

DIRECTED FISHERIES FOR DOLPHINS AND DUGONG IN SABAH, EAST MALAYSIA: PAST AND PRESENT

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ABSTRACT. *An interview survey was used to determine the nature and magnitude of directed catches of marine mammals and estimate the associated level of mortality in Sabah, East Malaysia. Between March 1997 and December 2004, we interviewed 1,186 fishermen, village headmen and/or knowledgeable villagers along the coastline. They were asked questions about sightings of marine mammals and past and present utilisation. A total of 294 (25%) interviewees said they have hunted the animals or reported hunting activities of their fathers or grandfathers in the past. Of this, 231 (79%) hunters caught dugongs (*Dugong dugon*), 14 (5%) hunted dolphins (*Tursiops* spp., *Stenella* spp.) and 49 (17%) hunted both groups of animals. The magnitude of dugong catches in the past was similar throughout Sabah, but significantly greater for dolphins in the Sulawesi and Sulu Seas than in the South China Sea. Fishermen using pump boats and/or gillnets are the majority of hunters. Harpoon or spear is the main hunting gear. About 326 dolphins and 796 dugongs were reported to be taken annually with an average catch of 5.2 dolphins (95% CI = 4.01, 6.34) and 2.8 dugongs (95% CI = 2.47, 3.21) per hunter. The bootstrapped estimates of dolphins and dugongs taken annually in each region and for each boat-type were extremely high and unsustainable. Most hunters had stopped hunting in the 1980's and only 32 (11%) said they still hunt dolphins or dugong, at least occasionally or opportunistically during fishing trips. A dedicated monitoring and educational program is urgently required to significantly reduce the threat.*

KEY WORDS. *Conservation; dolphin; Dugong dugon; hunting; Sabah; utilisation.*

INTRODUCTION

East Malaysia, which comprises the states of Sabah and Sarawak, and the Federal Territory of Labuan, occupies the northern one-third of the island of Borneo (Figure 1). Sabah is the second largest state in Malaysia with an estimated land area of 73,600 km² (DSM, 2001). It has, however, the longest coastline of any Malaysian state, of approximately 1,600 km (TRPDS, 1998). The state had a population of approximately 2.6 million in 2000, not counting the substantial number of illegal immigrants from Indonesia and the Philippines (DSM, 2001). It is estimated that considerably more than 75% of the population live and work in the coastal area.

The majority of Sabah coastal communities are from the ethnic Bajau, who

consist of several groups of people, such as the Bajau Laut, Bajau Pelauh and Bajau Ubian. Other ethnic groups are the Bugis, Sungai, Kedayan and Brunei. Most of them are artisanal fishermen who largely depend on the seas or rivers, and their surroundings, for food and to make a living. Many employ gillnets and traditional fishing gears, such as fish stakes and portable traps, hook-and-line, bag nets, lift nets, barrier nets and scoop nets, and use small non-powered or outboard-powered boats (DFS, 2003).

Besides the dugong, there are at least 17 species of cetaceans (two species of Mysticeti and 15 Odontoceti) that have been confirmed to occur in Sabah waters (Jaaman, 2001; 2004). The most common species found in coastal waters, especially in major bays and estuaries, are the Irrawaddy dolphin (*Orcaella brevirostris*) and Indo-Pacific humpbacked dolphin (*Sousa chinensis*) (Beasley and Jefferson, 1997; Jaaman et al., 2001; Jaaman, 2001; 2004). In addition, the Indo-Pacific bottlenose dolphin (*Tursiops aduncus*), spinner dolphin (*Stenella longirostris*) and pantropical spotted dolphin (*Stenella attenuata*) have been reported as the most abundant cetaceans in the open waters of East Malaysia (Beasley, 1998; Jaaman, 2001; 2004). The dugong was the most common marine mammal species recorded stranded between 1996 and 2001 (Lah-Anyi and Jaaman, 2002).

These marine mammals are familiar to and have coexisted with Sabah fishing communities for centuries. However, dolphins and dugongs are also killed in some locations, both incidentally in fisheries targeting other species and deliberately for human consumption and/or for use in cultural or traditional ceremonies (Jaaman et al., 1999; 2000; Jaaman and Lah-Anyi, 2002, 2003; Jaaman, 2004). In Malaysia, directed fisheries for dolphins and dugong are only known to occur in Sabah (Jaaman and Lah-Anyi, 2003; Jaaman, 2004). Despite federal and state legislation that protect the species, this activity is apparently not being monitored or documented.

This study represents a first attempt to determine the nature and magnitude of directed catches of marine mammals and estimate the associated level of mortality from hunting in Sabah by using interview surveys. Site visits and interviews have been used to collect information on marine mammal catches in Canada, Spain, Philippines, Thailand, Vietnam, Cambodia, Indonesia, Palau, Solomon Islands and the Torres Strait between Australia and Papua New Guinea (Barnes, 1991; 2005; Dolar et al., 1994; 1997; Lien et al., 1994; Marsh et al., 1995; 1997; 2002; Perrin et al. 1996; 2005; Persoon et al., 1996; Takekawa, 2000; López et al., 2003).

MATERIALS AND METHODS

Study area

The study area is the coastline of Sabah, which is surrounded by the South China Sea and the Palawan Thrust to the west, the Sulu Sea to the northeast and the Sulawesi Sea to the east. Overall, there are three fishing regions and 16 fishing districts (Figure 1, Table 1). The fisheries are predominantly coastal, with more than 70% of the catches taking place within 30 nautical miles (nm) from shore (DFS, 2003). According to the Summary of Annual Fisheries Statistics Sabah 2002 (DFS, 2004), the total landings from the marine fishery sector were 175,122 metric tons (mt) with a wholesale value of about RM584 million (US\$154 million). Commercial (gillnets, trawl nets and purse seines) and traditional gears contributed 130,331 (74%) and 44,792 (26%) mt,

respectively. Based on a listing made in 1998, there were 20,845 registered fishermen and the fishing fleet consisted of 10,456 boats (Table 1).

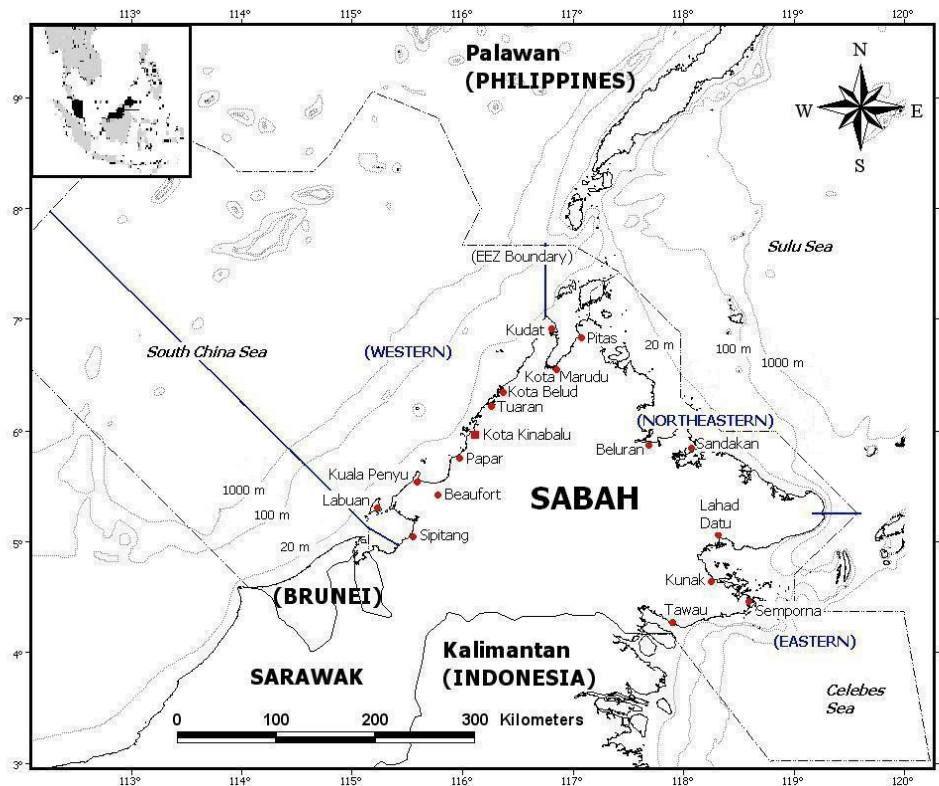


Figure 1. Sabah, with location of fishing districts/landing points (towns) and the survey regions.

Data collection

Semi-structured and informal interviews (based on Dolar *et al.*, 1994; 1997; Aragonés *et al.*, 1997) were used. Between March 1997 and December 2004, fishing villages, fish markets, fish landing jetties and anchored fishing boats in all fishing districts in the study area were visited. Interviews were conducted as part of a wider study on marine mammal interaction with fisheries in East Malaysia.

During site visits, fishermen, village headmen and/or knowledgeable villagers were asked questions about sightings of marine mammals, the incidence and frequency of hunting and the species involved (Table 1). In addition, their awareness of the government regulations on fisheries was also noted. To assess the reliability of the respondents and their answers, several test (validation) questions were asked (i.e. to which a respondent would be expected to know the answer and to which the answer is not known). Officers from relevant local authorities (Department of Wildlife Sabah, Department of Fisheries Sabah, Sabah Parks) who had extensive knowledge of the community, area, and local fishing industry assisted in conducting the interviews.

Any indication of marine mammal hunting activity in the area was photographed. Respondents' independent reviews of illustrations in field guides (Leatherwood and Reeves, 1983; Leatherwood *et al.*, 1988; Jefferson *et al.*, 1993; Tan, 1997) and a poster called *Mamalia Marin Malaysia* produced by the Universiti Malaysia Sabah were used to determine the species of marine mammal taken and

present in the area.

Table 1. Fishing regions, districts, landings and register of fishermen and boats in Sabah (based on DFS, 2004).

Region/District/Landings	Gear-type	Number of fishermen ^a	Number of boats ^a
Western (South China Sea) / 7 districts – Kota Belud, Tuaran, Kota Kinabalu, Papar, Beaufort, Kuala Penyu and Sipitang / 78583 metric tons	Traditional	2537	887
	Gillnets	1852	1743
	Trawl nets	970	246
	Purse seines	366	88
	All gears	5725	2964
Northeastern (Sulu Sea) / 5 districts – Sandakan, Beluran, Pitas, Kota Marudu and Kudat / 44634 metric tons	Traditional	3119	1915
	Gillnets	3147	1981
	Trawl nets	3297	993
	Purse seines	270	26
	All gears	9833	4915
Eastern (Sulawesi Sea) / 4 districts – Tawau, Semporna, Kunak and Lahad Datu / 51905 metric tons	Traditional	2648	1654
	Gillnets	942	632
	Trawl nets	856	183
	Purse seines	841	108
	All gears	5287	2577
All regions / 16 districts / 175122 metric tons	Traditional	8304	4456
	Gillnets	5941	4356
	Trawl nets	5123	1422
	Purse seines	1477	222
	Grand Total	20845	10456

^a Listing made in 1998.

Analysis of hunting rates

Interview data were analysed to estimate a “minimum” hunting rate. Data were divided into strata on the basis of fishing region and boat-type. Fishing boats were categorised as non-powered, outboard-engine, pump-engine and inboard-engine boats. A total of 1,186 respondents was interviewed. The respondents are assumed to be representative in each category, i.e. the proportion of respondents reporting catches and the calculated hunting rates can be raised to give estimates for catches by all fishermen in the state.

The basic question asked to respondents reporting catches was how many marine mammals were taken by them each month or year. Not all answers were fully quantitative and some respondents gave qualitative answers, such as “a few” or “some” or “many”. These respondents were then asked to give the number of animals versus the number of months/years in a range. When answers encompassed a range of values, such as 1 per 2-3 months, 1 per 6 months, 2-5 per year, 5-10 per year, 10-20 per 5 years, or 10-20 per 10 years, the mid-point value was taken and all estimated hunting rates were standardised into the number of animals taken per year. For answers such as > 10 per year, > 20 per 5 years, or > 20 per 10 years, the minimum figure was taken and divided by the number of years.

The overall mean annual catch per hunter for each region and boat-type is given by the total number of animals taken per year divided by the number of fishermen

reporting animal catches. Separate totals were estimated for dolphins and dugongs. The total number of animals taken annually is estimated using the number of fishermen in each region and boat-type, reported in the Summary of Annual Fisheries Statistics Sabah 2002 (DFS, 2004), as a raising factor. To calculate summary statistics, data from respondents using outboard- and pump-engine boats were combined in the outboard-powered category (since that the Summary of Annual Fisheries Statistics Sabah 2002 only gave figures for non-powered, outboard- and inboard-powered categories).

Analysis of factors affecting the reported incidence of hunting of marine mammals was based on Generalised Linear Models (GLM), fitted using BRODGAR software (Highland Statistics Ltd.). The response variables were the presence (1) or absence (0) of hunting in the past of (a) all marine mammals, (b) cetaceans or (c) dugongs. Explanatory variables considered were: interview year, region, ethnic origin, fishing gear-type and boat-type, which were all nominal variables. The models were run assuming a binomial distribution for the response variable and using a logit link function.

The initial models had the formula:

$$(Y1) \sim \alpha + \text{as.factor}(\text{interview year}) + \text{as.factor}(\text{region}) + \text{as.factor}(\text{ethnic origin}) + \text{as.factor}(\text{fishing gear type}) + \text{as.factor}(\text{boat-type}) + \varepsilon_i$$

Where; Y1 is the occurrence of hunting, α is the intercept, ε_i is the residual (unexplained information or noise, $\varepsilon_i \sim N(0, \sigma^2)$). Nominal explanatory variables were recoded as binomial dummy variables. For example, the regions analysed were Western, Northeastern and Eastern. Two dummy variables were thus created, for Northeastern and Eastern, and a significant coefficient value indicates a difference from Western. In each case, the final (best-fit) model was identified using stepwise removal of non-significant terms until no further decrease in the Akaike Information Criterion (AIC) value was seen. The individual probability (P) value associated with each explanatory variable in the final model was used to identify significant effects on the occurrence of hunting. Binomial GLM was also used to determine the factors affecting respondents' awareness (either aware or not aware) of the government regulations on wildlife and fisheries.

Similar analyses were carried out on the variation in numbers of cetaceans and dugongs reported to be killed. The incidence of hunting was rare and can be modelled with a Poisson distribution. However, the numbers of animals reported caught per year varied widely, ranging from 0.2 to 18 (i.e. the distributions were "over-dispersed"). In this case, a quasi-Poisson distribution that includes a dispersion parameter, and log link function was assumed for the response variables.

Confidence limits for the total number of marine mammals caught annually by fishermen were estimated using a bootstrap procedure. A purpose-written BASIC programme was used to simulate the data collection procedure, repeatedly re-sampling with replacement from the set of N interviews in a stratum to generate multiple sets of N interviews. In the present application 10,000 repeats were used, each yielding an estimate of the number of animals taken, raised to the level for all fishermen in the region. In each case, the 10,000 estimates were then sorted and the 251st and 9,750th values represent the 95% confidence limits (i.e. only 5% of values are more extreme). Interviews were stratified by fishing region and boat-type and confidence limits derived separately for each region and boat-type. Confidence limits were also derived for the total across all regions and all boat-types, by running a version of the programme in which all strata were sampled, the total number of animals taken stored, and the

procedure repeated 10,000 times.

RESULTS

Hunting rates estimated from interview data

Of 1,186 respondents interviewed, 294 (25%) said they hunted marine mammals or reported hunting activities of their fathers/grandfathers in the past (Table 2). Two hundred and thirty-one (79%) caught dugongs, 14 (5%) caught dolphins and 49 (17%) caught both groups of marine mammals. Hunting was reported in all interview year, interview season, region, ethnic origin, fishing gear-type and boat-type categories, except by fishermen using inboard-powered boats.

An estimated total of 326 dolphins and 796 dugongs was reported taken annually with a mean catch of 5.2 dolphins (95% CI = 4.01 – 6.34) and 2.8 dugongs (95% CI = 2.47 – 3.21) per hunter (Table 2). The Northeastern region recorded the highest number of dolphin or dugong hunters, number of animals caught and mean annual catch per hunter. The pump-engine boat category recorded the highest number of dolphin hunters, number of animals caught and mean annual catch per hunter. Although the numbers of dugong hunters and animals caught were highest in the pump-engine boat category, the highest mean annual dugong catch per hunter was recorded in the outboard-engine boat category.

Around 4,626 dolphins (95% CI = 3,267 – 6,185) and 12,279 dugongs (95% CI = 10,554 – 14,103) were estimated to be caught annually by fishermen in the past (Table 3). About half of the estimated total numbers of dolphins and dugongs caught were from the Northeastern region. The combined outboard-powered boat category contributed the majority of the total estimated catch.

Factors affecting the reported hunting incidence

In conducting GLM analysis, data from fishermen using inboard-powered boats were excluded as this category reported no marine mammal hunting (i.e. all values for numbers of animals caught were zero). All fishermen using non-powered boats reported zero dolphin catches and these data were excluded from the dolphin hunting analysis.

Binomial GLM confirmed the existence of significant effects of fishing gear-type and boat-type on the overall reported incidence of marine mammal hunting in the past (Table 4). A higher proportion of fishermen using gillnets admitted to hunting marine mammals, as compared to fishermen using traditional gears. A higher proportion of fishermen using non-powered boats said they hunted in the past, as compared to fishermen using boats with outboard- and pump-engines. There were no effects of interview year, region and ethnic group.

In the case of dolphin hunting, all fishermen who admitted hunting were from the ethnic Bajau and this variable was subsequently excluded from the model. Only region had significant effect on the reported incidence of dolphin hunting. A higher proportion of respondents from the Northeastern and Eastern regions said they hunted the animals, as compared to respondents from the Western region.

In the case of dugong hunting, there were significant fishing gear-type and boat-type effects. As for hunting of marine mammals in the past, there was a higher incidence of dugong hunting reported from fishermen using gillnets than traditional gears. A higher proportion of fishermen using non-powered boats said they hunted dugong in the past, as compared to fishermen using boats with outboard- and pump-

engines.

The quasi-Poisson GLM for numbers of dolphins reported killed included effects of interview year, region and boat-type, but only the effect of region and boat-type were significant (Table 5). Numbers reported killed were higher for the Northeastern and Eastern regions than the Western region and higher for fishermen using pump-engine boats than boats with outboard-engines. There was no effect of ethnic group. The quasi-Poisson GLM for numbers of dugongs reported killed included no significant effect of any of the explanatory variables.

Table 2. Summary of marine mammal hunting in Sabah; showing the total number of fishermen, number of fishermen interviewed, number of fishermen reporting animal catches and the mean annual catch per hunter.

Fishing region	Fishing boat	INTERVIEWS			DOLPHIN HUNTING					DUGONG HUNTING				
		Total number of fishermen	Number of fishermen interviewed	Number of fishermen with catch (hunters)	Number of fishermen with catch (hunters)	Number of animals taken annually	Mean annual catch per hunter	95% CI (lower limit)	95% CI (upper limit)	Number of fishermen with catch (hunters)	Number of animals taken annually	Mean annual catch per hunter	95% CI (lower limit)	95% CI (upper limit)
Eastern	Inboard	1658	129	0										
	Non-powered	1276	9	9	0					9	13			
	Outboard-engine	2353	64	19	11	27				15	43			
	Pump-engine		72	39	14	87				36	114			
	All boats	5287	274	67	25	114	4.6	2.61	6.52	60	170	2.8	1.96	3.70
North-eastern	Inboard	3084	162	0										
	Non-powered	2374	30	16	0					16	18			
	Outboard-engine	4375	152	52	13	40				49	196			
	Pump-engine		187	81	19	148				77	205			
	All boats	9833	531	149	32	188	5.9	4.10	7.62	142	419	3.0	2.41	3.49

Table 2: (Continue)

Western	Inboard	1795	126	0										
	Non-powered	1382	24	7	0					7	8			
	Outboard-engine	2548	109	44	1	1				44	112			
	Pump-engine		122	27	5	23				27	86			
	All boats	5725	381	78	6	24	4.0	2.44	5.63	78	206	2.6	2.03	3.27
All regions	Inboard	6537	417	0										
	Non-powered	5032	63	32	0					32	40	1.3	0.75	1.76
	Outboard-engine	9276	325	115	25	68	2.7	1.70	3.75	108	351	3.3	2.69	3.82
	Pump-engine		381	147	38	258	6.8	5.14	8.43	140	404	2.9	2.31	3.46
Grand total		20845	1186	294	63	326	5.2	4.01	6.34	280	796	2.8	2.47	3.21

Table 3. Bootstrap estimated total number of marine mammals killed annually by fishermen in Sabah, with 95% confidence intervals^{a,b}.

Fishing region	Fishing boat	Total number of fishermen ^a	Number of fishermen interviewed	Estimated total annual dolphin catch	95% CI (lower limit)	95% CI (upper limit)	Estimated total annual dugong catch	95% CI (lower limit)	95% CI (upper limit)
Eastern	Outboard	2353	136	1932	1031	3127	2800	1854	3941
	Non-powered	1276	9	0	0	0	865	723	957
	Total	3629	145	1931	1042	3097	3676	2686	4835
North-eastern	Outboard	4375	339	2384	1444	3553	5246	4126	6501
	Non-powered	2374	30	0	0	0	843	494	1242
	Total	6749	369	2390	1458	3549	6096	4902	7367
Western	Outboard	2548	231	265	64	515	2212	1608	2920
	Non-powered	1382	24	0	0	0	256	106	428
	Total	3930	255	258	64	514	2463	1824	3200
All regions	Outboard	9276	706	4636	3246	6239	10305	8673	12056
	Non-powered	5032	63	0	0	0	1965	1560	2407
Overall		14308	769	4626	3267	6185	12279	10554	14103

^a Excluding respondents/fishermen using inboard-powered boat

^b Western total, Northeastern total, Eastern total, all region outboard and all region non-powered are derived from separate runs of the bootstrap procedure and the figure will therefore not necessarily be exactly equal to the sum of figures from runs using data from single regions or boat-types.

Table 4. Results from binomial GLM for variation in the incidence of hunting between different categories of respondents. The table lists all explanatory variables with significant effects in the final models.

Response variable	Explanatory variable	Coefficient (and St Err)	Z-value	P-value
Hunt marine mammals	Fishing gear – traditional	-0.670 (0.165)	-4.223	0.0000
	Boat – outboard-engine	-0.995 (0.270)	-3.356	0.0008
	Boat – pump-engine	-0.863 (0.290)	-2.981	0.0029
Hunt dolphins	Region – Northeastern	1.371 (0.455)	3.022	0.0025
	Region – Eastern	2.125 (0.470)	4.528	0.0000
Hunt dugongs	Fishing gear – traditional	-0.761 (0.168)	-4.521	0.0000
	Boat – outboard-engine	-1.134 (0.299)	-3.793	0.0001
	Boat – pump-engine	-0.981 (0.292)	-3.363	0.0008

Table 5. Results from quasi-Poisson GLM of variation in numbers of marine mammals reported to be killed. The table lists all explanatory variables in the final models. Significant terms are indicated in bold face.

Response variable	Explanatory variable	Coefficient (and St Err)	Z-value	P-value
Number of dolphins reported killed	Year 1999	1.035 (0.571)	1.811	0.0705
	Year 2000	-0.448 (0.743)	-0.603	0.5465
	Year 2001	0.741 (0.827)	0.896	0.3707
	Year 2002	-0.123 (0.915)	-0.134	0.8933
	Year 2003	0.601 (0.660)	0.911	0.3629
	Year 2004	0.190 (0.780)	0.243	0.8082
	Region – Northeastern	1.605 (0.569)	2.822	0.0049
	Region – Eastern	2.089 (0.605)	3.451	0.0006
Number of dugongs reported killed	Boat – pump-engine	1.222 (0.332)	3.686	0.0002
	No effect			

Species sighted/hunted

Almost all of the respondents (1103, 93%) could readily distinguish between a dugong and a dolphin, and 1032 (87%) respondents regarded the animals as large predatory “fishes”. All 63 dolphin hunters interviewed were Bajau and full-time fishermen. Based from illustrations in the field guides and poster, and the hunters’ descriptions of the animals, 60 (95%) of the total hunters identified spinner dolphins, 44 (70%) identified bottlenose dolphins, and 18 (29%) identified spotted dolphins as their catches. In all regions, respondents also reported encountering larger cetaceans (e.g., pilot whale, sperm whale, killer whales, and baleen whales) sometimes at sea but had never attempted to hunt the animals, which they claimed were much bigger than their boats. The Irrawaddy and Indo-Pacific humpback dolphins, which were reported common in bays and estuaries, were also not hunted. They believed bad luck would come to those who disturb or harm the species. Other animals reported hunted were large rays (61%), turtles (48%) and whale sharks (13%).

Marine mammal hunting was reported from all 16 fishing districts, except in Tuaran and Beaufort, where dugong was the only species reported hunted. Dugongs were hunted at night, especially during the new moon periods, when the animals came to feed on seagrass in shallow waters close to shore. To hunt dolphins, hunters went out early in the morning when the sea was said to be relatively calm and dolphins were usually found close to coastal islands or reefs to feed. Six hunters (10%) reported to have hunted dolphins at night during their fishing trips.

Hunters used small non-powered, 10 – 25HP outboard- or water pump-engine boats (or commonly known as ‘pump boats’) for hunting marine mammals (Figure 2). In the Eastern and Northeastern regions, a pump boat is often fitted with a sail and outriggers, which allows it to be used efficiently and enables it to withstand rough sea condition. Overall, half of the hunters used pump boats and hunters using non-powered boats only reported dugong hunting (Table 2).

Four types of gears were reportedly used to hunt marine mammals; harpoon or spear, a combination of harpoon/spear and dynamite, dynamite, and fishing net. Specially made harpoons were used by 38 (60%) dolphin and 181 (65%) dugong hunters (Figure 3). These harpoons were locally known as “bujak”, “tempuling” or “sangkir”, depending on localities (Figure 4). Twenty (32%) dolphin and 61 (22%)

dugong hunters interviewed reported using a combination of harpoon and dynamite, and 5 (8%) dolphin and 27 (10%) dugong hunters used only dynamite to catch the animals (Figure 3). The other 11 (4%) hunters reported using fishing nets to catch dugongs.

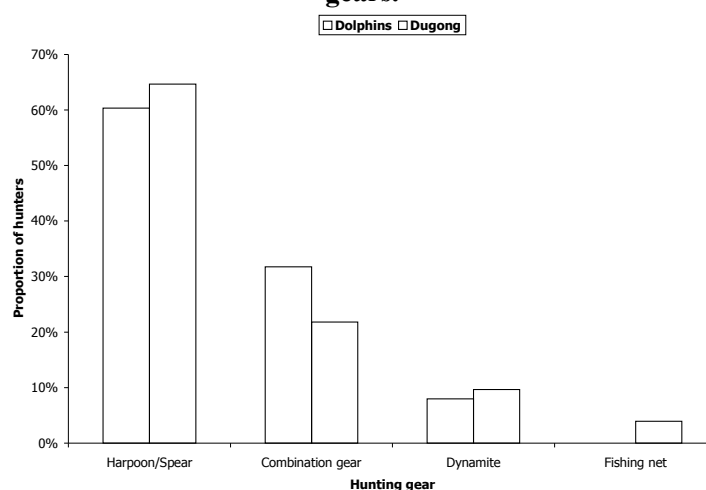
On 29 April 1999, three Bajau Pelauh from Semporna were caught by the Police in possession of 12 dead spinner dolphins. Although neither a harpoon nor dynamite were found in their boat, they later confessed that the dolphins were hunted using the combination of the gears. Examination of the carcasses found several wounds made by sharp object and swollen areas, particularly on the dorsal side.

All marine mammal hunters interviewed claimed that the meat and parts of caught animals were consumed by their family members. Two hundreds and fourteen (73%) hunters shared their catches among neighbours. One hundred (34%) hunters said they traded the meat/animals and 86 (29%) hunters reported using the meat/parts as shark baits.

Figure 2. Water pump-engine boats, or commonly known as “pump-boats”, fitted with sails and outriggers, used for fishing and/or hunting marine mammals offshore of Semporna, Sabah.



Figure 3. The proportion of marine mammal hunters using different type of hunting gears.



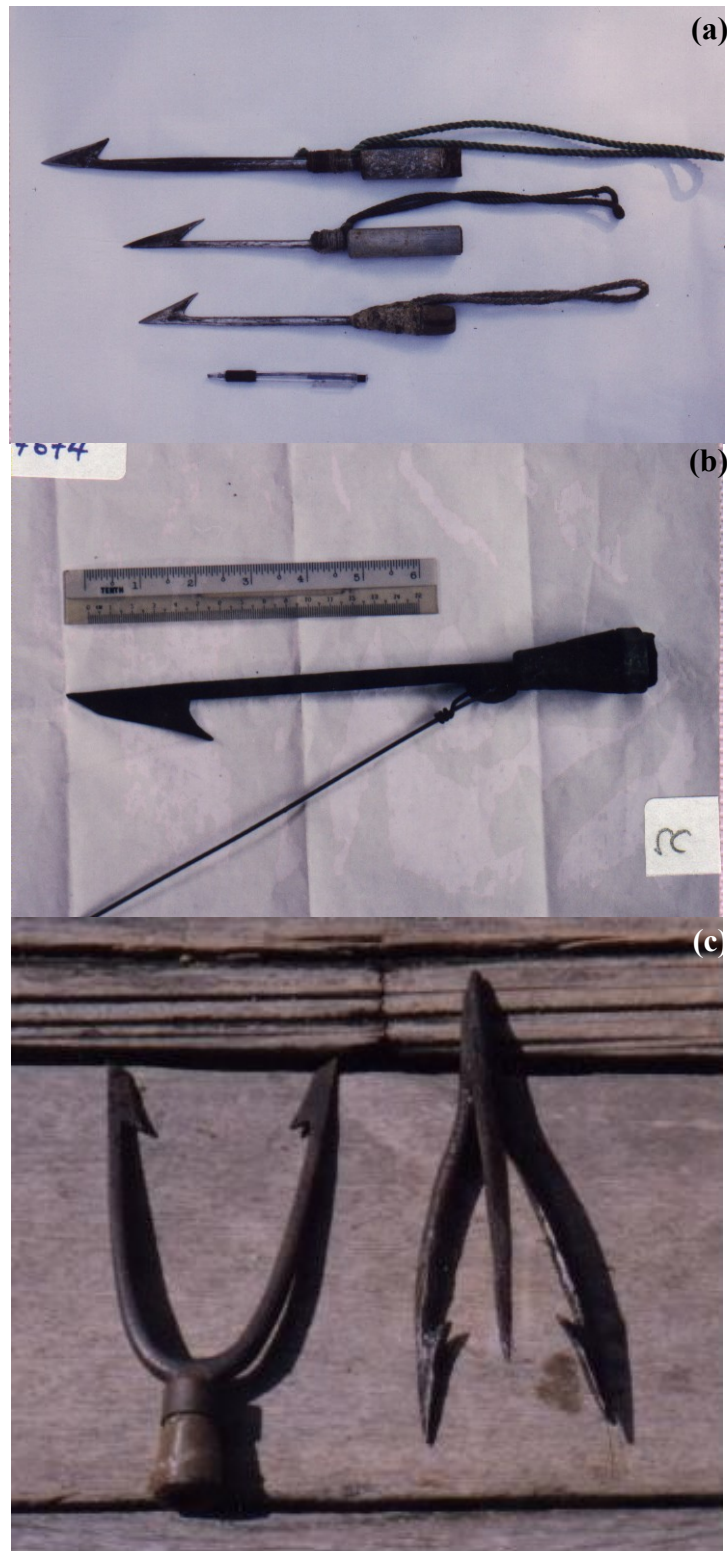


Figure 4. Harpoons, or locally known as (a) “bujak”, (b) “tempuling” or (c) “sangkir”, used to kill large fishes, turtles or marine mammals in Sabah.

Present utilisation

Two hundreds and sixty-two (89%) hunters interviewed said that they or their fathers/grandfathers had stopped hunting marine mammals mostly in the 1980's and only 32 (11%) said they still hunt dolphins or dugong, at least occasionally, or opportunistically during fishing trips. All hunters who said they presently hunt marine mammals were Bajau and 24 (75%) of them hunt dugongs, two (6%) hunt dolphins and six (19%) hunters take both species. Based on the percentage of present hunters and the estimated total number of marine mammals caught annually by fishermen in each category in the past (Table 3), there is presently an overall estimate of 587 dolphins (95% CI = 415 – 785) and 1,316 dugongs (95% CI = 1,131 – 1,511) caught per year (Table 6).

Table 6. Estimated total number of marine mammals taken annually by fishermen at present in Sabah^a.

Fishing region	Fishing boat	Total number of fishermen ^a	Number of fishermen interviewed	Number of fishermen still hunting dolphin	Estimated total annual dolphin catch	95% CI (lower limit)	95% CI (upper limit)	Number of fishermen still hunting dugong	Estimated total annual dugong catch	95% CI (lower limit)	95% CI (upper limit)
Eastern	Total	3629	145	5	52	13	103	12	493	365	640
North-eastern	Total	6749	369	3	224	137	333	14	601	483	726
Western	Total	3930	255	0	0	0	0	4	189	138	248
All regions	Outboard	9276	706	8	589	412	792	21	873	734	1021
	Non-powered	5032	63	0	0	0	0	9	553	439	677
Overall		14308	769	8	587	415	785	30	1316	1131	1511

^a Excluding respondents/fishermen using inboard-powered boat

Binomial GLM confirmed the existence of significant effects of interview year, region, fishing gear-type and boat-type on present marine mammal hunting (Table 7). A higher proportion of hunters interviewed in 1997 said they still hunt marine mammals, as compared to hunters interviewed in 1999. A higher proportion of hunters in the Eastern region admitted to presently hunt marine mammals than hunters in the Western region. A higher proportion of hunters using gillnet for fishing said they still hunt marine mammals, as compared to hunters using traditional fishing gear. A higher proportion of hunters with non-powered boats said they still hunt the animals, as compared to hunters using boats with outboard- and pump-engines.

Nine hundreds and sixty-one (81%) respondents and 23 (72%) hunters

interviewed were aware of the government regulation on fisheries (Fisheries Act 1985) imposed in the 1980's, which include bans on fishing, catching, or selling of any marine mammal species found in Malaysia waters. Binomial GLM confirmed the existence of significant effect of region on respondents' awareness of these regulations and bans. A lower proportion of respondents in the Eastern and Northeastern regions were aware of fisheries regulations and bans, as compared to respondents in the Western region. There were no effects of interview year, ethnic origin, fishing gear-type and boat-type.

Nevertheless, 239 (91%) hunters who had stopped hunting did not give these regulations as their main reason but cited the low availability of marine mammals. Most of the respondents (995, 84%) admitted that the number of dolphins and dugongs has dropped significantly in the past few decades. The dugong, in particular, was reported rarely seen in areas where it was once common, while the dolphins were reported often avoiding fishing boats.

Table 7. Results from binomial GLM for variation in the incidence of hunting between different categories of hunters/respondents. The table lists all explanatory variables in the final models. Significant terms are indicated in bold face.

Response variable	Explanatory variable	Coefficient (and St Err)	Z-value	P-value
Present hunting (hunters)	Year 1999	-1.965 (0.777)	-2.529	0.0114
	Year 2000	-0.921 (0.840)	-1.097	0.2725
	Year 2001	-1.440 (1.092)	-1.318	0.1874
	Year 2002	-1.088 (0.904)	-1.203	0.2288
	Year 2003	-0.884 (0.817)	-1.082	0.2792
	Year 2004	-0.681 (0.847)	-0.805	0.4211
	Region – Northeastern	0.490 (0.743)	0.660	0.5094
	Region – Eastern	1.732 (0.840)	2.064	0.0390
	Fishing gear – traditional	-1.091 (0.556)	-1.963	0.0496
	Boat – outboard-engine	-1.421 (0.651)	-2.184	0.0290
	Boat – pump-engine	-2.846 (0.714)	-3.985	0.0000
Aware of fisheries regulations/bans (respondents)	Region – Northeastern	-0.745 (0.235)	-3.169	0.0015
	Region – Eastern	-1.213 (0.268)	-4.536	0.0000

DISCUSSION

This study was based on an interview survey. Lien et al. (1994) suggested that interview surveys are not necessarily a reliable source of quantitative data on marine mammal catches, especially if fishermen wish to conceal the occurrence of such mortality. However, this survey method offers a means of obtaining a minimum estimate for numbers of animals killed (López et al., 2003). Interviews can also provide a variety of other useful data, e.g. about attitudes of fishermen towards marine mammals.

During interview sessions, at least an officer from relevant local authorities was

present. However, respondents mostly did not conceal the occurrence of marine mammal hunting in the past or at present and readily spoke about how hunting was carried out and what they do with a caught animal. This is probably because it was the first time they were asked such questions and they had not experienced punishment from the authorities for catching dolphins and/or dugongs, though the majority of them knew that hunting marine mammals is illegal. Dolar et al. (1994; 1997), Marsh et al. (1995) and Persoon et al., (1996) who conducted marine mammal-fisheries interaction interviews in the Philippines, Palau and Aru Islands, Indonesia, respectively, also reported the willingness of respondents in relaying information regarding marine mammal hunting and utilisation in their area. Nevertheless, results of this study need to be viewed cautiously and may be regarded as providing, at best, a rough guide to the scale of marine mammal hunting in East Malaysia.

Magnitude of the Marine Mammal Catches

The present study suggests that substantial numbers of dolphins and dugongs have been and probably continue to be caught for human consumption in Sabah waters. Hunting in the past was a deliberate activity; however, currently there are very few hunters left and hunting is more an opportunistic activity during fishing trips. This new evidence supports the previous suggestions made on the nature and magnitude of dolphin and dugong hunting in the Southeast Asian region. Perrin et al. (1996) stated that directed catches for cetaceans in the Southeast Asia are restricted to what appear to be low levels of sporadic take of inshore species in several areas. However, they suggested that the extent is likely underestimated. Recently, Perrin et al. (2005) added that significant dugong catches, either intentionally or opportunistically, for subsistence purposes are likely to continue in its range in the region.

The results indicate that the magnitude of dugong catches in the past was similar throughout Sabah, but significantly greater for dolphins in the Eastern and Northeastern regions than in the Western region. The present level of marine mammal hunting in the two regions is still a serious cause for concern since there are significantly higher proportions of respondents that were not aware of government bans on catching marine mammals, as compared to respondents in the Western region. The Eastern and Northeastern regions are apparently larger, less urbanised and a higher proportion of their populations do not receive formal education, as compared to the Western region (TRPDS, 1998). This might explain why people there are less aware of laws and matters pertaining to environmental conservation.

Fishermen using outboard- or pump-engines boats hunted both marine mammal species, whereas those using non-powered boats were able to hunt only dugongs. Pump boats were preferred, being used by more than half of the fishermen, and the number of dolphins reported to be killed is significantly higher for fishermen using pump boats than boats with outboard-engines. Since pump boats are used by the majority of hunters in the Eastern and Northeastern regions, this could also explain the higher estimated catch of dolphins in these regions, as compared to the Western region. Small to medium size pump boats are also used by cetacean hunters in the Philippines (Dolar et al., 1994; 1997) and hunters in Lembata and Solor Islands, Indonesia, used nine- to fifteen-man sail or outboard-engine boats to hunt whales, dolphins and other large marine species (Barnes, 1991; 2005). Outboard-engine boats are also used by dugong hunters in the Torres Strait and Palau, while dugout canoes are used to hunt dolphins and dugongs in the Solomon Islands (Takekawa, 2000) and Aru Islands, Indonesia (Persoon et al.,

1996), respectively.

The results also indicate that harpoon/spear is the main gear used to hunt marine mammals. Although there is some difference in shape and operating method, the finding is consistent with other reports on marine mammal hunting in the region (Barnes, 1991; 2005; Dolar et al., 1994; Persoon et al., 1996). It is not illegal to carry a harpoon at sea, thus many fishermen keep it in their boats and use it usually to kill sharks or turtles that are caught in their fishing gears. However, when an opportunity arises, such as a dugong being spotted close by or incidentally caught in fishing net, they are most likely to use the harpoon to hunt/kill the animal. The use of dynamite to catch fish, is illegal, but sometimes it is also used to kill marine mammals. This home-made bomb, which uses fertiliser as its main component, has devastated many reef areas in Sabah and other parts of the Southeast Asia and continues to be used, with a lack of commitment by the authorities to control its usage (Perrin et al., 2005; Oakley et al., 2000).

In addition, the legal system often shows leniency in relation to these kinds of crimes. According to Sabah Wildlife Conservation Enactment (1997), any person who kills a protected species (e.g. a cetacean) shall be liable on conviction to a maximum fine not exceeding RM50,000 (US\$12,500) or to imprisonment for five years or to both. In the case of the three Bajau Pelauh who were caught by the Semporna Police for hunting 12 spinner dolphins, they were given only six months jail term. In other cases when marine mammals or the meat/parts were confiscated by officers from relevant local authorities, often the culprits were released with warnings. Thus, hunting and trading of marine mammals in the rural areas probably continues unabated due to a lack of commitment in enforcing conservation laws and the low risk of getting a significant punishment. Similar situations are also reported to occur in the Philippines, Palau, the Torres Strait and Aru Tenggara Marine Reserve (Dolar et al., 1994; 1997; Marsh et al., 1995; 1997; Persoon et al., 1996).

Sustainability of the Marine Mammal Fishery

There is no estimate of marine mammal populations in Malaysian waters. However, the cetacean population is assumed to be small in numbers, as suggested for the populations in other countries in the Southeast Asian region (Perrin et al., 1996; 2005). While the status of the dugong population is not known for any country in the region, numbers are believed to have declined throughout the region with the possible exception of Australian waters (Perrin et al., 2005).

With the exception of the Eastern region, the annual total number of dugongs reported taken by hunters and the estimated number of dugongs taken by fishermen in other regions and boat-type categories are more than double than the totals for dolphins. This shows that dugong is much preferred and probably more common in the coastal waters than dolphins. Lah-Anyi and Jaaman (2002) found that dugongs were more commonly stranded than dolphins between 1996 and 2001. The spinner, bottlenose, and spotted dolphins that were identified as catches were reported to be abundant in the open waters (Beasley, 1998; Jaaman et al., 2001; Jaaman, 2004). Nevertheless, there is a possibility that respondents have mistakenly identified the species with other members of the Delphinidae family (e.g. striped, common, or Fraser's dolphins), which also could be abundant in the open waters. Only dugong and spinner dolphin carcasses were recovered from a number of hunters and fish traders during the survey period.

Respondents and hunters admitted that the number of dolphins and dugongs has dropped significantly in the past few decades. Though they are aware of the basic facts

with regard to the physical requirements of the dugong, most of them refused to accept the possibility of extinction due to the disturbance and hunting pressure. They tend to believe that the animal is capable of hiding in safer places, even though they know that dugong live off seagrass, which they said is less common in the coastal waters now. The same thought has also been recorded from dugong hunters in Aru Islands, Indonesia, about the animal's population in their area (Persoon et al., 1996).

Although marine mammal hunting in the past was a deliberate activity, hunters were probably opportunists and would kill other large species, such as the manta ray, turtle or whale shark, when the opportunity arose. As the chances of catching marine mammals are very small nowadays, only very few hunters still go out to hunt dolphins (8 hunters) or dugong (30 hunters). Marsh et al. (1997) reported that in the Torres Strait, between Australia and Papua New Guinea, dugongs and green turtles are hunted together and hunting would be expected to cease only when the combined density of the two species is so low that hunting is not worthwhile. Besides taking a large numbers of fish, many coastal villagers in Lembata and Solor Islands, Indonesia occasionally took dugong (Barnes, 2005). The situation is similar in Sabah, where opportunistic hunting of several large marine species continues, especially during fishing trips, depending on availability. In addition, many fishermen bring harpoon, or worst still dynamite, during fishing, thus there is a real danger of dolphin and dugong populations being seriously affected by opportunistic hunting unless the use of harpoon and dynamite is stopped.

The annual total number of dolphins and dugongs reported to be taken by the respondents and the estimated number of animals taken by fishermen in each region and boat-type categories in the past is considered very unsustainable. At the second meeting of the Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas (ASCOBANS), in 1997, it was agreed that, in general, an anthropogenic removal of more than 2% of the best available cetacean population estimate was an "unacceptable interaction" (ASCOBANS, 1997). Based on a dedicated sighting survey in the Southern Sulu Sea of the Philippines, there is an estimated 3,979 (CV=0.59) spinner dolphins, 3,455 (CV=0.32) pantropical spotted dolphins, and 415 (CV=0.96) bottlenose dolphins in the area (Dolar et al., 1997). Assuming that fishermen in the Northeastern region are catching dolphins from the same population and the 2% of anthropogenic removal is exclusively from hunting activities, the maximum sustainable catch will be 80 spinner dolphins, 69 pantropical spotted dolphins, and 8 bottlenose dolphins, or a total of 157 dolphins taken annually. The annual total number of dolphins reported taken by the respondents in the Northeastern region (Table 2) and the estimated number of dolphins taken by fishermen in any of the regions (Table 3) substantially exceeds this figure. Furthermore, this dolphin population is also subject to by-catches in fisheries (S. A. Jaaman, unpublished data), and directed and incidental catches in the neighbouring Philippines waters (Dolar, 1994; Dolar et al., 1994; 1997).

In the case of dugong hunting, the population simulations of Marsh (1995; 1999) suggested that the sustainable level of exploitation may be as low as 2% of females annually. If five females are taken in any of the regions each year, at least 250 female dugongs would be needed in the waters of each region for the population to be maintained, which is considered to be extremely unlikely. A similar suggestion has been made concerning the maintenance of dugong populations in Palau waters (Marsh et al., 1995) and in some other areas within the species' range (Marsh et al., 2002). The present utilisation level of an estimated 224 dolphins (95% CI = 137, 333) and 601 dugongs (95% CI = 483, 726) per year in the Northeastern region is also unsustainably

high.

The estimated number of dolphins or dugongs taken annually for consumption by fishermen in each region and boat-type categories is extremely high given the large quantities of fishes landed (175,122 metric tons) from the coastal waters (DFS, 2004). These directed catch estimates suggest some or all of the following: (1) the numbers of dolphins or dugongs reported taken by the respondents are too high; and (2) the respondents are not representative in each category.

Conservation recommendations

The introduction of Fisheries Act 1985 appears to have had little effect on directed catches of marine mammals in Sabah, East Malaysia. Several factors are evident, but the main ones are poor enforcement and the low risk of getting a significance punishment for catching the protected animals. There is apparently a shortage of manpower and proper equipment, limited funding and little initiative to conduct marine environmental conservation and management programs in Sabah. Although hunting nowadays is an opportunistic activity, it could still seriously affect dolphin and dugong populations, which are assumed to be low in numbers.

Therefore, it is suggested that the management and enforcement authorities and the community leaders should act promptly to establish a collaborative and dedicated monitoring program to identify significant directed catches of marine mammals in Sabah. This program should focus on minimising the threats through education with the backup of heavy penalties for contravention of regulations. However, this has to be done cautiously due to the fact that in some countries, enforcement of laws prohibiting direct takes or landing of incidental catches of marine mammals has increased the difficulty in obtaining information on such takes (Perrin *et al.*, 1996; 2005). Furthermore, enforcing law within a large area is often difficult and costly, thus it is essential to educate coastal communities towards compliance with fishing regulations and conserving their environment. This is an alternative to enforcement and would encourage their involvement in species monitoring.

Fishing communities should also be given alternative livelihoods, such as in mariculture or ecotourism sectors, if they have to reduce/stop fishing. Furthermore, the economic and social values of marine mammals among certain coastal communities that hunt and utilise the animals need to be investigated further. These communities should also have a significant role in any management, conservation and/or utilisation of natural resources in their areas.

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