but recent recommendations by the IWC to reduce the catch seem to have been at least partially effective. The central Okhotsk Sea *truei*-type population is the one in most danger of extirpation, primarily as a result of these large direct catches (Perrin, 1989).

Three *dalli*-type populations are affected by the squid driftnet fisheries: the south of the Kamchatka Peninsula, south of the Aleutian Islands, and central Gulf of Alaska stocks (Anon., 1991). The estimated total population size of at least 741,000 animals for these three stocks is thought to be capable of sustaining the annual catch of about 3000–6000 porpoises by the combined Asian squid fisheries (Anon., 1991). It must be emphasized, however, that this assessment is based on much incomplete information and several factors could result in significant impacts on any of these populations or currently undescribed subpopulations.

FINLESS PORPOISE *Neophocaena phocaenoides*

Distribution and abundance

Finless porpoises are found in the Indo-Pacific region, from the Persian Gulf to northern Japan, and south to Indonesia (see Klinowska, 1991 for review). Records of the occurrence of the species off South Africa are likely in error (Klinowska, 1991). Their range includes not only coastal marine waters, but also rivers, estuaries, mangrove areas, and lakes with connections to rivers.

There are no estimates of global abundance for the finless porpoise. Kasuya and Kureha (1979) estimated that the population in the Sea of Japan consisted of 1600–4900 individuals. There is some evidence to indicate separate stocks, but the available data are sparse and incomplete.

Mortality in gillnets

Incidental catches in gillnets are known from throughout most of the range of the finless porpoise (Table 6), but there are no reliable estimates of takes for any fishery. The highest known catches have been in China (Zhou & Wang, in press). Based on the species' coastal nature, the relative paucity of research on cetacean/fishery interactions in coastal areas of the species' range, and the prevalence of gillnet fisheries in its range, the true numbers of finless porpoises taken in gillnets are likely to be much higher than indicated in Table 6.

Status of affected populations

In addition to mortality in gillnets, finless porpoises also suffer from direct takes in Japan and China (Miyazaki, 1983; Leatherwood & Reeves, 1983). Other incidental catches occur in 'set net' (not a type of gillnet), beach seine, drag net, stow net, trap, and long-

Table 6. Records of finless porpoise catches in gillnets

Area	Fishery type	Known take	Estimated take	Sources
Japan	I—gillnet	2 (1976–1981) 23 (1970–89)	No estimate No estimate	Miyazaki, 1983; Tobayama *et al.*, 1990
Kanmon Pass,	I—driftnet and gillnet	2 (1985) 3 (1989)	No estimate No estimate	Shirakihara *et al.*, 1992
Yellow Sea	I—gillnet	—	No estimate	Wang Peilie, 1979
Bohai Sea	I—drift trammel net	9 (1990)	No estimate	Wang Peilie, 1979; Zhou Kaiya, pers. comm.
Yangtze River, China[b]	I—gillnet	80 (1974–90)[a]	10–20/year	Zhou & Wang, in press; IWC, 1991
Jiangsu Province, China	I—driftnet	11 (1984) 4 (1985) 23 (1986)[a] 19 (1989)[a]	No estimate No estimate No estimate No estimate	Zhou & Wang, in press
East China Sea	I—drift trammel net	8 (1987) 30 (1990)	No estimate No estimate	Zhou & Wang, in press; Zhou Kaiya, pers. comm.
Java	I—gillnet	2 (1975)	No estimate	Tas'san & Leatherwood, 1984
Thailand	I—driftnet	2 (year unknown)	No estimate	Northridge & Pilleri, 1986
Gulf of Mannar and Palk Bay, India	I—set gillnet	1–2 (pre-1975)	No estimate	Jones, 1975
Calicut, India	I—gillnet	1 (1973) 8 (1976)	No estimate No estimate	Balan, 1976; Mohan, 1985
Indian coast	I—seerfish, shark, acombroid, and pomfret gillnet	—	No estimate	Mohan, in press
Pakistan	I—coastal gillnets	—	No estimate	Niazi & Moazzam, 1990

[a] Mostly taken in gillnets.
[b] Nanjing section only.

line fisheries in Japan, China, and in the Indian Ocean (Jones, 1975; Miyazaki, 1983; Tobayama *et al.*, 1990; Zhou & Wang, in press).

Pollution, boat disturbance, and other types of habitat destruction have also been implicated as potential threats to finless porpoise populations (see Klinowska, 1991). Porpoises have apparently abandoned the lower Indus River, probably as a result of boat disturbance (Pilleri & Gihr, 1972*b*). Yangtze River and Chinese coastal populations are considered to be threatened, although their numerical status is not known (Perrin, 1989).

DISCUSSION AND CONCLUSIONS

It is clear that, in nearly every instance, the necessary data for the evaluation of impacts of gillnet mortality on porpoise populations are lacking. Notable exceptions, for which we have both reliable estimates of stock size and reasonable data on annual catches, are: harbor porpoises in central California and the Bay of Fundy/Gulf of Maine, and Dall's porpoises in the central and northwestern North Pacific, Bering Sea, and offshore of Japan. Even in these 'best case' situations, uncertainties about the accuracy of population estimates, incidental mortality estimates, and stock discreteness have resulted in serious doubts about the status of the populations involved. Also, the natural potential for increase is unknown for most porpoise populations.

There are several situations where good data on either estimated kills or stock size (but not the other) exist: harbor porpoises in Norway; Burmeister's porpoises in Peru; Dall's porpoises in the Sea of Japan/ Okhotsk Sea; and finless porpoises in the Sea of Japan. In all remaining situations, abundance and mortality data are nonexistent or inadequate to assess the situation.

For harbor porpoises in many areas, Burmeister's porpoises in Peru and Chile, and finless porpoises in Chinese waters, even the incomplete information available strongly suggests that stocks are at risk. This is largely due to gillnet entanglement, often exacerbated by other forms of human-caused mortality. There is

little doubt that the vaquita is in imminent danger of extinction from gillnet fishing in the Gulf of California.

Gillnet fishing appears to represent the single most significant threat to most porpoise populations. Conflicts between gillnet fisheries and porpoise populations need to be solved soon to avoid loss of at least one species and several populations of other porpoise species. Such extinctions and extirpations would represent a significant loss of genetic diversity in the family Phocoenidae.

Some attempts have been made to reduce or eliminate porpoise (and other small cetacean) mortality in gillnets by modifications of fishing gear. These efforts have generally operated under the assumption that porpoises are unable to detect monofilament gillnets (see Awbrey *et al.*, 1979), and have therefore attempted to increase the acoustic reflectivity of nets or to warn porpoises of the presence of nets through the use of sound generators. These technology-oriented attempts have so far been largely unsuccessful, or at best, inconclusive (see reviews in Dawson, 1991; Todd & Nelson, in press), and at present appear to offer little promise (IWC, in press).

We submit that such studies have failed to solve the problem because of a lack of understanding of the reasons why porpoises become entangled in gillnets. Only when the responses and mechanisms of detection (and non-detection) are understood will attempts to modify nets to reduce mortality have much chance of success. Such studies of gillnet detection are urgently needed, although in the meantime we must be willing to consider other types of solutions.

Clearly, we are a long way from a solution. New approaches to the porpoise/gillnet problem are needed. Until a suitable solution can be found, we suggest the following approaches. For fisheries that are known or suspected of endangering one or more porpoise populations, the only alternative may be to ban the use of gillnets, require fishermen to switch to more selective gear, or enforce time and area restrictions on gillnet use. This is the case for the gillnet fisheries in the northern Gulf of California that threaten the vaquita, and those in central California affecting the harbor porpoise. Fisheries in which data are inconclusive, but that are likely to have incidental take problems, should be monitored with 100% observer coverage (or reasonable approximation) and then managed appropriately, based on more complete data. Peruvian fisheries taking Burmeister's porpoises and many European fisheries with kills of harbor porpoises should be monitored. For those that are known (or strongly suspected) of having incidental takes that do not endanger porpoise populations, it is pertinent at least to monitor the fishery with observer coverage, as possible, giving lower priority to these fisheries than to those that have known problems. Gillnet fisheries around southern Chile and Argentina, with catches of Burmeister's and spectacled porpoises, could be handled in this way.

We agree with the general consensus that large-scale pelagic driftnets are ecologically destructive. The United Nations passed a resolution placing a global moratorium on pelagic driftnet fishing as of 31 December 1992 (UN General Assembly Resolution 46/215).

In addition, fishermen must be included to a greater degree in documenting, studying, and solving the problem of porpoise entanglement. They should be consulted for their perceptions of the problem and how it can be solved. Tuna fishermen were instrumental in developing much of the technology and techniques used to release dolphins from purse seine nets (see Coe *et al.*, 1985). Since porpoises caught in most gillnet fisheries are unused, some fishermen can be expected to be receptive and cooperative in attempts to prevent the bycatch, provided their economic and social situations are taken into account. Scientists, fishermen, managers, and environmentalists could benefit from working together, where possible, toward the common goal of realistic and livable solutions to the incidental catch problem. Where fishing closures or gear bans are needed to resolve urgent problems, government and private organizations concerned with marine mammals should be willing to provide limited compensation and economic incentives to fishermen for their cooperation.

A technological 'breakthrough' should not be viewed as the only potential solution to the problem of mortality of porpoises and other cetaceans in gillnets. The porpoise/gillnet problem may be an example of a 'no technical solution problem' as described by Garrett Hardin in his classic essay '*The tragedy of the commons*' (Hardin, 1968). Gillnet modifications may never provide the levels of reduction in take rate needed to turn many large takes into negligible, or at least sustainable, ones. Workable solutions will likely need to be tailored to each fishery and cetacean bycatch species and will probably involve compromises by both industry and conservationists. They will entail combinations of technological developments, scientific discoveries, management enforcement actions, educational programs, cooperative studies, and economic and social reforms.

ACKNOWLEDGEMENTS

We thank the following individuals, who reviewed the tables and generously provided unpublished information: R. W. Baird (Marine Mammal Research Group), J. Barlow (Southwest Fisheries Science Center—SWFSC), P. G. H. Evans (European Cetacean Society), D. E. Gaskin (University of Guelph), R. N. P. Goodall (Centro Austral de Investigaciones Cientificas), T. Kasuya (Far Seas Fisheries Research Lab), C. C. Kinze (Zoologisk Museum), S. Northridge (Renewable Resources Assessment Group), W. F. Perrin (SWFSC), A. J. Read (Woods Hole Oceanographic Institution—WHOI), G. K. Silber (Marine Mammal Commission), K. Van Waerebeek (Centro Peruano de Estudios Cetologicos), O. Vidal (Instituto Tecnologico y de Estudios Superiores de Monterrey), and Zhou Kaiya (Nanjing Normal University). Thanks also to S. Leatherwood (IUCN Cetacean Specialist Group), A. J. Read (WHOI), and two anonymous reviewers for their

thorough and thoughtful reviews of the manuscript. This represents Contribution No. 27 of the Marine Mammal Research Program, Texas A&M University.

REFERENCES

Ailing, A. K. & Whitehead, H. P. (1987). A preliminary study of the status of white-beaked dolphins, *Lagenorhynchus albirostris*, and other small cetaceans off the coast of Labrador. *Can. Field-Nat.*, **101**, 131–5.

Andersen, S. (1974). A typical case history of the net-caught harbour porpoise, *Phocoena phocoena* from Danish waters. *Aquat. Mammal.*, **2**, 1–6.

Andersen, S. H. (1982). Change in occurrence of the harbour porpoise *Phocoena phocoena* in Danish waters as illustrated by catch statistics from 1834 to 1970. In *Mammals in the seas. Vol. 4: Small cetaceans and sirenians. FAO Fish. Ser.*, **5**, 131–3.

Andersen, S. & Clausen, B. (1984). Bycatches of the harbour porpoise, *Phocoena phocoena* in Danish fisheries 1980–1981, and evidence for overexploitation. *Rep. int. Whal. Commn*, **34**, 745 (abstract).

Anon. (1991). Scientific review of the North Pacific high seas driftnet fisheries, Sidney BC, 11–14 June, 1991. Unpublished report for presentation to the United Nations, Department of Fisheries and Oceans, Sidney, BC.

Awbrey, F. T., Norris, J. C., Hubbard, A. B. & Evans, W. E. (1979). The bioaccoustics of the Dall porpoise–salmon driftnet interaction. *Hubbs/Sea World Res. Inst. Tech. Rep.*, **79–120**.

Baird, R. W. & Guenther, T. J. (in press). Harbour porpoises *Phocoena phocoena* on the BC coast: a preliminary examination of information from stranded and incidentally caught animals. *Rep. int. Whal. Commn (Special Issue)*.

Baird, R. W., Stacey, P. J. & Langelier, K. M. (1991). Strandings and incidental mortality of cetaceans on the BC coast, 1990. *IWC Sci. Comm. Rep.* SC/43/01.

Balan, V. (1976). A note on a juvenile Indian porpoise *Neomeris phocaenoides* (Cuvier) caught off Calicut. *Ind. J. Fish.*, **23**, 263–4.

Barlow, J. (1986). Factors affecting the recovery of *Phocoena sinus*, the vaquita or Gulf of California harbor porpoise. *SWFC Admin. Rep.*, LJ-86-37.

Barlow, J. (1988). Harbor porpoise *Phocoena phocoena* abundance estimation for California, Oregon, and Washington: 1. Ship surveys. *Fish. Bull. U. S.*, **86**, 417–32.

Barlow, J. & Hanan, D. (in press). An assessment of the status of harbor porpoise in central California. *Rep. int. Whal. Commn. (Special Issue)*.

Barlow, J., Baird, R. W., Heyning, J. E., Wynne, K., Manville, A. M., II, Lowry, L. F., Hanan, D., Sease, J. & Burkanov, V. N. (in press). A review of cetacean and pinniped mortality in coastal fisheries along the west coast of the US and Canada and the east coast of the Russian Federation. *Rep. int. Whal. Commn (Special Issue)*.

Benke, H., Kremer, H. & Pfander, A. F. (1991). Incidental catches of harbour porpoises *Phocoena phocoena* Linnaeus 1758 in the coastal waters of Angeln and Schwansen (Schleswig-Holstein, FRG) from 1987 to 1990. *Abstract, European Cetacean Society, Ann. Conf.*, 5th, p. 9.

Berggren, P. & Pettersson, F. (1990). Distribution and abundance of harbour porpoises *Phocoena phocoena* in Swedish waters. *Abstract, European Cetacean Society, Ann. Conf.*, 4th, p. 42.

Bigg, M. A. (1984). Canada (British Columbia) progress report on cetacean research, June 1983–March 1984. International Whaling Commission, Cambridge (unpublished report).

Bjørge, A. & Øien, N. (1990). Distribution and abundance of harbour porpoise *Phocoena phocoena* in Norwegian waters. *IWC Sci. Comm. Rep.*, SC/42/SM3.

Bouchet, G. C. (1981). Estimation of the abundance of Dall's porpoise *Phocoenoides dalli* in the North Pacific Ocean and Bering Sea. *NWAFC Proc. Rep.*, **81–1**.

Boyer, P. T. T. & Silber, G. K. (1990). Estimate of vaquita *Phocoena sinus* mortality in gillnet fisheries in the northern Gulf of California, Mexico. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract)*.

Brownell, R. L., Jr (1964). Observations of odontocetes in central Californian waters. *Norsk Hval-Tid.*, **3**, 60–6.

Brownell, R. L., Jr (1982). Status of the cochito *Phocoena sinus* in the Gulf of California. In *Mammals in the seas, Vol. 4: Small cetaceans and sirenians. FAO Fish. Ser.*, **5**, 85–90.

Brownell, R. L., Jr (1988). The vaquita: can it be saved? *Endang. Spec. Tech. Bull.*, **13**(2), 7–8.

Brownell, R. L., Jr & Praderi, R. (1976). Status of the Burmeister's porpoise *Phocoena spinipinnis* in southern South American waters. *FAO ACMRR/MM/SC/20 (Rev. 1)*.

Brownell, R. L., Jr & Praderi, R. (1982). Status of Burmeister's porpoise *Phocoena spinipinnis* in southern South American waters. In *Mammals in the seas, Vol. 4: Small cetaceans and sirenians. FAO Fish. Ser.*, **5**, 91–6.

Brownell, R. L., Jr & Praderi, R. (1984). *Phocoena spinipinnis. Mammal. Spec.*, **217**, 1–4.

Brownell, R. L., Jr, Findley, L. T., Vidal, O., Robles, A. & Manzanilla, N. S. (1987). External morphology and pigmentation of the vaquita *Phocoena sinus* (Cetacea: Mammalia). *Mar. Mammal Sci.*, **3**, 22–30.

Brownell, R. L., Jr, Heyning, J. E. & Perrin, W. F. (1989). A porpoise, *Australophocaena dioptrica*, previously identified as *Phocoena spinipinnis*, from Heard Island. *Mar. Mammal. Sci.*, **5**, 193–5.

Cadenat, J. (1949). Notes sur les cétacés observés sur les cotes du Sénégal de 1941 à 1948. *Bull. l'Inst. Franc. d'Afriq. Noire*, **11**, 1–15 (In French).

Calambokidis, J. & Barlow, J. (1991). Chlorinated hydrocarbon concentrations and their use for describing population discreteness in harbor porpoises from Washington, Oregon, and California. In *Marine Mammal Strandings in the United States*, ed. J. E. Reynolds III & D. K. Odell. *NOAA Tech. Rep.*, NMFS 98, pp. 101–10.

Celikkale, M. S., Karacam, H., Düzgünes, E., Ünsal, S. & Durukanoglu, H. F. (1989). Size and distribution of dolphin populations in the Black Sea. *Doga tu J. Zoology*, **13**, 189–96.

Christensen, O. & Lear, W. H. (1977). Bycatches in salmon drift-nets at West Greenland in 1972. *Meddelelser om Grønland*, **205**, 1–38.

Clarke, R. (1962). Whale observations and whale marking off the coast of Chile in 1958 and from Ecuador towards and beyond the Galapagos Islands in 1959. *Norsk Hval.-Tid.*, **7**, 265–87.

Clarke, R., Aguayo, L. A. & Basulto del Campo, S. (1978). Whale observation and whale marking off the coast of Chile in 1964. *Sci. Rep. Whales Res. Inst.*, **30** 117–77.

Clausen, B. & Andersen, S. (1988). Evaluation of bycatch and health status of the harbour porpoise *Phocoena phocoena* in Danish waters. *Dan. Rev. Game Biol.*, **13**, 1–20.

Coe, J. M., Holts, D. B. & Butler, R. W. (1985). The 'tuna-porpoise' problem: NMFS dolphin mortality reduction research, 1970–81. *Mar. Fish. Rev.*, **46**(3), 18–33.

Corcuera, J., Crespo, E. A., Aquilar, A. & Raga, J. A. (1990). Interactions between marine mammals and coastal fisheries of Neocochea and Claromeco (Buenos Aires Province, Argentina). *Paper presented at the IWC Symposium on Mortality of Ceteaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract)*.

Cowan, I. M. (1988). The marine mammals of British Columbia, their status and distribution. In *The wildlife of northern British Columbia—Past, present and future*, ed. R. J. Fox. Spatsizi Association for Biological Research, Smithers, BC, pp. 95–104.

Crespo, E. A. & Corcuera, J. F. (in press). Interactions between marine mammals and fisheries in some fishing areas of the coast of Argentina and Uruguay. *Rep. int. Whal. Commn* (Special Issue).

Dawson, S. M. (1991). Modifying gillnets to reduce entanglements of cetaceans. *Mar. Mammal Sci.*, **7**, 274–82.

Diamond, S. L. & Hanan, D. A. (1986). An estimate of harbor porpoise mortality in California set net fisheries 1 April, 1983 through 31 March 1984. *SWFC Admin. Rep.*, SWR-86-15.

Duguy, R. & Hussenot, E. (1982). Occasional captures of delphinids in the Northeast Atlantic. *Rep. int. Whal. Commn*, **32**, 461–2.

Evans, P. G. H. (1980). Cetaceans in British waters. *Mammal Rev.*, **10**. 1–52.

Evans, P. G. H. & Scanlan, G. (1989). Historical status changes of cetaceans in British and Irish waters. In *European research on Cetecean—3*, ed. P. G. H. Evans & C. Smeenk. European Cetacean Society, La Rochelle, pp. 51–5.

Everitt, R. D., Fiscus, C. H. & DeLong, R. L. (1979). Marine mammals of Northern Puget Sound and the Strait of Juan de Fuca: a report on investigations 1 November 1977–31 October 1978. *NOAA Tech. Memo.* ERL MESA-41.

Everitt, R. D., Fiscus, C. H. & DeLong, R. L. (1980). Northern Puget Sound marine mammals. *Interagency Energy/Environment R&D Rep.* EPA-600/7-80-139.

Flaherty, C. & Stark, S. (1982). Harbor porpoise *Phocoena phocoena* assessment in 'Washington Sound'. Final report submitted to US National Marine Fisheries Service, National Marine Mammal Lab, Seattle, WA.

Fontaine, P.-M., Barrette, C., Hammill, M. O. & Kingsley, M. C. S. (1990). Incidental take of harbour porpoise *Phocoena phocoena* in the Gulf of St-Lawrence and the St-Lawrence River Estuary, Quebec, Canada. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract).*

Frost, K. J. & Lowry, L. F. (1988). Marine mammals. In *The environment and resources of the southeastern Chukchi Sea: A review of the scientific literature*, ed. M. J. Hameedi & A. S. Naidu. NOAA and University of Alaska, Fairbanks, Alaska, pp. 85–101.

Frost, J. K., Lowry, L. F. & Burns, J. J. (1983). Distribution of marine mammals in the coastal zone of the eastern Chukchi Sea during summer and autumn. *Final Rep. Outer Cont. Shelf Environ. Asses. Prog.*, **20**, 563–650 (not seen, cited in Szczpaniak & Webber, 1985).

Gaskin, D. E. (1984) The harbour porpoise *Phocoena phocoena* (L.): regional populations, status, and information on direct and indirect catches. *Rep. int. Whal. Commn*, **34**, 569–86.

Gaskin, D. E. (1992). The status of the harbour porpoise *Phocoena phocoena* in Canada. *Can. Field.-Nat.*, **106**, 36–54.

Gaskin, D. E., Read, A. J., Watts, P. F. & Smith, G. J. D. (1985). Population dispersal, size, and interactions of harbour porpoises in the Bay of Fundy and Gulf of Maine. *Can. Tech. Rep. Fish. Aquat. Sci.*, **1291**.

Gearin, P. J., Mellin, S. R., DeLong, R. L. & Kajimura, H. (1990). Harbor porpoise interactions with the Makah chinook salmon set net fishery in Washingon State. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract).*

Gilbert, J. R. & Wynne, K. M. (1987). Marine mammal interactions with New England gillnet fisheries. Final report contract NA-84-EA-C-0070.

Goodall, R. N. P. (1978). Report on the small cetaceans stranded on the coasts of Tierra del Fuego. *Sci. Rep. Whales Res. Inst.*, **30**, 197–230.

Goodall, R. N. P. (in press). Notes on the biology of the spectacled porpoise *Australophocaena dioptrica. Rep. int. Whal. Commn (Special Issue).*

Goodall, R. N. P. & Cameron, I. S. (1980). Exploitation of small cetaceans off southern South America. *Rep. int. Whal. Commn*, **30**, 445–50.

Goodall, R. N. P., Galeazzi, A. R. & Lichter, A. A. (1988). Exploitation of small cetaceans off Argentina, 1979–1986. *Rep. int. Whal. Commn*, **38**, 407–10.

Goodall, R. N. P., Sciavini, A. C. M. & Fermani, C. (in press). Net fisheries and net mortality of small cetaceans off Tierra del Fuego, Argentina. *Rep. int. Whal. Commn* (Special Issue).

Greenpeace (1989). Status and threats to small cetaceanss around the UK and Ireland: work of the Rubicon 1987/88 (unpublished report (not seen, cited by P. G. H. Evans, pers. comm.)).

Hall, E. R. & Bee, J. W. (1954). Occurrence of the harbor porpoise at Point Barrow, Alaska. *J. Mammal.*, **35**, 122–3.

Hall, J. D. (1981). Aspects of the natural history of cetaceans of Prince William Sound, Alaska. PhD thesis, University of California, Santa Cruz.

Hanan, D. A. & Diamond, S. L. (1989). Estimates of sea lion, harbor seal, and harbor porpoise mortalities in California set net fisheries for the 1986–87 fishing year. Final report submitted to National Marine Fisheries Service, Southwest Fisheries Science Center, La Jolla, CA.

Hanan, D. A., Diamond, S. L. & Scholl, J. P. (1986). An estimate of harbor porpoise mortality in California set net fisheries 1 April 1984 through 31 March 1985. *SWFC Admin. Rep.* SWR-86-16.

Hanan, D. A., Diamond, S. L. & Scholl, J. P. (1987). An estimate of harbor porpoise mortalities in California set net fisheries 1 April 1985 through 31 March 1986. *SWFC Admin. Rep.* SWR-87-5.

Hardin, G. (1968). The tragedy of the commons. *Science, N.Y.*, **162**, 1243–8.

Heide-Jørgensen, M. P. & Leatherwood, S. (1987). Cetaceans of North and West Greenland. Report of a reconnaissance expedition August–September 1987. *Sea World Res. Inst./Hubbs Mar. Res. Cent. Tech. Rep.*, **87–206**.

Holt, R. S., Gerrodette, T. & Cologne, J. H. (1987). Research vessel survey design for monitoring dolphin abundance in the eastern tropical Pacific. *Fish. Bull., U.S.*, **85**, 435–46.

Houck, W. J. & Jefferson, T. A. (in press). Dall's and True's porpoise *Phocoenoides dalli* (True, 1885). In *Handbook of marine mammals, Volume 6: The Second Book of Dolphins and Porpoises*, ed. S. H. Ridgway & R. Harrison. Academic Press, London.

Iceland (1984). Progress report on cetacean research, June 1982 to May 1983. *Rep. int. Whal. Comm*, **34**, 199–201.

International North Pacific Fisheries Commission (INPFC) (1989). Research by Japan. *International North Pacific Fisheries Commission Annual Report, 1988.*

International North Pacific Fisheries Commission (INPFC) (1990). Final report of squid and bycatch observations in the Japanese driftnet fishery for neon flying squid *Ommastrephes bartrami* June–December, 1989 observer program. Joint report by National Sections of Canada, Japan, and the United States.

International North Pacific Fisheries Commission (INPFC) (1991). Final report of 1990 observations of the Japanese high seas squid driftnet fishery in the North Pacific Ocean. Joint report by National Sections of Canada, Japan, and the United States.

International Whaling Commission (IWC) (1991). Annex G. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn*, **41**, 172–90.

International Whaling Commission (IWC) (1992). Annex G. Report of the sub-committee on small cetaceans. *Rep. int. Whal. Commn*, **42**, 178–232.

International Whaling Commission (IWC) (in press). Report of the workshop on mortality of cetaceans in passive fishing nets and traps. *Rep. int. Whal. Commn*, (Special Issue).

Jamieson, G. S. & Heritage, G. D. (1988). Experimental flying squid fishery off British Columbia, 1987. *Can. Indust. Rep. Fish. Aquat. Sci.*, **186**.

Jefferson, T. A. (1987). A study of the behavior of Dall's porpoise *Phocoenoides dalli* in the Johnstone Strait, British Columbia. *Can. J. Zool.*, **65**, 736–44.

Jefferson, T. A. (1988). *Phocoenoides dalli. Mammal Spec.*, **319**, 1–7.

Jefferson, T. A., Curry, B. E. & Black, N. A. (in press). Harbor porpoise mortality in the Monterey Bay halibut gillnet fishery, 1989. *Rep. int. Whal. Commn* (Special Issue).

Jones, L. L. (1984). Incidental take of the Dall's porpoise and the harbor porpoise by Japanese salmon driftnet fisheries in the western North Pacific. *Rep. int. Whal. Commn*, **34**, 531–8.

Jones, L. L. (1990). Incidental takes of Dall's porpoise in high seas gillnet fisheries. *IWC Sci. Comm. Rep.* SC/42/SM12.

Jones, L. L., Bouchet, G. C. & Turnock, B. J. (1987). Comprehensive report on the incidental take, biology and status of Dall's porpoise. *Int. North Pac. Fish. Commn* Doc. 3156.

Jones, L. L., Dahlberg, M. & Fitzgerald, S. (in press). High seas driftnet fisheries of the North Pacific Ocean. *Rep. int. Whal. Commn* (Special Issue).

Jones, S. (1975). Dolphins and porpoises caught in seines along the coast of India. FAO ACMRR/MM/EC/17 (unpublished report).

Kapel, F. O. (1977). Catch of belugas, narwhals and harbour porpoises in Greenland, 1954–75, by year, month, and region. *Rep. int. Whal. Commn*, **27**, 507–20.

Kapel, F. O. (1984). Revised statistical data on the catch of harbour porpoise *Phocoena phocoena* in Greenland. *Rep. int. Whal. Commn*, **34**, 746 (abstract).

Kasuya, T. (1982). Preliminary report of the biology, catch and populations of *Phocoenoides* in the western North Pacific. In *Mammals in the seas, Vol. 4: Small cetaceans and sirenians. FAO Fish. Ser.*, **5**, 3–19.

Kasuya, T. & Kureha, K. (1979). The population of finless porpoise in the inland Sea of Japan. *Sci. Rep. Whales Res. Inst.*, **31**, 1–44.

Kayes, R. J. (1985). The decline of porpoises and dolphins in the southern North Sea: a current status report. Greenpeace International, Oxford (unpublished report).

Kinze, C. C. (1985). Intraspecific variation in Baltic and North Sea harbour porpoises *Phocoena phocoena* (L., 1758). *Vidensk. Medd. fra. Dansk naturh. Foren*, **146**, 63–74.

Kinze, C. C. (1990). Incidental catches of harbour porpoises *Phocoena phocoena* in Danish waters 1986–89: recent data and behavioural implications. *IWC Sci. Comm. Rep.*, SC/42/SM51.

Kinze, C. C. (in press). Cetacean mormality in passive fishing nets and traps in the Baltic Sea: a review. *Rep. int. Whal. Commn* (Special Issue).

Klinowska, M. (1991). *Dolphins, porpoises and whales of the world: The IUCN Red Data Book.* IUCN, Gland, Switzerland and Cambridge, UK.

Kraus, S. D. (1990). Fishery entanglements of marine mammals in the Gulf of Maine, 1975–1990. In *The resources and uses of Stellwagen Bank, Part II: Proceedings of the Stellwagen Bank Conference*, ed. J. H. Archer. Center for Marine Conservation, Washington, DC, pp. 107–111.

Kremer, H. & Schultze, G. (1990). A review of cetaceans in German waters. *IWC Sci. Comm. Rep.*, SC/42/SM26.

Langelier, K. M., Stacey, P. J. & Baird, R. W. (1990). Stranded whale and dolphin program of BC—1989 report. *Wildl. Vet. Rep.*, **3**, 10–11.

Larsen, B. H. (1990). Harbour porpoise *Phocoena phocoena* around the Faroe Islands. *IWC Sci. Comm. Rep.*, SC/42/SM52.

Laurin, J. (1976). Preliminary study of the distribution, hunting and incidental catch of harbour porpoise *Phocoena phocoena* L. in the Gulf and Estuary of the St Lawrence. *FAO Rep.*, ACMRR/MM/SC/93.

Lear, W. H. & Christensen, O. (1975). By-catches of harbour porpoise *Phocoena phocoena* in salmon driftnets at West Greenland in 1972. *J. Fish. Res. Bd Can.*, **32**, 1223–8.

Leatherwood, S. & Reeves, R. R. (1983). *The Sierra Club handbook of whales and dolphins.* Sierra Club Books, San Francisco, California.

Lennert, C., Kruse, S. & Beeson, M. (1991). Preliminary report on incidental marine mammal bycatch in California gillnet fisheries. *IWC Sci. Comm. Rep.*, SC/43/03.

Lien, J. (1987). Incidental catches of harbour porpoise *Phocoena phocoena* in Newfoundland. CAFSACWP/87/168, 6 pp. (not seen, cited in Lien *et al.*, 1989).

Lien, J., Stenson, G. B. & Ni, I. H. (1989). A review of incidental entrapment of seabirds, seals, and whales in inshore fishing gear in Newfoundland and Labrador: a problem for fishermen and fishing gear designers. In *Proceedings of the World Symposium on Fishing Vessel and Fishing Gear Design*, ed. J. Huntington. Marine Institute, St Johns, Newfoundland, pp. 67–71.

Lindroth, A. (1962). Baltic salmon fluctuations, 2. Porpoise and salmon. *Inst. Freshwater Res. Rep.*, **44**, 1055–12.

Lindstedt, I. (1990). Mortality of harbour porpoises in the Swedish gill net fishery. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract).*

Lindstedt, I. (1991). Harbour porpoises found dead in Sweden 1988–1990. *European Cetacean Soc. Ann. Conf*, 5th (abstract).

Lindstedt, I. & Lindstedt, M. (1989). Incidental catch of harbour porpoises *Phocoena phocoena* in Swedish waters in the years 1973–1988. In *European research on Cetacean*—3, ed. P. G. H. Evans & C. Smeenk. European Cetacean Society, La Rochelle, pp. 96–8.

Maigret, J. (in press). Relationship between marine mammals and the fisheries on the West African coasts. *Rep. int. Whal. Commn* (Special Issue).

Matkin, C. O. & Fay, F. H. (1980). Marine mammal–fishery interactions on the Copper River and in Prince William Sound, Alaska, 1978. Final report to the US Mar. Mamm. Commn MMC-78/07.

Mercer, M. C. (1973). Observations on distribution and intraspecific variation in pigmentation patterns of odontocete Cetacea in the western North Atlantic. *J. Fish. Res. Bd Can.*, **30**, 1111–30.

Miller, D. J., Herder, M. J. & Scholl, J. P. (1983). California marine mammal–fishery interaction study, 1979–1981. *SWFC Admin. Rep.*, LJ-83-13C.

Mitchell, E. (1975). Porpoise, dolphin and small whale fisheries of the world: status and problems. *IUCN Monogr.*, **3**

Miyashita, T. (1991). Stocks and abundance of Dall's porpoise in the Okhotsk Sea and adjacent waters. *IWC Sci. Comm. Rep.*, SC/43/SM7.

Miyashita, T. & Kasuya, T. (1988). Distribution and abundance of Dall's porpoises off Japan. *Sci. Rep. Whales Res. Inst.*, **39**, 121–50.

Miyazaki, N. (1980). Catch records of cetaceans off the coast of the Kii Peninsula. *Mem. Natn. Sci. Mus.*, **13**, 69–82.

Miyazaki, N. (1983). Catch statistics of small cetaceans taken in Japanese waters. *Rep. int. Whal. Commn*, **33**, 621–31.

Miyazaki, N., Amano, M. & Fujise, Y. (1987). Growth and skull morphology of the harbour porpoises in the Japanese waters. *Mem. Natn. Sci. Mus.*, **20**. 137–46.

Mizue, K. & Yoshida., K. (1965). On the porpoises caught by the salmon fishing gill-net in Bering Sea and the North Pacific Ocean. *Bull. Fac. Fish., Nagasaki Univ.*, **19**, 1–36 (in Japanese with English summary).

Mizue, K., Yoshida, K. & Takemura, A. (1966). On the ecology of the Dall's porpoise in Bering Sea and the North Pacific Ocean. *Bull. Fac. Fish., Nagasaki Univ.*, **21**, 1–21 (in Japanese with English summary).

Mohan, R. S. Lal. (1985). Observations on the by-catch of dolphins *Stenella longirostris, Tursiops aduncus, Sousa chinensis,*

and *Delphinus delphis tropicalis* in the gill nets off Calicut coast, India. *Proc. Symp. Endangered Mar. Anim. Mar. Parks*, **1**, 78–83.

Mohan, R. S. Lal. (in press). A review of the mortality of cetaceans in gill nets and the gill net fisheries of the North-eastern Indian Ocean region. *Rep. int. Whal. Commn* (Special Issue).

Møhl-Hansen, U. (1954). Investigations on reproduction and growth of the porpoise *Phocaena phocaena* (L.) from the Baltic. *Vidensk. Medd. fra. Dansk naturh. Foren*, **116**, 369–96.

Nedelec, C. & Prado, J. (1990). Definition and classification of fishing gear categories. *FAO Fish. Tech. Pap.*, **222**(Rev. 1).

Niazi, M. S. & Moazzam, M. (1990). Fisheries and cetacean mortality along the coast of Pakistan. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract)*.

Norris, K. S. & Prescott, J. H. (1961). Observations on Pacific cetaceans of Californian and Mexican waters. *Univ. Calif. Publs Zool.*, **63**, 291–402.

Northridge, S. (1988). Marine mammals and fisheries: a study of conflicts with fishing gear in British waters. Wildlife Link's Seals Group, London (unpublished report).

Northridge, S. (1991*a*). Driftnet fisheries and their impacts on non-target species: a worldwide review. *FAO Fish. Tech. Pap.*, **320**.

Northridge, S. (1991*b*). An updated review of interactions between marine mammals and fisheries. *FAO Fish. Tech. Pap.*, **251** (Suppl. 1).

Northridge, S. & Lankester, K. (1990). Sightings of the harbour porpoise in the North Sea with some notes on interactions with fisheries. *IWC Sci. Comm. Rep.*, SC/42/SM46.

Northridge, S. & Pilleri, G. (1986). A review of human impact on small cetaceans. *Invest. Cet.*, **18**, 221–61.

Ohsumi, S. (1975). Incidental catch of cetaceans with salmon gillnet. *J. Fish. Res. Bd Can.*, **32**, 1229–35.

Otterlind, G. (1976). The harbour porpoise *Phocoena phocoena* endangered in Swedish waters. *Int. Counc. Explor. Sea Rep.*, C.M. 1976/N:16.

Payne, P. M., Power, G. & Yustin, C. T. (1990). Interactions between the New England sink-gillnet fishery and the harbor porpoise *Phocoena phocoena. IWC Sci. Comm. Rep.*, SC/090/G41.

Perrin, W. F. (compiler) (1989). *Dolphins, porpoises, and whales: An action plan for the conservation of biological diversity: 1988–1992*. IUCN, Gland, Switzerland.

Piatt, J. F. & Nettleship, D. N. (1987). Incidental catch of marine birds and mammals in fishing nets off Newfoundland, Canada. *Mar. Pollut. Bull.*, **18**, 344–9.

Pike, G. C. & MacAskie, I. B. (1969). Marine mammals of British Columbia. *Fish. Res. Bd Can., Bull.*, **171**.

Pilleri, G. & Gihr, M. (1972*a*). Burmeister's porpoise *Phocoena spinipinnis* Burmeister, 1865, off the Punta del Diablo, Uruguay. *Invest. Cet.*, **4**, 163–72.

Pilleri, G. & Gihr, M. (1972*b*). Contribution to the knowledge of the cetaceans of Pakistan, with particular reference to the genera *Neomeris, Sousa, Delphinus*, and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaeorientalis*). *Invest. Cet.*, **4**, 107–62.

Pilleri, G. & Gihr, M. (1974). Second record of Burmeister's porpoise *Phocoena spinipinnis* off Los Cerros, Uruguay. *Invest. Cet.*, **5**, 151–3.

Pinedo, M. C. (1989). Primero registro de *Phocoena spinipinnis* (Cetacea, Phocoenidae) para o litoral do Rio Grande do Sul, Brasil, com medidas osteologicas e analise do conteudo estomacal. *Atlantica, Rio Grande*, **11**, 85–99 (in Spanish).

Polacheck, T. (1989). Harbor porpoises and the gillnet fishery. *Oceanus*, **32**, 63–70.

Polacheck, T. & Wenzel, F. W. (1990). What do stranding data say about harbor porpoise *Phocoena phocoena? IWC Sci. Comm. Rep.*, SC/42/SM39.

Praderi, R. (1990). Mortality of dolphins in shark gillnets fisheries off Uruguay. *IWC Sci. Comm. Rep.*, SC/090/G1.

Prescott J. H. & Fiorelli, P. M. (1980). Review of the harbor porpoise *Phocoena phocoena* in the US Northwest Atlantic. Final report to the US Mar. Mamm. Comm, MMC-78/08, 58 pp.

Rae, B. B. (1965). The food of the common porpoise *Phocoena phocoena. J. Zool.*, **146**, 114–22.

Rae, B. B. (1973). Additional notes on the food of the common porpoise *Phocoena phocoena. J. Zool.*, **169**, 127–31.

Read, A. J. (in press). Gill net and trap fisheries in the northwest Atlantic. *Rep. int. Whal. Commn* (Special Issue).

Read, A. J. & Gaskin, D. E. (1988). Incidental catch of harbor porpoises by gill nets. *J. Wildl. Manage.*, **52**, 517–23.

Read, A. J. & Gaskin, D. E. (1990*a*). The effects of incidental catches on harbour porpoises *Phocoena phocoena* in the Bay of Fundy and Gulf of Maine. *IWC Sci. Comm. Rep.*, SC/42/SM21.

Read, A. J. & Gaskin, D. E. (1990*b*). Changes in growth and reproduction of harbour porpoise *Phocoena phocoena* from the Bay of Fundy. *Can. J. Fish. Aquat. Sci.*, **47**, 2158–63.

Read, A. J., Kraus, S. D., Bisack, K. D. & Palka, D. (1993). Harbour porpoises and gill nets in the Gulf of Maine. *Conserv. Biol.*, **7**, 189–93.

Read, A. J., Van Waerebeek, K., Reyes, J. C., McKinnon, J. S. & Lehman, L. C. (1988). The exploitation of small cetaceans in coastal Peru. *Biol. Conserv.*, **46**, 53–70.

Reyes, J. C. & Oporto, J. A. (in press). Gillnet fisheries and cetaceans in the southeast Pacific. *Rep. int. Whal. Commn* (Special Issue).

Robles, A., Vidal, O. & Findley, L. T. (1987). La totaoba y la vaquita. *Info. Cientif. Technol.*, **9**(124), 4–6 (in Spanish).

Ropelewski, A. (1957). The common porpoise *Phocaena phocaena* L. as a by-catch in Polish Baltic fisheries. *Prace Morskiego Instytutu Rybackiego*, **9**, 427–37 (translated from Polish).

Scheffer, V. B. & Slipp, J. W. (1948). The whales and dolphins of Washington State with a key to the cetaceans of the west coast of North America. *Amer. Midl. Nat.*, **39**, 257–337.

Sequeira, M. L. & Ferreira, C. (in press). Coastal fisheries and cetacean mortality in Portugal. *Rep. int. Whal. Commn* (Special Issue).

Shirakihara, M., Shirakihara, K. & Takemura, A. (1992). Records of the finless porpoise *Neophocaena phocaenoides* in the waters adjacent to Kanmon Pass, Japan. *Mar. Mammal Sci.*, **8**, 82–5.

Silber, G. K. (1990*a*). Distributional relations of cetaceans in the northern Gulf of California, with special reference to the vaquita *Phocoena sinus*. PhD thesis, University of California, Santa Cruz.

Silber, G. K. (1990*b*). Occurrence and distribution of the vaquita *Phocoena sinus* in the northern Gulf of California. *Fish. Bull., U.S.*, **88**, 339–46.

Skora, K. E., Pawliczka, I. & Klinowska, M. (1988). Observations on the harbour porpoise *Phocoena phocoena* on the Polish Baltic coast. *Aquat. Mammal.*, **14**, 113–19.

Skora, K. E. (1991). Notes on cetacea observed in the Polish Baltic Sea: 1979–1990. *Aquat. Mammal.*, **17**, 67–70.

Smeenk, C. (1987). The harbour porpoise *Phocoena phocoena* (L., 1758) in the Netherlands: stranding records and decline. *Lutra*, **30**, 77–90.

Smith, G. J. D., Read, A. J. & Gaskin, D. E. (1983). Incidental catch of harbour porpoise *Phocoena phocoena* (L.) in herring weirs in Charlotte County, New Brunswick, Canada. *Fish. Bull., U.S.*, **81**, 660–2.

Smith, T. D. (1982). Current understanding of the status of small cetacean populations in the Black Sea. In *Mammals in the seas, Vol. 4: Small cetaceans and sirenians. FAO Fish. Ser.*, **5**, 121–30.

Smith, T. D., Palka, D., Bisack, K. & DiNardo, G. (1991). Preliminary estimates of harbor porpoise abundance and by-catch. *Northeast Fish. Sci. Cent. Ref. Doc.*, 91-04.

Stacey, P. J., Baird, R. W. & Duffus, D. A. (1990). A preliminary evaluation of incidental mortality of small cetaceans, primarily Dall's porpoise *Phocoenoides dalli*, harbour porpoise *Phocoena phocoena*, and Pacific white-sided dolphins *Lagenorhynchus obliquidens*, in inshore fisheries in British Columbia, Canada. *IWC Sci. Comm. Rep.*, SC/42/SM20.

Stenson, G. B. & Reddin, D. G. (1990). Incidental catches of small cetaceans in drift nets during salmon tagging experiments in the Northwest Atlantic. *Paper presented at the IWC Symposium on Mortality of Cetaceans in Passive Fishing Nets and Traps, La Jolla, CA (Abstract)*.

Stick, K. C. & Hreha, L. (1989). Summary of the 1988 Washington/Oregon experimental thresher shark gill net fishery. *St. Wash. Dept. Fish., Prog. Rep.*, **275**.

Szczepaniak, I. D. & Webber, M. A. (1985). Status of the harbor porpoise *Phocoena phocoena* in the eastern North Pacific, with an emphasis on California. Center for Environmental Education, Washington DC, (unpublished report).

Tas'an & Leatherwood, S. (1984). Cetaceans live-captured for Jaya Ancol Oceanarium, Djakarta, 1974–1982. *Rep. int. Whal. Commn*, **34**, 485–9.

Tobayama, T., Inagaki, Y., Ryohno, M. & Hiratsuka, K. (1990). Review of the incidental catches of cetaceans in Japan. *IWC Sci. Comm. Rep.*, SC/090/G36.

Todd, S. & Nelson, D. (in press). Annex F. A review of modifications to the webbing and setting strategies of passive fishing gear to reduce incidental by-catch of cetaceans. *Rep. int. Whal. Commn* (Special Issue).

Torres, N., D., Yañez, V. J. & Cattan, P. E. (1979). Mamiferos marinos de Chile: antecedentes y situacion actual. *Biol. Pesq. Chile*, **11**, 49–81 (in Spanish).

Tsunoda, L. M. (1989). Observation on board a Japanese high-seas squid gillnet vessel in the North Pacific Ocean 1 July–14 August 1986. *NWAFC Proc. Rep.*, 89-02.

Van Waerebeek, K. & Guerra, C., C.G. (1987). Appendix 4. Review of the distribution and status of the Burmeister's porpoise in Chile. Report: cetacean survey in II Region of Chile, August–September 1986. In *Exploitation and biology of small cetaceans in the coastal waters of Peru and northern Chile*, ed. D. E. Gaskin & A. J. Read. UNEP/IUCN Final Report. United Nations Environment Program, Nairobi, pp. 72–96.

Van Waerebeek, K. & Reyes, J. C. (1990). Catch of small cetaceans at Pucusana Port, central Peru, during 1987. *Biol. Conserv.*, **51**, 15–22.

Van Waerebeek, K. & Reyes, J. C. (in press). Interactions between small cetaceans and Peruvian fisheries in 1988–1989 and analysis of trends. *Rep. int. Whal. Commn* (Special Issue).

Verway, J. & Wolff, W. J. (1982) The common or harbour porpoise *Phocoena phocoena*. In *Marine Mammals of the Wadden Sea*, ed. P. J. H. Reijnders & W. J. Wolff. A. A. Balkema, Rotterdam, pp. 51–8.

Vidal, O. (in press). Population biology and exploitation of the vaquita *Phocoena sinus*. *Rep. int. Whal. Commn* (Special Issue).

von Brandt, A. (1984). *Fish catching methods of the world.* Fishing News Books, Farnham, Surrey, England.

Wang Peilie (1979). A survey of medium and small sizes toothed whales in Bohai and Yellow Sea. *Chin. J. Zool.*, **2**, 31–4 (in Chinese).

Woodley, T. H. & Read, A. J. (1991). Potential rates of increase of a harbour porpoise *Phocoena phocoena* population subjected to incidental mortality in commercial fisheries. *Can. J. Fish. Aquat. Sci.*, **48**, 2429–35.

Wynne, K. (1990). Marine mammal interactions with the salmon drift gillnet fishery on the Copper River Delta, Alaska 1988–1989. *Alaska Sea Grant Coll. Prog. Tech. Rep.*, 90-05.

Yablokov, A. V. & Belkovich, V. M. (1968). Cetaceans of the Arctic: prospects for their proper utilization and conservation. *Problems North*, **11**, 199–218 (not seen, cited in Mitchell, 1975).

Yatsu, A., Hiramatsu, K. & Hayase, S. (in press). A review of the Japanese squid driftnet fishery with notes on cetacean bycatch. *Rep. int. Whal. Commn* (Special Issue).

Yurick, D. B. & Gaskin, D. E. (1987). Morphometric and meristic comparisons of skulls of harbour porpoise *Phocoena phocoena* (L.) from the North Atlantic and North Pacific. *Ophelia*, **27**, 53–75.

Zhou Kaiya & Wang Xiaoyan (in press). Brief review of passive fishing gears and incidental catches of small cetaceans in Chinese waters. *Rep. int. Whal. Commn* (Special Issue).