Abstract. – Fishery observers aboard foreign commercial fishing vessels collected information on the incidental catch of marine mammals in the Exclusive Economic Zone (EEZ) off the northeastern United States since March 1977. Observer coverage on foreign vessels was 25–35% during 1977–82, and increased to 58%, 86%, 95%, 98%, 100%, and 100%, respectively, in 1983–88. During 1981–88, observers have covered most joint-venture fishing operations. During 1977–88, observers reported 538 marine mammals captured incidental to direct and joint-venture fishing activities. Eight cetacean species and three unidentified baleen whales were caught, principally in the fisheries for Atlantic mackerel *Scomber scombrus*, and squid *Illex illecebrosus* and *Loligo pealei*. Pilot whales *Globicephala* spp. (297/538) and common dolphins *Delphinus delphis* (203/538) comprised 93% of the catch. Chi-square tests indicate that significant differences in diel rates of capture occurred between the two species. The number of *Globicephala* spp. captured at night (2000–0400 h) in the Atlantic mackerel fishery was significantly less ($\chi^2 = 8.28$, $P<0.03$) than the number caught during day (0800–1600 h) or dawn/dusk (1600–2000 h, 0400–0800 h). The number of *D. delphis* captured during daylight in the *Loligo* squid fishery was significantly less ($\chi^2 = 44.48$, $P < 0.001$) than the number caught at night or dawn/dusk. A minke whale *B. acutorostrata* (released alive) and individuals of two endangered species, a humpback whale *Megaptera novaeangliae* (released alive) and a right whale *Eubalaena glacialis*, were also captured incidental to fishing activity. During December 1986–February 1988, observers collected whole, dead, non-endangered mammals for detailed shoreside examination. Trawl contents at the time of capture and subsequent analysis of mammal stomach contents suggest that *L. pealei* is a major component of the mid-shelf and shelf-edge diet of common dolphins and pilot whales. Further, pilot whales, considered principally as teuthophagous, were observed to selectively feed on mackerel while on the Continental Shelf.

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Incidental Take of Marine Mammals in Foreign Fishery Activities Off the Northeast United States, 1977–88

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Marine mammal/fishery interactions in United States waters have received widespread attention in recent years (Bonner 1982, Fowler 1982, Lowry 1982, Loughlin et al. 1983, Loughlin and Nelson 1986). These interactions, generally involving commercial fisheries (Mate 1980), are of two types: (1) direct or operational, and (2) indirect or ecological (Lowry 1982).

In the shelf waters off the northeastern United States, marine mammal/commercial fishery interactions have been described only for fisheries occurring in nearshore waters (Gilbert and Wynne 1985). These interactions occur in the fixed-gear fisheries for American lobster *Homarus americanus*, the surface-gillnet fishery for Atlantic herring *Clupea harengus* and Atlantic mackerel *Scomber scombrus*, and the groundfish-gillnet fishery for assorted finfish, principally Gadidae and Pleuronectidae. Two principal marine mammals taken incidentally in these fisheries are the harbor porpoise *Phocoena phocoena* and the harbor seal *Phoca vitulina*. The gray seal *Halichoerus grypus* is infrequently captured. These three species are known to feed on fish caught in nets and to become entangled, thereby damaging fishing gear.

Marine mammal/fishery interactions in the deeper, offshore waters off the northeastern United States have not been previously documented. Under the provisions of the United States Marine Mammal Protection Act (MMPA) of 1972 a General Permit system was established by the National Marine Fisheries Service (NMFS) allowing incidental taking of marine mammals in commercial fishing operations. All domestic and foreign fishing vessels were required to have a valid permit on board that established an allowable limit on the number of non-endangered marine mammals that could be taken within a specified fishery (i.e., mackerel, squid). The Magnuson Fishery Conservation and Management Act of 1976 as amended in 1983, (MFCMA, Public Law 94-265) mandated the placement of Fisheries Compliance Inspectors, or observers,

beginning in 1984, on 100% of all foreign fishing vessels operating within the 200-mile outershelf and slope waters off the United States. (This area is further referred to as the Exclusive Economic Zone, or EEZ). Since that time in 1984, reporting of marine mammal takes incidental to foreign fishing activities has been more effectively monitored by species and fishery.

In this paper we summarize the observed incidental take of marine mammals from all foreign fishing activities that operated within the EEZ off the northeastern United States from 1977 to 1988. The incidental take of common dolphins *Delphinus delphis* and of pilot whales *Globicephala* spp.*, the two most frequently caught species, are examined relative to the type of fishery in which they were taken, the nationality involved in the fishery operation, and the time of the incidental take (day versus night). Morphological measurements, sex, and stomach contents for 33 of the common dolphins taken during 1986 and 1988 are also reported in this study. These measurements and records are the first such information taken from any marine mammal specimens recently killed in the waters off the northeastern United States.

Summary of foreign fisheries

Fishing operations

Large-scale foreign fishing activity began off the U.S. east coast in the early 1960s with the arrival of the distant-water fleet (DWF) from Europe and Japan. Initially, the DWF harvested groundfish (Atlantic cod *Gadus morhua*, haddock *Melanogrammus aeglefinus*, hakes, flounders, etc.) and pelagics (Atlantic herring and Atlantic mackerel) (Brown and Halliday 1983). Declining fish stocks, coupled with management measures implemented in the late 1960s, under the auspices of the International Commission for the Northwest Atlantic Fisheries, resulted in the DWF shifting emphasis to "under-utilized" species, such as long-finned squid *Loligo pealei*, short-finned squid *Illex illecebrosus*, and Atlantic butterfish *Peprilus triacanthus*.

The MFCMA, which became effective March 1977, significantly altered DWF activities within the EEZ. Fishing effort was immediately reduced, and the number of foreign vessels operating within the east coast EEZ declined from a high of 161 vessels in 1977 to 26 in 1988. From 1977 through 1982, an average of 120 different foreign vessels per year (range 102–161) operated within the EEZ. In 1982, there were 112 different foreign vessels; 16%, or 18, were Japanese tuna longline vessels operating off the east coast. The Northeast Region Observer Program assumed responsibility for observer coverage of the east coast Japanese tuna longline fishery in 1982. This fishery has been conducted from the Canadian boundary-line south to Florida and, prior to 1982, in the Gulf of Mexico. In 1983, a decrease in the total allowable catch allocated to each foreign country fishing off the east coast resulted in fewer foreign vessels operating within the EEZ. Between 1983 and 1988, the numbers of foreign vessels operating within the EEZ each year were 67, 52, 62, 33, 27, and 26, respectively. Observer coverage (the ratio of observer coverage days to the number of foreign fishing days) ranged from 25 to 35% for the period 1977–82. Coverage increased steadily since 1982, and was maintained at 58%, 86%, 95%, 98%, 100%, and 100% in 1983-1988, respectively.

Since 1977, fourteen nations have been given catch allocations to operate off the east coast within the EEZ. Direct fishing (DWF catching and processing their own catches) was limited to five Outer Continental Shelf locations referred to as fishery windows (Fig. 1) and to specified times of year. From 1977–83, the DWF led by Italy, Spain, and Japan principally targeted long-finned and short-finned squid within these windows. Direct squid fishing operations ceased at the end of the 1986 fishing season.

Joint-venture fishing operations (U.S. captains transfer their catches to foreign processing vessels) began in 1981. Squid joint ventures, which were unrestricted areally, were authorized without any associated direct fishing allocations. In 1983 the German Democratic Republic (GDR), and in 1984 the Netherlands, commenced joint-venture operations for Atlantic mackerel off the east coast. Mackerel joint ventures which have been authorized with associated allocations for direct fishing have not been restricted to the fishery windows. In 1988, Poland also commenced commercial fishing operations for Atlantic mackerel that included joint-venture and direct fishing. Prior to 1988, Poland conducted a research fishery each year between 1981 and 1987 for Atlantic mackerel that involved Polish catching/processing vessels staffed with Polish and U.S. fishery data collectors.

Foreign vessels engaged in *Loligo* and *Illex* squid fishing operations used off-bottom trawls, and did not utilize squid attracting devices, such as lights, during night-time fishing. In the Atlantic mackerel fishery, both off-bottom high-opening trawls and pelagic trawls

*The distribution of the Atlantic pilot whale *Globicephala melaena*, the northern species, overlaps with the short-finned pilot whale *G. macrorhyncha*, mainly a southern species, between about 35°30'N to 38°00'N (Leatherwood et al. 1976). Although, *G. melaena* is the most common and the most likely taken in the DWF foreign fisheries, there is a possibility that the southern species might also be occasionally taken. Therefore, in this paper both pilot whales are considered together.

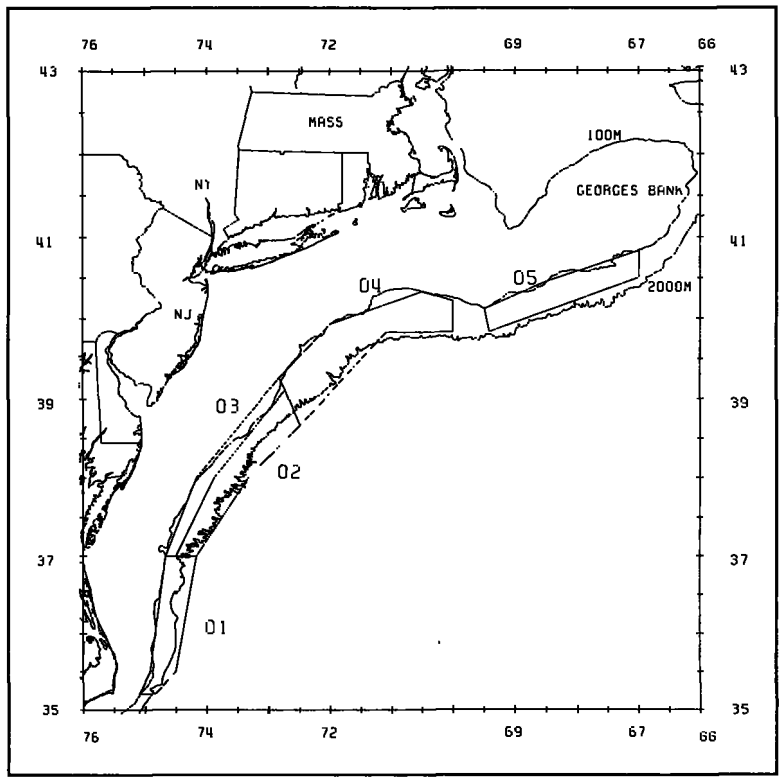

Figure 1
Foreign fishery windows within the EEZ off the northeastern United States.

have been used; currently the DWF utilizes several different pelagic trawls.

Principal target species

Loligo or long-finned squid

Although *Loligo* occurs from the Gulf of Mexico north to New Brunswick, Canada (Summers 1967), the distribution of long-finned squid (hereafter referred to as *Loligo*) is primarily from Cape Hatteras, North Carolina, to Georges Bank and into the Gulf of Maine (Lange 1980). *Loligo* overwinters along the shelf edge from Cape Hatteras to Georges Bank at water temperatures generally >8°C (Lange and Sissenwine 1980). During spring and summer *Loligo* moves into nearshore waters to spawn (Summers 1967). Commercial concentrations are found primarily off southern New England and the mid-Atlantic regions from about Georges Bank to Baltimore Canyon (Lange 1980, Lange and Johnson 1981). DWF fishing prior to the MFCMA occurred at depths of 100–500 m along the shelf edge from November through March (Lange 1980), but since 1977 fishing operations have been restricted in area and season. Since 1987, the allocation for *Loligo* has been reduced strictly to bycatch in the Atlantic mackerel fishery; therefore, DWF *Loligo* fishing has been suspended.

Illex or short-finned squid

The short-finned squid (hereafter referred to as *Illex*) is a more northern species than *Loligo*, ranging from Florida to Newfoundland (Squires 1957). In late autumn (October–December), *Illex* moves offshore toward the shelf edge and beyond (Lange and Sissenwine 1980). Spawning is believed to occur offshore at great depths, primarily from December to March (Lange and Sissenwine 1980). During warmer months *Illex* move nearshore to feed (Lange 1980). Commercial concentrations occur from the mid-Atlantic, near Baltimore Canyon, to Newfoundland (Lange and Johnson 1981). The DWF *Illex* fishery took place from June through October, while this species is on the shelf (Lange 1980). In 1987, *Illex* allocations for DWF fisheries were suspended. At present, there is no direct foreign fishing effort for this species.

Atlantic mackerel

Atlantic mackerel, a major target species of the DWF, overwinter along the edge of the continental shelf between Cape Hatteras and Sable Island, Nova Scotia (Anderson and Paciorkowski 1980). The overwintering population consists of two components (southern and northern), which separate in spring. The southern component moves nearshore in early spring along the

Virginia Capes and proceeds northeastward to spawn off the New Jersey and Long Island coasts from mid-April to early May. By midsummer, the southern component reaches the Gulf of Maine where it remains throughout summer (Anderson and Paciorkowski 1980). Migration out of the Gulf of Maine begins in autumn as the southern component returns to deeper, offshore waters. The northern component migrates further north in spring along the Nova Scotian shelf to the Gulf of St. Lawrence where spawning occurs during June–July (Anderson and Paciorkowski 1980). The northern component begins leaving the Gulf of St. Lawrence in September and returns to the mid-Atlantic region to overwinter.

The seasonal DWF mackerel fishery occurs in the mid-Atlantic region during the winter when both components of the mackerel population concentrate primarily along the shelf edge (Anderson and Paciorkowski 1980), although commercial quantities are sometimes encountered in waters as shallow as 30 m.

Methods and materials

Data collection on incidental take

Observers monitor compliance with applicable fishing regulations, collect biological data and samples, and serve in a liaison role, when needed, between foreign and domestic captains. In the northeast region, observer training is the responsibility of the NMFS Observer Program. Between 1977 and 1985, observers routinely recorded the number of marine mammals taken incidentally in foreign fishing activities. In 1986, a new sampling protocol was implemented to collect additional information on marine mammals, sea turtles, and marine debris. Observers are now required to complete sighting forms, document the circumstances of capture and obtain biological data on incidentally captured marine mammals* and sea turtles. Marine mammal biological sampling includes five straight-line body measurements (e.g., snout to fluke notch, flipper length, flipper width, fluke width, and dorsal fin height), girth at pectorals, sex, and total weight. Additionally, when feasible, incidentally caught marine mammals are frozen whole, brought ashore, and later examined by researchers at the Smithsonian Institution.

Data analysis on incidental take

A paired Mann-Whitney test (Zar 1974) was used to test for differences between the total number of cetaceans killed per day (kill-rate) in the 1984–88 Netherlands and the GDR mackerel fishery. Data for Poland were not included, because that country did not begin commercial fishing until 1988. Because a Mann-Whitney test examines only differences in paired data sets, a Friedman rank sums test (Hollander and Wolfe 1973) was used to examine the kill-rates between Italy, Spain, and Japan in the 1984–86 *Loligo* squid fishery.

Randomly selected samples of 334 trawl logs from the 1985 Atlantic mackerel fishery (from Netherlands) and 1018 trawl logs from the 1985 *Loligo* squid fishery (from Italy) were used to determine the expected level of fishing effort (number of tows) for each of three time periods—Day (0800–1600), Dawn/Dusk (0400–0800 and 1600–2000), and Night (2000–0400)—within each fishery. The Chi-Square Statistic was then used to determine whether there were significant differences in the numbers of common dolphins and pilot whales incidentally taken in each fishery (relative to fishing effort) due to time of day of the take.

Data analysis on stomach contents, sex and total length

A total of 95 common dolphins and 169 pilot whales taken between 1986 and 1988 were measured (total standard length) and sexed at sea. Stomach contents from 33 of the common dolphins were examined by Smithsonian Institution personnel, and the information was provided for this paper. Prior to 1986, stomach contents and sex data were not collected.

Results

Observers reported 538 marine mammals incidentally caught during foreign fishing activities in the EEZ off the northeast United States between March 1977 and December 1988 (Table 1). Pilot whales were the most frequently caught marine mammal with 297 caught, representing 55% of the total marine mammal take between 1977 and 1988 (Table 1). Common dolphins were the next most-frequently-taken cetacean with 203 caught, composing 38% of the total incidental takes. Approximately 5% of the total catch consisted of three other members of the Delphinidae: Atlantic white-sided dolphin *Lagenorhychus acutus*, bottlenose dolphin *Tursiops truncatus*, and Risso's dolphin *Grampus griseus* (Table 1).

Six large whales were reported caught or entangled during fishing operations. One subadult or juvenile right whale *Eubalaena glacialis* (based on observer identification and estimated length of 6 m) and one unidentified baleen whale were taken in the *Loligo* fishery. A humpback *Megaptera novaeangliae*, minke

*In this paper, an incidental take is defined as any live marine mammal or any carcass caught during foreign fishing activity.

Table 1

Summary of incidental take of marine mammals as reported by U.S. fisheries observers on foreign vessels in the shelf and slope waters of the northeastern United States. Values in parantheses represent animals released alive. (jv = joint venture)

Year/ Fishery	Country	Common dolphin	Pilot whale	White-sided dolphin	Bottlenose dolphin	Risso's dolphin	Unid. dolphin	Right whale	Humpback whale	Minke whale	Unid. whale	Total
1977–83												
Illex	Italy		1				2					3
	Japan		1									1
	Mexico		1									1
	Spain		3									3
	USA (jv)		6									6
Loligo	Italy	2	2									4
	Japan	1	3				1					5
	Mexico				1							1
	Spain	1	5					1			1(1)	8(1)
Tuna	Japan		2				1		1(1)		1	5(1)
Hake	USSR		2		1						1	4
Mackerel	Poland	4	13		1							18
Totals		8	39		3		4	1	1(1)		3(1)	59(2)
1984												
Illex	USA (jv)		1									1
Loligo	Italy	3	3	2								8
	Spain		7									7
Tuna	Japan					1						1
Mackerel	GDR		1									1
	Netherlands		11									11
	Poland				1							1
Totals		3	23	2	1	1						30
1985												
Loligo	Italy	56	1			1						58
	Japan	1										1
	Spain	4	4				1					9
Mackerel	GDR		8	3								11
	Netherlands	5	32		3							40
	Poland		1									1
	USA (jv)		1									1
Totals		66	47	3	3	1	1					121
1986												
Loligo	Italy	54	1			1						56
	Spain	1										1
	USA (jv)		2									2
Tuna	Japan									1(1)		1(1)
Mackerel	GDR	4	12(1)									16(1)
	Poland	3	1(1)									4(1)
	USA (jv)	14	4									18
Totals		76	20(2)			1				1(1)		98(3)
1987*												
Illex	Italy					1						1
Mackerel	GDR	11	12(1)									23(1)
	Netherlands	7	11									18
	USA (jv)	1	3									4
Totals		19	26(1)			1						46(1)
1988												
Mackerel	GDR	20	27									47
	Netherlands		50	4	1							55
	Poland	11	58(3)	4	1		1					75(3)
	USA (jv)		7									7
Totals		31	142(3)	8	2		1					184(3)
1977–88 Totals		203	297(6)	13	9	4	6	1	1(1)	1(1)	3(1)	538(10)

*Directed foreign *Loligo* fishing operations ceased in 1986.

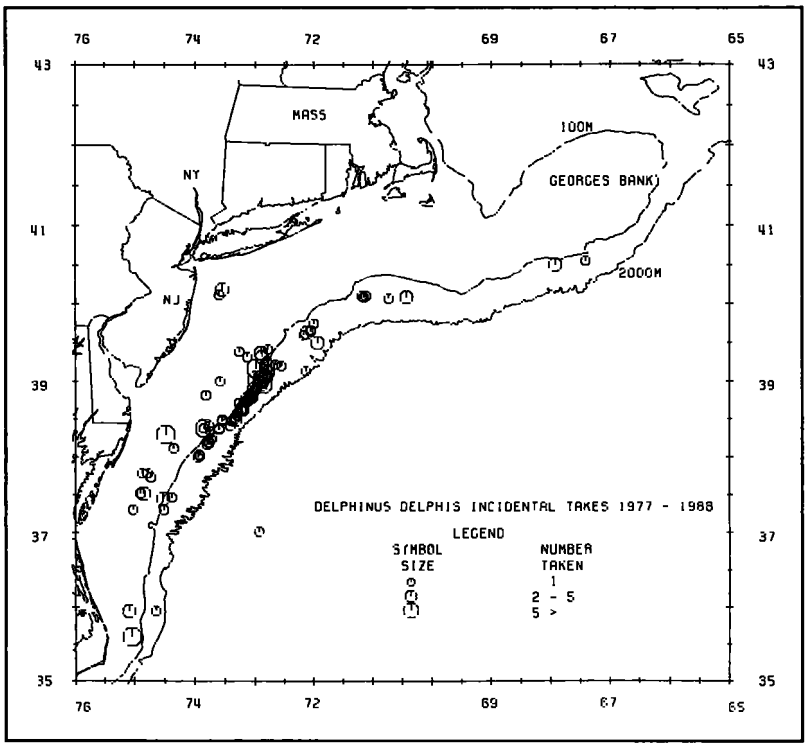

Figure 2
Distribution of incidental takes of common dolphin in foreign fishing activities off the northeastern United States, 1977–88.

Balaenoptera acutorostrata, and an unidentified baleen whale were also reported taken in the tuna longline fishery (Table 1). Another unidentified baleen whale was taken in the hake fishery.

Location of incidental takes of common dolphins and pilot whales

A total of 68% (n = 136) of the common dolphins captured in foreign fishing activities were caught along the shelf edge, represented by the 100-m isobath, between 37°30'N and 40°00'N latitudes (Fig. 2), and 69% (n = 138) of the common dolphins were taken between December and February. Most (n = 152) of the pilot whales captured during foreign fishing activities also occurred along the shelf edge (Fig. 3), and 83% (n = 246) were captured between March and July. Of the total number of pilot whales taken incidentally to fishing, 8% (n = 24) were captured between December and February, as compared with 69% for common dolphins.

Incidental takes by fishery and country

During 1977–83, 54% (32/59) of the incidental bycatch of marine mammals in foreign fishing activities was taken in the *Loligo* and *Illex* fisheries (Table 1). This high percentage is consistent with the distribution of DWF fishing effort during this period. Since 100% observer coverage of most fisheries did not begin until 1984, the number of marine mammals taken during this period is probably under-represented.

***Loligo* and *Illex* fisheries** A total of 61% (n = 123) of the total number of common dolphins taken during 1977–88 (n = 203) were caught in the *Loligo* fishery, and 94% (n = 116/123) of these takes occurred during 1985–86. Again, takes prior to 1984 were probably under-represented. Italian vessels caught 93% of the common dolphins taken in the *Loligo* fishery.

The total number of pilot whales caught in the *Loligo* fishery (n = 28) was 9.4% of the total number of pilot whales taken incidentally to all foreign fishing activities. Of the pilot whales taken in the *Loligo* fishery between 1984–86, 61% (n = 11/18) were taken by Spain.

No common dolphins were taken in the *Illex* fishery; however, 13 pilot whales were taken between 1977 and 1984. Of the pilot whales taken, 46% (n = 6) were caught by U.S. joint-venture vessels.

Atlantic mackerel fishery During 1984–88, 76 common dolphins were taken in the fishery for Atlantic mackerel (Table 1). Of the common dolphins taken in this fishery, 46% (n = 35/76) were caught by GDR vessels, 19% (n = 15) by U.S. joint-venture vessels, 18% (n = 14) by Polish vessels, and 17% (n = 12) by Dutch vessels.

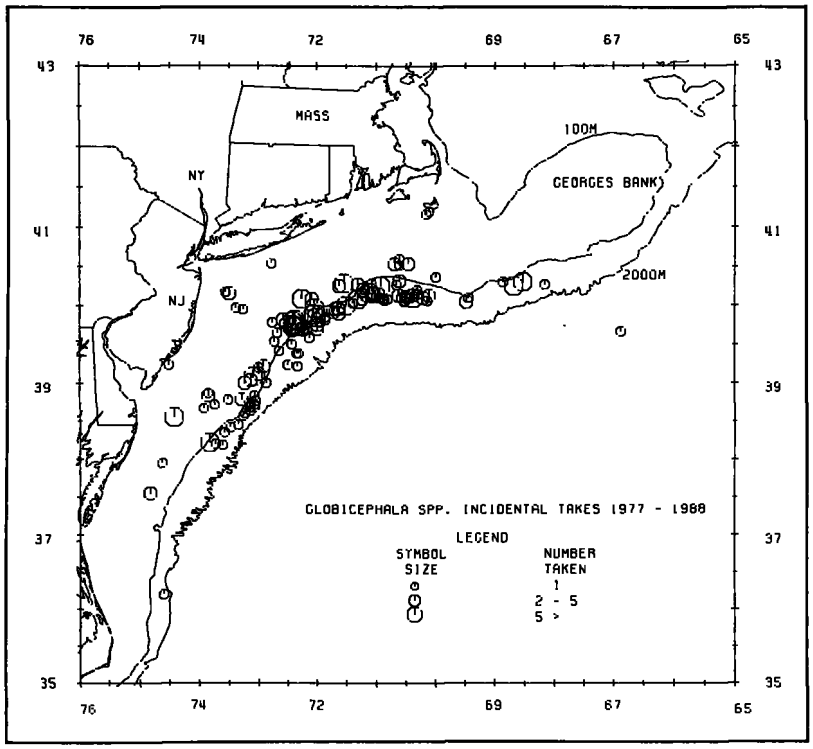

Figure 3
Distribution of incidental takes of pilot whales in foreign fishing activities off the northeastern United States, 1977–88.

Of the DWF fisheries mortality of pilot whales since 1984, 93% occurred in the Atlantic mackerel fishery (Table 1). During 1984–87, the Netherlands and the GDR caught 54 and 33 animals, respectively, which combined represent 90% ($n = 97$) of the pilot whales taken in the mackerel fishery during that 4-year period. In 1988, Poland began commercial fishing for Atlantic mackerel and caught 41% ($n = 58$) of the pilot whales taken that year. Although the Netherlands did not fish in the EEZ during 1986, they still caught 44% (104/239) of the pilot whales taken since 1984 in the Atlantic mackerel fishery.

Summary of kill rates by fishery and country

***Loligo* fishery** The total number of marine mammals (all species) killed per days fished (k/d rate) by Italy in the directed *Loligo* fishery was more than six times that of either Japan or Spain between 1984 and 1986 (period of nearly 100% observer coverage) (Table 2). During the years 1985 and 1986, this rate was approximately 10 times greater than the same rate for Spain, in spite of comparable number of days fished (Table 2). The k/d rates for 1984–86 between the three countries, however, are not significantly different using the Friedman test ($P<0.19$).

Atlantic mackerel fishery The k/d rate in the Atlantic mackerel fishery has varied both over years and among countries (Table 3). Between 1984 and 1988, the average kill rate for the GDR and the Netherlands was 0.12 k/d. The Netherlands annual k/d rates were 4 to 17 times greater than GDR rates, and differences in the k/d rates between these two countries are significant, $P<0.06$. With the inclusion of the 1988 takes by Poland, the all-years (pooled) k/d rate increases to 0.14 (Table 3). The 1988 k/d rates for each country were the highest observed during the 5-year period, 1984–88 (Table 3).

Summary of incidental take by fishery and time of day

***Loligo* fishery** The incidental take of common dolphins during daylight hours (0800–1600) was significantly less ($\chi^2 = 44.48$, 2 df, $P<0.001$) than the number captured during dawn/dusk or the night (Table 4). The number of pilot whales captured in the *Loligo* fishery did differ significantly by time period ($\chi^2 = 1.02$, 2 df) (Table 4).

Atlantic mackerel fishery Similar to the *Loligo* fishery, the number of common dolphins captured during daytime hours was significantly less ($\chi^2 = 20.42$, 2 df, $P<0.001$) than the number caught in tows at other time periods throughout the day (Table 5). The number of pilot whales caught in tows conducted during the night (2000–0400) was significantly less ($\chi^2 = 8.28$, 2 df,

Table 2

Numbers of cetaceans killed and days fished by Italy, Japan, and Spain while *Loligo* squid fishing off the northeastern United States, 1984–86. Numbers do not include animals captured and released alive.

	1984			1985			1986			Total		
	days	kill	k/d	days	kill	k/d	days	kill	k/d	days	kill	k/d
Italy	1000	8	0.01	631	58	0.09	524	56	0.11	2155	122	0.06
Japan	267	0	0	73	1	0.01	26	0	0	366	1	<0.01
Spain	678	7	0.01	936	9	0.01	511	1	<0.01	2125	17	0.01
Total	1945	15	0.01	1640	68	0.04	1061	57	0.05	4646	140	0.03

Table 3

Numbers of cetaceans killed and days fished by German Democratic Republic (GDR), Poland, and Netherlands while Atlantic mackerel fishing off the northeastern United States, 1984–88. Numbers do not include animals captured and released alive.

	1984			1985			1986			1987			1988			Total		
	days	kill	k/d	days	kill	k/d	days	kill	k/d	days	kill	k/d	days	kill	k/d	days	kill	k/d
GDR	166	1	0.01	213	11	0.05	306	15	0.05	415	22	0.05	344	47	0.14	1444	96	0.07
Poland*	—	—	—	—	—	—	—	—	—	—	—	—	306	72	0.24	306	72	0.24
Netherlands	65	11	0.17	131	40	0.31	0	0	0	94	18	0.19	95	55	0.58	385	124	0.32
Total	231	12	0.05	344	51	0.15	306	15	0.05	509	41	0.08	745	173	0.23	2135	292	0.14

*Does not include scientific research.

Table 4

Observed and expected catch by time of day of common dolphins and pilot whales taken in the 1977–86 *Loligo* squid fishery off the northeastern United States.

Time of day*	Observed frequency	Expected frequency	χ^2
Common dolphins			
0800–1600	11	46	26.63
2000–0400	57	35	13.83
0400–0800			
1600–2000	55	42	4.02
$\chi^2 = 44.48$, 2 df			
$P<0.001$			
Pilot whales			
0800–1600	11	9	0.444
2000–0400	5	7	0.571
0400–0800			
1600–2000	9	9	0.000
$\chi^2 = 1.015$, 2 df			
$P<0.6017$, ns			

*Day (0800–1600), night (2000–0400), dawn/dusk (0400–0800, 1600–2000).

Table 5

Observed and expected catch by time of day of common dolphins and pilot whales taken in the 1984–88 Atlantic mackerel fishery off the northeastern United States.

Time of day*	Observed frequency	Expected frequency	χ^2
Common dolphins			
0800–1600	7	25.7	13.610
2000–0400	36	25.7	4.130
0400–0800			
1600–2000	34	25.7	2.680
$\chi^2 = 20.42$, 2 df			
$P<0.001$			
Pilot whales			
0800–1600	91	80	1.510
2000–0400	59	80	5.510
0400–0800			
1600–2000	90	80	1.250
$\chi^2 = 8.28$, 2 df			
$P<0.03$			

*Day (0800–1600), night (2000–0400), dawn/dusk (0400–0800, 1600–2000).

Table 6

Summary of stomach contents of 33 common dolphins killed in foreign fishing activities off the northeastern United States, 1986–88.

TL (cm)	Sex	Stomach content		Fishery
		Weight (kg)	Description	
195	M	1.17	Partial digested squid, few fish bones	Squid
205	M	0.48	Partly digested squid pens and beaks, a few hake otoliths	Squid
194	M	0.27	~50 cc squid beaks and pens, no fish remains	Squid
226	M	3.38	Mostly whole squid and some well-digested fish	Squid
205	M	0.89	1 L digested fish and 8–11 pairs of squid beaks	Squid
180	F	0.19	Squid	Squid
208	M	No data	No data	Squid
190	M	0.99	Squid	Squid
207	M	0.28	Squid	Squid
210	F	Empty		Squid
193	M	2.68	4 intact mackerel, a few squid beaks and pens, and two unknown fish	Mackerel
188	M	0.16	Few fish vertebrae and squid pens and beaks	Mackerel
209	M	2.20	No data	Mackerel
199	M	1.99	3 partially digested mackerel, squid beaks and pens	Mackerel
193	M	0.91	3/4 L fish bones, few small squid beaks	Mackerel
200	M	1.18	1 intact mackerel, 1 partly digested mackerel, no squid parts	Mackerel
202	M	No data	3/4 L fish including 3 whole mackerel and 2 pairs of squid beaks	Mackerel
196	M	2.15	6–7 intact mackerel and some squid beaks	Mackerel
200	M	1.90	1.5 L partially digested fish and 3 pairs of squid beaks	Mackerel
194	F	2.8	6 mackerel, 4 whole squid	Mackerel
188	F	1.34	Mackerel in fore stomach, squid pen in pyloric	Mackerel
203	M	1.81	3 mackerel (33 cm SL) and 2–3 well-digested mackerel	Mackerel
207	M	1.94	Mackerel	Mackerel
208	M	1.34	Mackerel	Mackerel
223	M	4.2	16 mackerel (30 cm SL) in main stomach, trace squid in pyloric	Mackerel
190	F	0.15	Trace squid	Mackerel
198	F	1.86	Squid and 1 mackerel (30 cm)	Mackerel
214	M	3.83	14 mackerel (25–38 cm SL)	Mackerel
216	M	1.21	Mackerel	Mackerel
205	M	3.04	Mackerel	Mackerel
216	M	3.86	7 mackerel (35 cm), and equal volume of digested mackerel	Mackerel
195	F	1.87	No data	Mackerel
204	F	1.99	Mackerel in fore stomach	Mackerel

$P<0.03$) than the number of pilot whales caught during the day or dawn/dusk (Table 5).

Food habits and morphometrics based on examination of animals collected in DWF fisheries

Food habits Stomach contents of 17 common dolphins taken in the mackerel fishery and 10 taken in the *Loligo* fishery reflected the target species of the respective fisheries (Table 6). Nine of the stomachs examined from dolphins taken in the Atlantic mackerel fishery contained only Atlantic mackerel. Eleven of the stomachs contained mixed fish (Atlantic mackerel and/or unidentifiable parts) and squid. One of the stomachs contained only squid. Data were not recorded for two stomachs. Examination of two stomachs taken from pilot whales caught in the Atlantic mackerel fishery contained only Atlantic mackerel.

In comparison, 4 of the 10 stomachs examined from dolphins taken in the *Loligo* fishery contained only unidentifiable squid parts. Four other stomachs contained squid spp. and unidentifiable fish parts. One stomach was empty and data were not reported for one stomach.

Morphometrics The sex ratio of the 95 common dolphins measured at sea during 1986–88 was 52 males, 22 females, and 21 not determined (70.3% male). These animals ranged in size from 150 to 290 cm (Fig. 4). The size range for males was 150–290 cm ($\bar{x}$ 209 cm), 185–260 cm ($\bar{x}$ 202 cm) for females. Of the dolphins measured, 33 were <200 cm in length. This places them in the prepubescent length-category provided by Collett and Saint-Girons (1984).

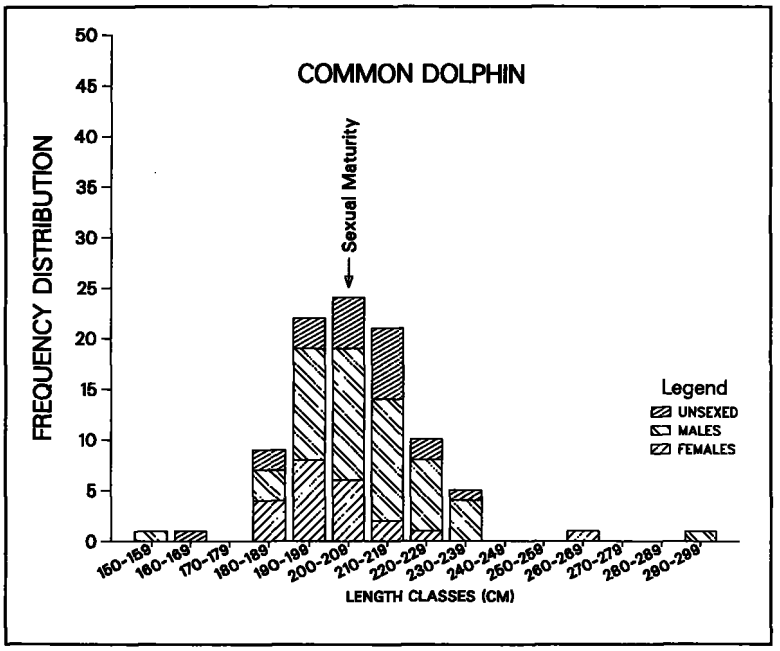

Figure 4
Length distribution of incidentally captured common dolphins measured by observers aboard foreign fishing vessels off the northeastern United States, 1986–88. Size at attainment of sexual maturity is from Perrin and Reilly (1984).

A total of 169 pilot whales measured during 1986–88 included 104 females, 40 males, and 25 not determined (72.2% female). These animals ranged in size from 199 to 510 cm (Fig. 5). Of the females, 85% (n = 88) measured 366–510 cm ($\bar{x}$ 429 cm), which is greater than the average length at attainment of sexual maturity (365 cm) as reported for *G. melaena* in the western North Atlantic by Perrin and Reilly (1984). The size range for the males was 199–470 cm ($\bar{x}$ 325 cm). No males recorded by observers reached the average length at attainment of sexual maturity (490 cm) reported by Perrin and Reilly (1984).

Discussion

Distribution of common dolphins and pilot whales relative to timing and location of take

The location (Figs. 2, 3) and timing of the incidental take (midwinter to late spring) of these two species are directly related to the seasonal distribution of each species. From mid-January to May, the distribution of common dolphins generally extends from Cape Hatteras northeastward to Georges Bank in mid- to outershelf waters (Hain et al. 1981, CETAP 1982, Payne et al. 1984). During mid- to late summer, many common dolphins move northward out of the EEZ onto the Scotian Shelf (Sergeant 1958, Sergeant and Fisher 1957) before returning southward to Georges Bank during late fall and winter. Therefore, the distribution of this species is most restricted during midwinter and early spring in the mid-Atlantic, coincident to the DWF *Loligo* and Atlantic mackerel fisheries.

Likewise, pilot whales are also distributed along the outershelf of the mid-Atlantic and southern New England waters of the EEZ during midwinter and spring (December–May). Throughout spring and early summer, pilot whales move northward along the shelf-edge and by summer–late fall their distribution is most widespread throughout the EEZ (CETAP 1982, Payne et al. 1984). Pilot whales were taken when their distribution was most concentrated along the southern New England shelf-edge in spring.

Incidental take by fishery and country

A large percentage of common dolphins were taken by Italy during *Loligo* squid fishing operations. This occurred despite reduction of Italian allocation and effort (i.e., days fished) in the *Loligo* fishery during 1985 and 1986. The Netherlands took a large percentage of pilot whales in the 1984–88 Atlantic mackerel fishery despite fewer days on grounds than GDR vessels. These takes appear to be more related to differences in fishing strategies (i.e., gear configuration, trawling and haulback speeds) than total effort. Currently there is insufficient information to evaluate the effect of different fishing techniques between countries on the total take or the k/d rates. Increased observer coverage and documentation of fishing activities should be helpful in evaluating and developing recommendations for modifying current fishing practices, resulting in a reduction of incidental marine mammal mortality.

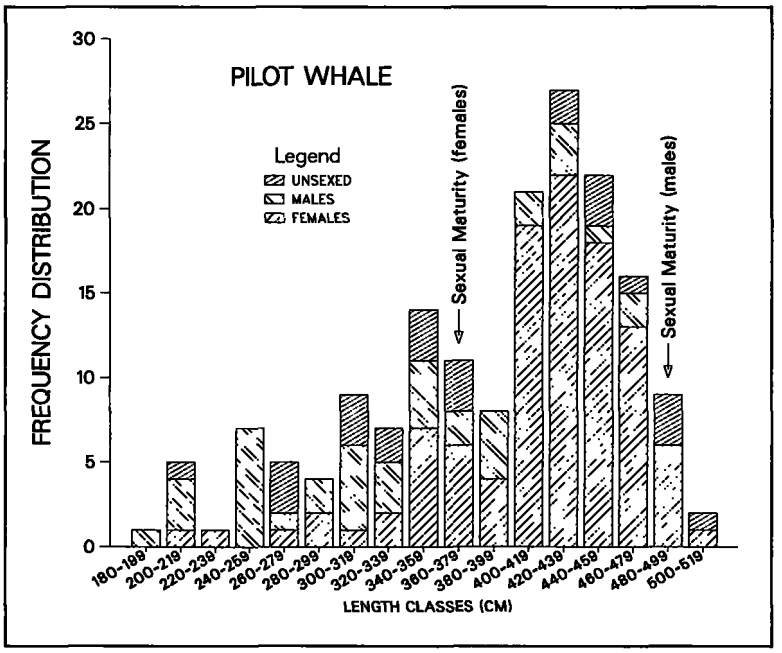

Figure 5
Length distribution of incidentally captured pilot whales measured by observers aboard foreign fishing vessels off the northeastern United States, 1986–88. Size at attainment of sexual maturity is from Perrin and Reilly (1984).

Incidental take of common dolphins and pilot whales relative to time of day and fishery

Significantly more common dolphins were captured during the *Loligo* fishery at night than during other time periods throughout the day. Possibly the diurnal movement upward at night would concentrate *Loligo* nearer the surface, thereby also concentrating common dolphins feeding on this prey. This would result in an increased likelihood of common dolphins capture due to a narrowing of the fishing area within the water column.

If common dolphins follow squids downward during daylight hours, then this would account for the lack of surface-feeding observations during the daytime. Conversely, if common dolphins feed principally at night, then common dolphins might become spatially separated from squid during daylight hours, resulting in a decreased likelihood of incidental capture. Although the reasons that common dolphins are caught at night in the DWF *Loligo* fishery are not readily apparent, it does seem that the day/night differences in capture are also related to a behavioral phenomenon of the dolphins, and not simply fishing practices.

Conversely, the take of pilot whales was significantly greater during daylight hours. Pilot whales were observed on numerous occasions in active pursuit and opportunistically feeding in and around the mouth of the net during haulback operations. Similar observations have been reported for the Pacific bottlenose dolphin and other species in Leatherwood (1975). The large size and widespread opening of pelagic mackerel trawls might serve to corral larger delphinid species such as pilot whales. Current data do not allow conclusive determination of whether the high incidence of pilot whale mortality during daylight hours is behavioral or the result of fishing practices by the Netherlands, GDR, and Poland.

Food habits

Common dolphins have been reported to feed on a wide variety of epipelagic and mesopelagic schooling finfishes and squids (Collett et al. 1981, Fiscus 1982, Fiscus and Niggol 1965, Fitch and Brownell 1968, Jones 1981, Nishiwaki 1972, Norris and Prescott 1961, Major 1986). Prey items collected from stomachs of common dolphins captured in the DWF indicate that *Loligo* and Atlantic mackerel are important prey items for dolphins during midwinter in the shelf waters of the mid-Atlantic.

Information on the dietary habits of pilot whales is limited, but they are considered teuthophagous, feeding principally on squid with fish as an alternative. Atlantic cod and Greenland turbot *Reinhardtius hippoglossoides*, which were taken off Newfoundland by overwintering pilot whales when squid were not available, are the only finfish prey items reported from the northwest Atlantic (Sergeant 1962, Mercer 1975).

We have not examined any stomachs of pilot whales taken in the DWF squid fisheries. However, it seems likely, based on qualitative examination of the relative abundance and co-occurrence of pilot whales and *Loligo* and known preferences for squid from the literature,

that *Loligo* is a principal prey item of pilot whales in the shelf waters of the mid-Atlantic during late winter and early spring. It also seems apparent that Atlantic mackerel could be considered an important prey of pilot whales in the mid-Atlantic. This conclusion is based on the observations of pilot whales feeding around and in the opening of the mackerel trawls, the occurrence of mackerel in the stomachs of two pilot whales taken in the Atlantic mackerel fishery, and the high incidence of mortality in the Atlantic mackerel fishery. It is possible, however, that feeding on Atlantic mackerel is an opportunistic phenomenon related to fisheries only, and that pilot whales do not otherwise prey significantly on mackerel.

Sex and maturity of common dolphins and pilot whales taken in foreign fishing operations

It is likely that most of the common dolphins killed in the *Loligo* and Atlantic mackerel fisheries were sexually immature. Estimates of total length at sexual maturity for male common dolphins are extremely variable between populations (Hui 1979, Perrin and Reilly 1984, Collett and Saint-Girons 1984). Collett and Saint-Girons (1984) found that, in the northeast Atlantic, sexual maturity in male common dolphins is reached at 200 cm, with animals <190 cm prepubescent. Several species of dolphins, including common dolphins, are known to travel in herds segregated by age and sex. In the northwest Atlantic, segregation by age and sex has been found in bottlenose dolphins (Irvine et al. 1981, Shane et al. 1986) and the harbor porpoise (Gaskin 1982). Irvine et al. (1981) found that subadult males formed bachelor groups, and sexually mature adult males rarely mixed with subadult males. Also, male and subadult female dolphins may follow fishing nets more often than females with calves. The dolphins reported in Table 6 were not captured simultaneously (i.e., having come from one group or pod) but rather were captured on several separate occasions. Although female common dolphins with calves have been observed in the areas of foreign fishing activity, none have been captured during trawling operations.

The size/sex composition of pilot whales killed in the Atlantic mackerel fishery indicates that most of the animals were sexually mature females. The size and sex ratios of pilot whales killed in the Atlantic mackerel fishery are similar to those ratios observed from pilot whale mass strandings in New England waters (Greg Early, New England Aquarium, Boston, MA, pers. commun., May 1988). Pilot whales are gregarious and social groupings are believed to be comprised of several sexually mature females and a few mature males (Martin et al. 1987).

Incidental take of common dolphins and pilot whales relative to available abundance estimates for each species

Estimates of the total number of common dolphins and pilot whales are available both for the shelf-edge alone and the combined all-shelf and shelf-edge waters of the northeastern United States (an area which is contained within the EEZ) by season (CETAP 1982). These estimates are based on standardized aerial surveys conducted during November 1978–January 1982, using line-transect methodology. Although these estimates are not for the same time period as the majority of the incidental take described in this paper, and these estimates have very high degrees of uncertainty (e.g., standard deviations of the estimates equal to the estimates themselves), they are the only population estimates available which can provide an indication of the relative magnitude of these incidental takes.

The shelf-edge abundance estimate for common dolphins during winter (most incidental takes for this species occurred during December and February) is 15,703 (CV 0.78) (CETAP 1982, table 17, p. 261). The average take per year for 1977–88 was 17 and 39 in 1984–88. These takes represent 0.11% and 0.25% of the winter abundance estimate. The maximum annual rate of take based on this winter abundance estimate was 0.48 ($n = 76$) in 1986 and was nearly twice the 1984–88 average.

Similar CETAP shelf-edge estimates for pilot whales during spring and summer are 6823 (CV 0.52) (spring) and 5251 (CV 079) (summer) (CETAP 1982, table 15, p. 233). The average take per year for 1977–88 was 25 and 46 in 1984–88. These takes represent 0.37% and 0.67% (spring) and 0.48% and 0.88% (summer) of the average seasonal abundance estimates for this species. The maximum annual rate of take based on the spring and summer abundance estimates, respectively, were 2.01% and 2.70% ($n = 142$) in 1988 and were three times the 1984–88 spring and summer rates of take.

The shelf-wide abundance estimates for common dolphins 31,124 (CV 0.59) (winter), and pilot whales 11,417 (CV 0.37) (spring) and 9808 (CV 0.66) (summer) are nearly twice the shelf-edge estimates, which reduces the above estimated rates of incidental take by nearly 50% if animals from the shelf-edge and shelf are considered as a single population.

To place pilot whale takes within the EEZ in perspective, present pilot whale incidental kill levels are comparable with recent mass strandings in New England waters (Greg Early, New England Aquarium, Boston, MA, pers. commun., May 1988). They do not approach the mortalities reported by Mercer (1975) for the historical Newfoundland drive fisheries (1948–71: Total 54,248; average 2260/yr). The impact of trophic

changes in the offshore cetacean communities, and the unknown DWF incidental mortality levels on components of the dolphin stocks when the DWF is fishing outside the EEZ, may be more of a factor in structuring present dolphin population trends than the levels of incidental takes that occur within the EEZ.

Also, we do not know the historical rates of take during the period 1960–76, when over 100 fishing vessels operated inside the EEZ per year. Since these fleets were not restricted by time or space, it is not unreasonable to assume that the number of dolphins taken pre-MFCMA were equal to or greater than the present. However, extrapolation of current levels of take to historical DWF fishing effort off the U.S. east coast (beyond speculation) would not be appropriate for several reasons. These include differences in the spatial/seasonal components of the fisheries over time and changes in the principal targeted species that have occurred during the past several decades. Likewise, the marine mammal/finfish/squid associations might have, likewise, changed during this time period. Also, technological changes in fishing gear and vessels have improved greatly during the past two decades, which might have increased the rate of take in recent years. Changes in the nationalities, and their associated fishing techniques, represented in the DWF have also occurred and could effect the rate of take of mammal species.

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