



## Review

# The global extent and character of marine mammal consumption by humans: 1970–2009

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## ABSTRACT

The killing and consumption of marine mammals fuels tense global struggles between advocates of sustainable use and advocates of complete protection for these animals. However, reporting on the extent and character of marine mammal consumption by people is uneven and often anecdotal. We developed a consistent approach to summarize information from approximately 900 sources. It is now clear that human consumption of marine mammals is geographically widespread, taxonomically diverse, and often of uncertain sustainability. Since 1990, people in at least 114 countries have consumed one or more of at least 87 marine mammal species. Although changing social, ecological, or political circumstances are leading to reduced killing and consumption of marine mammals in some regions, in other regions the prevailing socio-economic conditions and new technologies are leading to increased killing and consumption, particularly of small cetaceans. Consumption of marine mammals is considered a significant aspect of food security and cultural well being in many regions, and provides some economic (including cash) benefits to people in at least 54 countries. Our review highlights an escalation in utilization of small cetaceans caught in conjunction with fishing activities since 1970, a form of fishing-up-the-food-chain. Where consumption relates to food security and poverty, we found evidence of deliberate killing of animals caught both deliberately and accidentally in fishing gear. Constraints on government agencies responsible for implementing regulations, often due to the geographic remoteness of catches, mean that greater understanding is needed of the motivations that underlie consumption of marine mammals so that more effective conservation measures can be designed and implemented.

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## Contents

1. Introduction .....	2771
2. Methods .....	2771
3. Results .....	2774
3.1. Extent of human consumption of marine mammals .....	2774
3.2. Non-Targeted-Salvage acquisition of marine mammals .....	2778
3.2.1. Strandings .....	2778
3.2.2. Inadvertent captures in fishing gear .....	2778
3.3. Non-Targeted-Deliberate acquisition of marine mammals .....	2778
3.3.1. Strandings .....	2778
3.3.2. Entrapment .....	2778
3.3.3. Incidental captures in fishing gear .....	2778
3.4. Targeted acquisition of marine mammals .....	2781
3.5. Exchange of marine mammal products for human consumption .....	2782
4. Discussion .....	2783

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Acknowledgements .....	2784
Appendix A. Supplementary material .....	2784
References .....	2784

## 1. Introduction

Despite a long history of human consumption of marine mammals, the last three decades have seen the practice develop into a tense global struggle between advocates of sustainable use and those seeking the complete protection of marine mammals (Wenzel, 1991; Shoemaker, 2005; Lavigne, 2006). However, amidst persistent debates over the appropriate relationship between people and marine mammals, the actual extent and character of marine mammal consumption remain ambiguous. Furthermore, the issue of whether people should or should not kill and consume marine mammals is not merely an academic concern that revolves around the sensibilities and belief systems of people who dine out and attend conferences. In some settings, such as in much of the Arctic and in remote rural outposts of many island or continental states, the consumption of marine mammals can be a central element of food security, economic viability, and cultural continuity (e.g., AHDR, 2004; Read, 2008).

The hunting and consumption of wild mammals is common globally, and such exploitation is a major threat to many species (Nasi et al., 2008; Schipper et al., 2008). Broad reviews of terrestrial hunting of wild mammals for food have been conducted under various headings, but most notably ‘bush meat.’ For marine mammals, the directed hunting of large cetaceans that are considered to fall within the competence of the International Whaling Commission (all baleen whales and the sperm whale; Table 1) is well described (Clapham and Baker, 2009; Donovan, 2009); but large cetaceans constitute only a small fraction of the full diversity of marine mammal species (12% of species), many of which are hunted, netted, or trapped. The global extent and character of the acquisition of these other species of marine mammals for use as human food have received little synthesis, and consequently mention of these is often missing from reviews of wild animal usage. This prompted Clapham and Van Waerebeek (2007) to call for urgent implementation of research aimed at assessing the scope of what they termed the ‘marine bush meat’ problem.

Acquisition of marine mammals for food is not always deliberate (often termed ‘directed’). Incidental catches of marine mammals in fishing gear (often referred to as ‘bycatch’) create opportunities for food procurement. Hundreds of thousands of small cetaceans (Table 1) die in fishing gear around the world each year, and this gives some idea of the scale of the potential for converting bycatch into direct acquisition of food (Read, 2008). Incentives for such conversion may be particularly prevalent in some developing regions where hunger and poverty are exacerbated by declining fish catches, which results in a growing gap between the supply and demand for food or income (Brashares et al., 2004; Hall et al., 2010). Weak management institutions in many of these regions (Barrett et al., 2001) limit the ability of managers to monitor or respond to net-catches or to address underlying causes driving the killing and retention of captured marine mammals. Also, incentives to not report the capture of marine mammals may stem from managers or bureaucrats attempting to demonstrate on paper, if not in practice, that they are accomplishing their mandated goals. The transition to intentional capture or killing of marine mammals incidentally caught in fishing gear may be a logical adaptation by fishermen seeking new livelihood strategies that foster nutritional or economic security, but it has contributed to what Read (2008) warns is a ‘looming crisis’ in marine mammal conservation.

Establishing if deliberate or incidental catches of marine mammals are cumulatively threatening their populations is problematic. Even in affluent countries with resources dedicated to the conservation of marine mammals, population status and trends are difficult to assess (Taylor et al., 2007). Suggested solutions to the problem of assessment in the United States involve either substantially greater financial investment in surveys or different decision criteria for triggering management actions. Both approaches, however, are unrealistic in regions where funding is more limited and institutions are weaker than in the United States. An alternate approach would be to focus, at least initially, on understanding which groups of people are catching marine mammals, their motivations, and what species or stocks are being affected. This review summarizes what is known about the contemporary global extent and character of marine mammal acquisition for human consumption. We first develop a theoretically coherent way of distinguishing categories of acquisition based on the commons literature (Ostrom et al., 1999), and then use this framework to describe practices in countries around the globe.

## 2. Methods

Mitchell (1975a,b) reviewed porpoise, dolphin, and small whale fisheries around the world, and Brownell et al. (1978) reviewed global marine mammal catches between 1966 and 1975. We developed a database, and initially populated it with catch data from Mitchell (1975a,b) and Brownell et al. (1978) that pertained to the acquisition of products from marine mammals for human consumption since 1970. The choice of 1970 as a starting date for this study allowed us to seamlessly build on the Mitchell and Brownell et al. reviews.

We consulted approximately 900 sources of information, including reports from the International Whaling Commission, North Atlantic Marine Mammal Commission, national management agencies, and non-governmental organizations, the newsletter of the IUCN Sirenia Specialist Group (Sirenews), and personal communications from numerous researchers and managers. We identified academic sources by searching databases of the peer-reviewed literature and library catalogues (particularly of the Marine Mammal Commission, Smithsonian Institution, and International Whaling Commission). We used a ‘snowball approach’ – reviewing references identified in one source after another and contacting local experts as necessary to confirm ambiguous information and provide new leads. Only where we could be certain that the acquisition of marine mammal carcasses provided food for humans (i.e., the focus of this study) was it included. Other taking meant exclusively to obtain such products as animal feed, fishing bait, oil, furs, medicines, or aphrodisiacs, or to control or reduce the marine mammal population (without making use of the killed animals as food), was not included (see full list of sources in Supplementary materials, Tables 1 and 2).

For consistency, species names were adjusted as necessary to reflect the taxonomy recognized by the Society for Marine Mammalogy (SMM, 2009); and we considered countries as those places with a two-letter Federal Information Processing Standard (FIPS) 10-4 code which uniquely identifies countries, dependencies, and areas of special sovereignty. This provided a potential suite of 124 species (Table 1) and 194 independent states and over 60 dependencies or areas of special sovereignty.

**Table 1**  
Taxonomic groupings of marine mammals (SMM, 2009), and if used for human consumption 1970–2009.

Order	Family	Species <sup>b</sup>	Common name	Consumed <sup>a</sup>		
				1970–1989	1990–2009	
Carnivora	Otariidae	<i>Arctocephalus pusillus</i>	Cape fur seal	X	X	
		<i>Arctocephalus gazella</i>	Antarctic fur seal	–	–	
		<i>Arctocephalus tropicalis</i>	Subantarctic fur seal	–	–	
		<i>Arctocephalus australis</i>	South American fur seal	X	X	
		<i>Arctophoca philippii</i>	Juan Fernández fur seal	–	–	
		<i>Callorhinus ursinus</i>	Northern fur seal	X	X	
		<i>Zalophus californianus</i>	California sea lion	X	X	
		<i>Zalophus wollebaeki</i>	Galápagos sea lion	–	–	
		<i>Eumetopias jubatus</i>	Steller sea lion	X	X	
		<i>Neophoca cinerea</i>	Australian sea lion	–	–	
		<i>Phocarcctos hookeri</i>	New Zealand sea lion	–	–	
		<i>Otaria byronia</i>	South American sea lion	X	X	
		Odobenidae	<i>Odobenus rosmarus</i>	Walrus	X	X
			Phocidae	<i>Erignathus barbatus</i>	Bearded seal	X
		<i>Phoca vitulina</i>		Harbor seal	X	X
		<i>Phoca largha</i>		Spotted seal	X	X
		<i>Pusa hispida</i>		Ringed seal	X	X
		<i>Pusa caspica</i>		Caspian seal	–	–
		<i>Pusa sibirica</i>		Baikal seal	X	X
		<i>Halichoerus grypus</i>		Gray seal	X	X
	<i>Histiophoca fasciata</i>	Ribbon seal		X	X	
	<i>Pagophilus groenlandicus</i>	Harp seal		X	X	
	<i>Cystophora cristata</i>	Hooded seal		X	X	
	<i>Monachus monachus</i>	Mediterranean monk seal		–	–	
	<i>Monachus schauinslandi</i>	Hawaiian monk seal		–	–	
	<i>Mirounga leonina</i>	Southern elephant seal		–	–	
	<i>Mirounga angustirostris</i>	Northern elephant seal		–	–	
	<i>Leptonychotes weddellii</i>	Weddell seal		–	–	
	<i>Ommatophoca rossii</i>	Ross seal		–	–	
	<i>Lobodon carcinophaga</i>	Crabeater seal		–	–	
	<i>Hydrurga leptonyx</i>	Leopard seal		–	–	
	Ursidae	<i>Ursus maritimus</i>		Polar bear	X	X
		Mustelidae		<i>Enhydra lutris</i>	Sea otter	–
	<i>Lontra felina</i>		Marine otter	–	–	
	Cetartiodactyla (Cetacea)	Balaenidae	<i>Eubalaena glacialis</i>	North Atlantic right whale	–	–
			<i>Eubalaena japonica</i>	North Pacific right whale	x	x
			<i>Eubalaena australis</i>	Southern right whale	X	–
			<i>Balaena mysticetus</i>	Bowhead whale	X	X
		Neobalaenidae	<i>Caperea marginata</i>	Pygmy right whale	–	x
			Eschrichtiidae	<i>Eschrichtius robustus</i>	Gray whale	X
		Balaenopteridae		<i>Megaptera novaeangliae</i>	Humpback whale	X
<i>Balaenoptera acutorostrata</i>			Common minke whale	X	X	
<i>Balaenoptera bonaerensis</i>			Antarctic minke whale	X	X	
<i>Balaenoptera edeni</i>			Bryde's whale	X	X	
<i>Balaenoptera omurai</i>			Omura's whale	–	X	
<i>Balaenoptera borealis</i>			Sei whale	X	X	
<i>Balaenoptera physalus</i>			Fin whale	X	X	
<i>Balaenoptera musculus</i>			Blue whale	X	†	
Physeteridae			<i>Physeter macrocephalus</i>	Sperm whale	X	X
			Kogiidae	<i>Kogia breviceps</i>	Pygmy sperm whale	X
<i>Kogia sima</i>				Dwarf sperm whale	X	X
Ziphiidae			<i>Ziphius cavirostris</i>	Cuvier's beaked whale	X	X
			<i>Berardius arnuxii</i>	Arnoux's beaked whale	–	–
		<i>Berardius bairdii</i>	Baird's beaked whale	X	X	
		<i>Tasmacetus shepherdi</i>	Shepherd's beaked whale	–	–	
		<i>Indopacetus pacificus</i>	Longman's beaked whale	–	–	
		<i>Hyperoodon ampullatus</i>	Northern bottlenose whale	X	X	
		<i>Hyperoodon planifrons</i>	Southern bottlenose whale	X	X	
		<i>Mesoplodon hectori</i>	Hector's beaked whale	–	–	
		<i>Mesoplodon mirus</i>	True's beaked whale	–	–	
		<i>Mesoplodon europaeus</i>	Gervais' beaked whale	–	x	
		<i>Mesoplodon bidens</i>	Sowerby's beaked whale	–	–	
		<i>Mesoplodon grayi</i>	Gray's beaked whale	–	–	
		<i>Mesoplodon perrini</i>	Perrin's beaked whale	–	–	
		<i>Mesoplodon peruvianus</i>	Pygmy beaked whale	X	X	
		<i>Mesoplodon bowdoini</i>	Andrews' beaked whale	–	–	
		<i>Mesoplodon traversii</i>	Spade-toothed whale	–	–	
		<i>Mesoplodon carlhubbsi</i>	Hubbs' beaked whale	–	x	
		<i>Mesoplodon ginkgodens</i>	Ginkgo-toothed beaked whale	–	x	
		<i>Mesoplodon stejnegeri</i>	Stejneger's beaked whale	–	x	
		<i>Mesoplodon layardii</i>	Strap-toothed beaked whale	–	X	
		<i>Mesoplodon densirostris</i>	Blainville's beaked whale	–	X	

Table 1 (continued)

Order	Family	Species <sup>b</sup>	Common name	Consumed <sup>a</sup>	
				1970–1989	1990–2009
	Platanistidae	<i>Platanista gangetica</i>	South Asian river dolphin	X	X
	Iniidae	<i>Inia geoffrensis</i>	Boto	X	X
	Pontoporiidae	<i>Pontoporia blainvillei</i>	Franciscana	X	X
	Monodontidae	<i>Monodon monoceros</i>	Narwhal	X	X
	Delphinidae	<i>Delphinapterus leucas</i>	Beluga	X	X
		<i>Cephalorhynchus commersonii</i>	Commerson's dolphin	X	–
		<i>Cephalorhynchus eutropia</i>	Chilean dolphin	X	X
		<i>Cephalorhynchus heavisidii</i>	Heaviside's dolphin	X	–
		<i>Cephalorhynchus hectori</i>	Hector's dolphin	–	–
		<i>Steno bredanensis</i>	Rough-toothed dolphin	X	X
		<i>Sousa teuszii</i>	Atlantic hump back dolphin	X	X
		<i>Sousa chinensis</i>	Indo-Pacific hump back dolphin	X	X
		<i>Sotalia fluviatilis</i>	Tucuxi	X	X
		<i>Sotalia guianensis</i>	Guiana dolphin	‡	X
		<i>Tursiops truncatus</i>	Common bottlenose dolphin*	}X	X
		<i>Tursiops aduncus</i>	Indo-Pacific bottlenose dolphin*		X
		<i>Stenella attenuata</i>	Pantropical spotted dolphin	X	X
		<i>Stenella frontalis</i>	Atlantic spotted dolphin	X	X
		<i>Stenella longirostris</i>	Spinner dolphin	X	X
		<i>Stenella clymene</i>	Clymene dolphin	–	X
		<i>Stenella coeruleoalba</i>	Striped dolphin	X	X
		<i>Delphinus delphis</i>	Short-beaked common dolphin*	}X	X
		<i>Delphinus capensis</i>	Long-beaked common dolphin*		X
		<i>Lagenodelphis hosei</i>	Fraser's dolphin	X	X
		<i>Lagenorhynchus albirostris</i>	White-beaked dolphin	X	X
		<i>Lagenorhynchus acutus</i>	Atlantic white-sided dolphin	X	X
		<i>Lagenorhynchus obliquidens</i>	Pacific white-sided dolphin	X	X
		<i>Lagenorhynchus obscurus</i>	Dusky dolphin	X	X
		<i>Lagenorhynchus australis</i>	Peale's dolphin	X	X
		<i>Lagenorhynchus cruciger</i>	Hourglass dolphin	–	–
		<i>Lissodelphis borealis</i>	Northern right-whale dolphin	X	X
		<i>Lissodelphis peronii</i>	Southern right-whale dolphin	X	X
		<i>Grampus griseus</i>	Risso's dolphin	X	X
		<i>Peponocephala electra</i>	Melon-headed whale	X	X
		<i>Feresa attenuata</i>	Pygmy killer whale	X	X
		<i>Pseudorca crassidens</i>	False killer whale	X	X
		<i>Orcinus orca</i>	Killer whale	X	X
		<i>Globicephala melas</i>	Long-finned pilot whale	X	X
	<i>Globicephala macrorhynchus</i>	Short-finned pilot whale	X	X	
	<i>Orcaella brevirostris</i>	Irrawaddy dolphin	–	X	
	<i>Orcaella heinsohni</i>	Australian snubfin dolphin	–	–	
	Phocoenidae	<i>Neophocaena phocaenoides</i>	Indo-Pacific finless porpoise*	}X	}X
		<i>Neophocaena asiaorientalis</i>	Narrow-ridged finless porpoise*		
		<i>Phocoena phocoena</i>	Harbor porpoise	X	X
		<i>Phocoena sinus</i>	Vaquita	–	–
		<i>Phocoena spinipinnis</i>	Burmeister's porpoise	X	X
		<i>Phocoena dioptrica</i>	Spectacled porpoise	X	–
		<i>Phocoenoides dalli</i>	Dall's porpoise	X	X
Sirenia	Trichechidae	<i>Trichechus manatus</i>	West Indian manatee	X	X
		<i>Trichechus senegalensis</i>	West African manatee	X	X
		<i>Trichechus inunguis</i>	Amazonian manatee	X	X
	Dugongidae	<i>Dugong dugong</i>	Dugong	X	X

<sup>a</sup> X = reported as consumed; x = reported as consumed, but never confirmed as more than one in a year; – = no reports of consumption.

<sup>b</sup> Cetacean species regarded as 'large cetaceans,' i.e. those falling within the competence of the International Whaling Commission are the Balaenidae, Neobalaenidae, Eschrichtiidae, Balaenopteridae, Physeteridae; all other cetaceans are regarded as "small cetaceans" in this review.

<sup>†</sup> No blue whales since 1972, but blue/fin hybrids reportedly caught in Iceland have been consumed in Japan (Cipriano and Palumbi, 1999).

<sup>‡</sup> The Guiana dolphin has only recently been described so some earlier catches of this species may have been denoted as tucuxi.

\* Due to changes in taxonomy since 1970, we do not distinguish between species of *Delphinus*, *Tursiops*, and *Neophocaena*, except in this table.

To characterize catches of marine mammals for human consumption, we first determine whether the (1) catching and (2) killing of the marine mammal were intentional. We then determine whether the person(s) who acquired the marine mammal carcass intended to (3) consume, or, alternatively, (4) exchange or sell the products to other people who would then consume them as food. These four attributes relate to the two collective action problems that usually require resolution for effective conservation of common-pool resources such as marine mammals (Ostrom et al., 1999). First, internal or external rules controlling access (i.e., the catching) are needed; and second, rules that constrain the behavior of those doing the catching (i.e., killing the animal and using the

carcass) are needed. The question of intent is further used to distinguish three categories of acquisition of marine mammals as food for humans – Targeted, Non-Targeted-Deliberate, and Non-Targeted-Salvage (Table 2).

We follow Hall (1996) by making the distinction between catches that were Targeted – the captured species is/are the primary objective of the operation – and catches that were Non-Targeted. Such acquisition is distinguished from 'bycatch,' which is by definition discarded (Hall, 1996). Differentiating accidental drowning in fishing gear (Non-Targeted-Salvage) from deliberate killing while targeting fish (Non-Targeted-Deliberate), or even from Targeted acquisition, is often difficult (e.g., see Lukoschek et al.,

**Table 2**  
Criteria for categorizing the acquisition of marine mammals.

Category of acquisition	Intent	
	Catch	Kill
Targeted	Yes	Yes
Non-Targeted-Deliberate	No	Yes
Non-Targeted-Salvage	No	No

**Table 3**  
Criteria for categorizing the use of marine mammal carcasses for consumption.

Category of consumption	Intent	
	Consume	Exchange
Primary consumption	Yes	No
Secondary consumption	No	Yes

2009). Death in fishing operations usually results from drowning or suffocation (particularly in conjunction with gill nets, trawl nets, purse seines, pot or trap lines, and longlines), but in some circumstances animals are killed deliberately when captured alive in non-lethal gear (such as seine or pound nets or weirs). Such acquisition reflects greater intent to acquire a carcass than our salvage category where we would expect fishermen to try to avoid capture, or attempt to release a live marine mammal. Presence of economic incentives to kill and retain captured marine mammals, such as markets for food products, are an important distinction between our Salvage and Deliberate categories of Non-Targeted acquisition.

Marine mammals may have profound nutritional, social, and cultural importance in some communities and in some places they may also have an inherent exchange value. We do not distinguish commodities sold for cash from those that are exchanged for other forms of remuneration. There is, after all, a general lack of consensus on what levels of cash exchange are appropriate for making such distinctions (Reeves, 2002). For example, Takekawa (1996) describes how dolphin teeth are used as currency by Fanalei hunters in the Solomon Islands, and Gurven (2004) discusses the complex social and economic motivations driving the acquisition and distribution of food products in subsistence societies. In this paper, we differentiate consumption by the catcher and his or her immediate kin and social network from consumption by someone else following exchange (including sale) of marine mammal parts into wider networks and commodity streams. Therefore, after assigning a case to one of the three categories of acquisition, we establish for each country (and only for cases since 1990) whether the products were or were not exchanged outside local kin and social networks. By doing so, we make what we consider an important distinction between internal and external (including foreign) demand for marine mammal products for human consumption (Table 3).

We acknowledge some biases in our data. First, the illegality of killing and possessing marine mammals often results in their covert acquisition and consumption, although DNA analysis of market products is shedding some light on such practices in a few areas (e.g., Baker and Palumbi, 1994; Baker, 2008). Second, corruption of officials, or lack of attention to *de facto* practices, can lead to under-reporting, which in some cases is probably substantial. Third, market or landing-site surveys underestimate total numbers of animals killed and consumed because they miss animals that are processed or consumed at sea, as well as animals that are landed at locations and times when monitors are not present. Only a few percent of the marine mammals actually consumed may be noted in official reports. We sought to address this bias at least partially by including information on consumption taking place on fishing boats or in homes, which is typically reported in social science studies based on interviews, questionnaires, and direct obser-

vation. Fourth, non-directed catches (e.g., use of stranded animals or animals incidentally caught in fishing gear) are often reported only anecdotally in non-scientific media. Again, we obtained, critically evaluated, and, when appropriate, included media reports in our database, but we recognize that many such reports could have escaped our attention. Collectively, we expect that these four factors bias our data toward underestimating the overall extent and magnitude of acquisition and consumption.

### 3. Results

#### 3.1. Extent of human consumption of marine mammals

Since 1970, one or more of at least 92 species of marine mammals (Table 1) have been either captured deliberately or incidentally or obtained opportunistically for human consumption in at least 125 countries (Table 4). We found evidence for a slightly larger array of countries and a greater number of species since 1990 than we found for the period 1970–1989, but this can be attributed primarily to more extensive reporting in the last two decades (Table 5). We found no evidence from 1990 to the present of people catching and consuming five of the species of cetaceans reported in the 1970s or 1980s (southern right whale, blue whale, spectacled porpoise, Commerson's dolphin, and Heaviside's dolphin; Table 1), and no evidence of consumption in 11 countries where evidence of consumption had been found in the 1970s or 1980s (Table 4).

A few directed hunts ended well before 1990, such as the Newfoundland drive hunt for small cetaceans (Fielding, 2007) and some, such as whaling for humpback whales at Bequia (St. Vincent and the Grenadines) and the hunting of dugongs in the Andaman Islands (India), have declined in extent as a result of death or retirement of key individuals (Price, 1985; Das, 1996). Some hunts faded away as marine mammals became locally rare, a common result of overly intensive hunting (Marsh et al., 2002). Conversely, in other areas, hunting for food increased. For example, the collapse of the Soviet Union in the early 1990s led to Chukotkan people consuming more marine mammal meat (e.g., bowhead whales and gray whales), which is now an order of magnitude cheaper for the consumer than store-bought alternatives (Litovka, 2008). Hunts are also being revitalized as aboriginal groups reestablish pre-colonial traditions. For example, the Makah have initiated the hunting of gray whales, and expressed interest in resuming their 'suspended use' of humpback whales (Sepez, 2008); the Iwi tribes of New Zealand continue to seek permission to collect and consume edible products from stranded whales (Cawthorn, 1997; pers. comm., 14 April 2010); British Columbia First Nations have been seeking permission to hunt large cetaceans (Reeves, 2009); and the Bitu 'Ama community of the Solomon Islands reportedly were planning to resume drive hunting for small cetaceans (Kahn, 2006).

Our estimates of the number of carcasses used for consumption suggest that in at least 27 countries, 100s or 1000s of marine mammals provide food for human consumption each year (Table 6; Fig. 1A). Many of the countries with the greatest use of marine mammals for food (many thousands per year) are at least partly in high northern latitudes, although Japan is by far the largest consumer of marine mammals based on the annual number of animals killed for consumption. Forty-eight countries could not be classified for a minimum magnitude of usage due to lack of data, although for most we expect catches and consumption to be low.

People in some countries consume large numbers of only a single species, such as the dugong in Australia, whereas in other countries, people may consume a suite of as many as 32 species (Japan since 1990; Table 6; Fig. 1B). People in at least 12 countries



**Table 4**

Marine mammal species caught and used for human consumption by country (or dependency) during the period 1970–2009 (ordered: large then small cetaceans, pinnipeds, sirenians, fissipeds).

Region <sup>a</sup>	Sub-region <sup>a</sup>	Country <sup>b</sup>	Species taken <sup>c</sup>	
Americas	<u>Northern America</u>	Canada	Bowhead whale, (common minke whale), beluga, narwhal, harbor porpoise, (long-finned pilot whale), ( <i>Risso's dolphin</i> ), (Atlantic white-sided dolphin), <i>Pacific white-sided dolphin</i> , white-beaked dolphin, (killer whale), hooded seal, bearded seal, gray seal, harp seal, ringed seal, harbor seal, Steller sea lion, walrus, polar bear	
		Greenland	Bowhead whale, common minke whale, <i>sei whale</i> , fin whale, humpback whale, (sperm whale), beluga, narwhal, harbor porpoise, long-finned pilot whale, Atlantic white-sided dolphin, white-beaked dolphin, killer whale, hooded seal, bearded seal, harp seal, ringed seal, harbor seal, walrus, polar bear	
		United States	Bowhead whale, gray whale, (common minke whale), <i>sei whale</i> , <i>humpback whale</i> , beluga, <i>harbor porpoise</i> , bearded seal, ribbon seal, ringed seal, spotted seal, harbor seal, northern fur seal, Steller sea lion, California sea lion, walrus, <i>sea otter</i> , polar bear	
	<u>Central America</u>	Belize	West Indian manatee	
		Costa Rica*	West Indian manatee	
		Guatemala*	West Indian manatee	
		Honduras	West Indian manatee	
		Mexico	West Indian manatee	
		Nicaragua	West Indian manatee	
		Panama	West Indian manatee	
		<u>Caribbean</u>	Cuba	West Indian manatee
			(Dominica)	(Killer whale), (short-finned pilot whale), (unspecified delphinids)
			Dominican Republic	West Indian manatee
	Haiti		Unspecified delphinids, (West Indian manatee)	
	Jamaica		West Indian manatee	
	(Martinique)		(Killer whale), (short-finned pilot whale), (unspecified delphinids)	
	Puerto Rico		West Indian manatee	
	St. Lucia		( <i>Sperm whale</i> ), common dolphin, pygmy killer whale, short-finned pilot whale, Fraser's dolphin, killer whale, melon-headed whale, false killer whale, (pantropical spotted dolphin), Clymene dolphin, striped dolphin, Atlantic spotted dolphin, bottlenose dolphin	
	St. Vincent and the Grenadines		<i>Bryde's whale</i> , humpback whale, (sperm whale), dwarf sperm whale, (pygmy killer whale), short-finned pilot whale, Risso's dolphin, Fraser's dolphin, killer whale, melon-headed whale, false killer whale, (pantropical spotted dolphin), Clymene dolphin, striped dolphin, Atlantic spotted dolphin, spinner dolphin, rough-toothed dolphin, (bottlenose dolphin), ( <i>unspecified beaked whales</i> )	
	Trinidad and Tobago*		Striped dolphin, bottlenose dolphin, West Indian manatee	
	<u>South America</u>	Argentina	Franciscana, Burmeister's porpoise, common dolphin, dusky dolphin	
		Bolivia	Boto	
		Brazil	(Antarctic minke whale), ( <i>sei whale</i> ), <i>Bryde's whale</i> , (fin whale), ( <i>humpback whale</i> ), (sperm whale), <i>pygmy sperm whale</i> , dwarf sperm whale, franciscana, (common dolphin), short-finned pilot whale, Fraser's dolphin, (false killer whale), tucuxi, Guiana dolphin, Atlantic spotted dolphin, spinner dolphin, (rough-toothed dolphin), bottlenose dolphin, ( <i>southern bottlenose whale</i> ), <i>Gervais' beaked whale</i> , ( <i>Cuvier's beaked whale</i> ), Amazonian manatee, West Indian manatee	
		Chile	(Southern right whale), <i>pygmy right whale</i> , ( <i>sei whale</i> ), (blue whale), (fin whale), (sperm whale), Burmeister's porpoise, (Commerson's dolphin), Chilean dolphin, long-finned pilot whale, Peale's dolphin, (bottlenose dolphin), South American fur seal	
		Colombia	Boto, Amazonian manatee, West Indian manatee	
		Ecuador	Amazonian manatee	
		French Guiana*	Unspecified delphinids, West Indian manatee	
		Peru	Common minke whale, ( <i>sei whale</i> ), (fin whale), (sperm whale), (pygmy sperm whale), (dwarf sperm whale), Burmeister's porpoise, common dolphin, (pygmy killer whale), short-finned pilot whale, long-finned pilot whale, Risso's dolphin, false killer whale, dusky dolphin, southern right whale dolphin, pantropical spotted dolphin, bottlenose dolphin, pygmy beaked whale, <i>Cuvier's beaked whale</i> , South American fur seal, South American sea lion, Amazonian manatee	
		Suriname	West Indian manatee	
		(Uruguay)	(Spectacled porpoise)	
		Venezuela	(Boto), common dolphin, tucuxi, Clymene dolphin, Atlantic spotted dolphin, spinner dolphin, bottlenose dolphin, West Indian manatee	
		Europe	<u>Northern Europe</u>	Denmark
Estonia	Gray seal, ringed seal			
Faeroe Islands	(Common minke whale), (fin whale), harbor porpoise, long-finned pilot whale, Atlantic white-sided dolphin, white-beaked dolphin, (killer whale), bottlenose dolphin, northern bottlenose whale, <i>gray seal</i>			
Finland	Gray seal, (ringed seal)			
Iceland	common minke whale, ( <i>sei whale</i> ), fin whale, humpback whale, (sperm whale), harbor porpoise, white-beaked dolphin, (killer whale), bearded seal, gray seal, harbor seal			
(Latvia)	(gray seal)			
Norway	Common minke whale, ( <i>sei whale</i> ), (fin whale), ( <i>sperm whale</i> ), <i>harbor porpoise</i> , (long-finned pilot whale), ( <i>killer whale</i> ), ( <i>northern bottlenose whale</i> ), hooded seal, bearded seal, gray seal, harp seal, ringed seal, harbor seal			
Sweden*	Gray seal, harbor seal			
<u>Western Europe</u>	France			(Harbor porpoise), (common dolphin), (long-finned pilot whale), (Risso's dolphin), (striped dolphin), (bottlenose dolphin), unspecified delphinids, <i>gray seal</i> , <i>harp seal</i>
	(Germany [only former GDR])			(Common minke whale), (unspecified small cetaceans)

(continued on next page)

Table 4 (continued)

Region <sup>a</sup>	Sub-region <sup>a</sup>	Country <sup>b</sup>	Species taken <sup>c</sup>
	<u>Eastern Europe</u>	Bulgaria	Harbor porpoise, common dolphin, bottlenose dolphin
		Georgia*	<i>Unspecified delphinids</i>
		Russian Federation	Bowhead whale, ( <i>Pacific right whale</i> ), gray whale, common minke whale, (sei whale), (Bryde's whale), (blue whale), (fin whale), (sperm whale), beluga, (harbor porpoise), (long-finned pilot whale), <i>killer whale</i> , (southern bottlenose whale), hooded seal, bearded seal, ribbon seal, harp seal, ringed seal, spotted seal, harbor seal, Baikal seal, northern fur seal, (Steller sea lion), walrus, polar bear
		Ukraine*	Harbor porpoise, common dolphin, bottlenose dolphin
	<u>Southern Europe</u>	Italy	Common dolphin, long-finned pilot whale, Risso's dolphin, striped dolphin, bottlenose dolphin ( <i>Humpback whale</i> ), (blue whale), (sperm whale), ( <i>harbor porpoise</i> ), common dolphin, ( <i>unspecified pilot whale</i> ), (striped dolphin), ( <i>bottlenose dolphin</i> )
		Portugal	( <i>Sei whale</i> ), (fin whale), ( <i>humpback whale</i> ), (sperm whale), common dolphin, long-finned pilot whale, bottlenose dolphin
		Spain	( <i>Sei whale</i> ), (fin whale), ( <i>humpback whale</i> ), (sperm whale), common dolphin, long-finned pilot whale, bottlenose dolphin
Africa	<u>Northern Africa</u>	Egypt, Arab Rep.	Dugong
		Sudan	Dugong
	<u>Western Africa</u>	Benin	West African manatee
		Cape Verde	( <i>Humpback whale</i> ), common dolphin, melon-headed whale, bottlenose dolphin
		Côte d'Ivoire	<i>Unspecified delphinids</i> , west African manatee
		Gambia, The	Atlantic humpback dolphin, bottlenose dolphin, west African manatee
		Ghana	<i>Humpback whale</i> , sperm whale, <i>dwarf sperm whale</i> , common dolphin, short-finned pilot whale, Pygmy killer whale, Risso's dolphin, Fraser's dolphin, melon-headed whale, false killer whale, pantropical spotted dolphin, Clymene dolphin, Atlantic spotted dolphin, spinner dolphin, rough-toothed dolphin, bottlenose dolphin, <i>Cuvier's beaked whale</i> , west African manatee
		Guinea	( <i>Common minke whale</i> ), Bryde's whale, pygmy sperm whale, Atlantic humpback dolphin, bottlenose dolphin, west African manatee
		Guinea-Bissau	<i>Unspecified delphinids</i> , west African manatee
		Liberia	West African manatee
		Mali	West African manatee
		Mauritania	Atlantic humpback dolphin, unspecified other delphinids
		Niger	West African manatee
		Nigeria	Bottlenose dolphin, west African manatee
		(Saint Helena)	(pantropical spotted dolphin), (bottlenose dolphin)
		Senegal	<i>Common minke whale</i> , Bryde's whale, harbor porpoise, common dolphin, (pygmy killer whale), short-finned pilot whale, (Risso's dolphin), Atlantic humpback dolphin, pantropical spotted dolphin, (rough-toothed dolphin), bottlenose dolphin, west African manatee
		Sierra Leone	<i>Unspecified delphinids</i> , west African manatee
		Togo	<i>Antarctic minke whale</i> , <i>humpback whale</i> , west African manatee
	<u>Middle Africa</u>	Angola	West African manatee
		Cameroon	<i>Humpback whale</i> , <i>sperm whale</i> , unspecified delphinids, west African manatee
		Chad	West African manatee
		Congo, Dem. Rep.	West African manatee
		Congo, Rep.	Atlantic humpback dolphin, bottlenose dolphin, west African manatee
		Equatorial Guinea	<i>Humpback whale</i> , west African manatee
		Gabon	Common dolphin, false killer whale, bottlenose dolphin, west African manatee
		São Tomé and Príncipe*	<i>Unspecified delphinids</i>
	<u>Southern Africa</u>	Namibia	(Heaviside's dolphin), Cape fur seal
		South Africa	( <i>Common minke whale</i> ), (Bryde's whale), (fin whale), <i>humpback whale</i> , (sperm whale), (Heaviside's dolphin), (common dolphin), Risso's dolphin, Fraser's dolphin, dusky dolphin, ( <i>killer whale</i> ), (bottlenose dolphin), strap-toothed whale, (Cape fur seal)
	<u>Eastern Africa</u>	Comoros	Dugong
		Djibouti*	Dugong
		Eritrea*	Dugong
		Kenya	Dugong
		Madagascar	<i>Humpback whale</i> , <i>sperm whale</i> , <i>dwarf sperm whale</i> , Fraser's dolphin, <i>killer whale</i> , melon-headed whale, Indo-Pacific humpback dolphin, spinner dolphin, bottlenose dolphin, dugong
		Mayotte	<i>Dugong</i>
		Mozambique	Indo-Pacific humpback dolphin, dugong
		Seychelles	Spinner dolphin, bottlenose dolphin
		Somalia	<i>Unspecified delphinids</i> , (dugong)
		Tanzania	<i>Humpback whale</i> , Risso's dolphin, Indo-Pacific humpback dolphin, pantropical spotted dolphin, spinner dolphin, rough-toothed dolphin, bottlenose dolphin, dugong
Asia	<u>Western Asia</u>	Bahrain*	Dugong
		Georgia	Harbor porpoise, common dolphin, bottlenose dolphin
		(Israel)	( <i>Common dolphin</i> ), (bottlenose dolphin)
		Oman	( <i>Dwarf sperm whale</i> ), common dolphin, Indo-Pacific humpback dolphin, spinner dolphin, bottlenose dolphin
		Qatar*	Dugong
		Saudi Arabia	Dugong
		Turkey	<i>Harbor porpoise</i> , ( <i>common dolphin</i> ), ( <i>bottlenose dolphin</i> )
		United Arab Emirates	( <i>Common dolphin</i> ), dugong
		Yemen, Rep.*	Dugong

Table 4 (continued)

Region <sup>a</sup>	Sub-region <sup>a</sup>	Country <sup>b</sup>	Species taken <sup>c</sup>
	<u>Eastern Asia</u>	China	(Common minke whale), <i>unspecified large cetacean</i> , finless porpoise, (false killer whale), spinner dolphin, other unspecified small cetaceans, gray seal, harp seal, (dugong)
		Japan	<i>North Pacific right whale</i> , <i>gray whale</i> , common minke whale, Antarctic minke whale, sei whale, Bryde's whale, fin whale, <i>humpback whale</i> , <i>blue/fin hybrid whale</i> , sperm whale, (pygmy sperm whale), dwarf sperm whale, (finless porpoise), (harbor porpoise), Dall's porpoise, common dolphin, (pygmy killer whale), short-finned pilot whale, Risso's dolphin, Fraser's dolphin, Pacific white-sided dolphin, northern right whale dolphin, killer whale, melon-headed whale, false killer whale, pantropical spotted dolphin, striped dolphin, (spinner dolphin), rough-toothed dolphin, bottlenose dolphin, Baird's beaked whale, <i>Hubbs' beaked whale</i> , <i>Blainville's beaked whale</i> , <i>Cuvier's beaked whale</i> , (bearded seal), gray seal, harp seal, (ribbon seal), (ringed seal), spotted seal, Steller sea lion, (dugong)
		(Korea, Dem. Rep.) Korea, Rep.	Unknown but likely at least includes large cetaceans in the 1970s ( <i>Pacific right whale</i> ), common minke whale, Antarctic minke whale, Bryde's whale, (fin whale), <i>humpback whale</i> , (sperm whale), finless porpoise, harbor porpoise, common dolphin, short-finned pilot whale, Risso's dolphin, Pacific white-sided dolphin, killer whale, false killer whale, bottlenose dolphin, Baird's beaked whale, <i>Blainville's beaked whale</i> , <i>Stejneger's beaked whale</i> , <i>Cuvier's beaked whale</i> , spotted seal, (dugong)
		Taiwan	<i>Common minke whale</i> , (Bryde's whale), <i>sperm whale</i> , pygmy sperm whale, dwarf sperm whale, short-finned pilot whale, common dolphin, Risso's dolphin, Fraser's dolphin, killer whale, false killer whale, pantropical spotted dolphin, (striped dolphin), spinner dolphin, rough-toothed dolphin, bottlenose dolphin, <i>ginkgo-toothed beaked whale</i> , gray seal, harp seal, (dugong).
	<u>South-Eastern Asia</u>	Cambodia*	Irrawaddy dolphin, Indo-Pacific humpback dolphin, dugong
		Indonesia	Unspecified minke whale, Bryde's whale, (fin whale), <i>humpback whale</i> , sperm whale, (pygmy sperm whale), dwarf sperm whale, pygmy killer whale, short-finned pilot whale, Risso's dolphin, Fraser's dolphin, Irrawaddy dolphin, killer whale, melon-headed whale, false killer whale, pantropical spotted dolphin, spinner dolphin, Bottlenose dolphin, <i>Blainville's beaked whale</i> , <i>Cuvier's beaked whale</i> , dugong
		Malaysia	Finless porpoise, Irrawaddy dolphin, pantropical spotted dolphin, spinner dolphin, bottlenose dolphin, dugong
		Myanmar	Finless porpoise, Irrawaddy dolphin, Indo-Pacific humpback dolphin, spinner dolphin, bottlenose dolphin, dugong
		Philippines	<i>Common minke whale</i> , Bryde's whale, Omura's whale, ( <i>humpback whale</i> ), ( <i>sperm whale</i> ), pygmy sperm whale, dwarf sperm whale, pygmy killer whale, short-finned pilot whale, Risso's dolphin, Fraser's dolphin, Irrawaddy dolphin, melon-headed whale, pantropical spotted dolphin, striped dolphin, spinner dolphin, bottlenose dolphin, <i>Blainville's beaked whale</i> , dugong
		Thailand*	Irrawaddy dolphin, unspecified delphinids, dugong
		Vietnam*	<i>Risso's dolphin</i> , dugong
	<u>Southern Asia</u>	Bangladesh	South Asian river dolphin
		India	South Asian river dolphin, finless porpoise, common dolphin, Risso's dolphin, Indo-Pacific humpback dolphin, (pantropical spotted dolphin), spinner dolphin, bottlenose dolphin, dugong
		(Nepal)	(South Asian river dolphin)
		Pakistan	<i>South Asian river dolphin</i>
		Sri Lanka	( <i>Fin whale</i> ), ( <i>sperm whale</i> ), pygmy sperm whale, dwarf sperm whale, common dolphin, pygmy killer whale, (short-finned pilot whale), Risso's dolphin, Fraser's dolphin, (killer whale), melon-headed whale, false killer whale, pantropical spotted dolphin, striped dolphin, spinner dolphin, rough-toothed dolphin, bottlenose dolphin, southern bottlenose whale, ( <i>Cuvier's beaked whale</i> ), dugong
Oceania	<u>Australia and New Zealand</u>	Australia	Dugong
		New Zealand	<i>Unspecified cetacean</i>
	<u>Melanesia</u>	New Caledonia	( <i>Short-finned pilot whale</i> ), <i>bottlenose dolphin</i> , dugong
		Papua New Guinea	(Common dolphin), (Risso's dolphin), (pantropical spotted dolphin), (spinner dolphin), (rough-toothed dolphin), dugong
		Solomon Islands	(Common dolphin), (pygmy killer whale), Risso's dolphin, Fraser's dolphin, (false killer whale), pantropical spotted dolphin, striped dolphin, spinner dolphin, (rough-toothed dolphin), <i>Cuvier's beaked whale</i> , dugong
		Vanuatu	( <i>Short-finned pilot whale</i> ), dugong
	<u>Micronesia</u>	Kiribati	Melon-headed whale, unspecified delphinids
		Marshall Islands*	Melon-headed whale, unspecified delphinids
		Micronesia, Fed. Sts.* (Northern Mariana Islands)	Unspecified delphinids (Sperm whale)
		Palau	Dugong
	<u>Polynesia</u>	(French Polynesia)	(Unspecified delphinids)
		Tonga	<i>Humpback whale</i>

<sup>a</sup> United Nations Statistics Division standard geographical regions recommended for statistical use.

<sup>b</sup> Countries are places with a two-letter United States Federal Information Processing Standard (FIPS) 10–4 code; encompassing independent states, dependencies, and areas of special sovereignty. We only include countries where consumption was confirmed since 1970. Countries listed in parentheses are only confirmed for 1970–1989; and countries with a \* are only confirmed for 1990–2009. Those we report only since 1990 (i.e., with a \*) may reflect a lack of reporting in previous years, represent new practices, or be in newly recognized countries (e.g., Ukraine and Georgia).

<sup>c</sup> Species listed in parentheses are only confirmed for 1970–1989. Italicized species represent rare use of a stranding or idiosyncratic catches by a few individuals (catches <1 per year). Dotted underlines represent species consumed exclusively from imports.

*Delphinus*, *Tursiops*, and *Neophocaena* species designations remain the topic of taxonomic debate and were unresolved during the period of this study (1970 to present). Therefore, we only use the genus-level 'common dolphin,' 'bottlenose dolphin,' and 'finless porpoise' designations, respectively. We also caution with respect to the difficulties in field identification of *Kogia* spp., minke whales in the southern hemisphere, and delphinids and baleen whales generally.

Other species may have been caught and consumed prior to 1970, but are not included here.

Marine mammals may be targeted or incidentally caught outside of a country's territorial boundaries and legally imported or smuggled. We attribute catches to countries according to the nationalities of the consumer.



**Table 5**

Number of countries with evidence of marine mammal consumption, and number of species consumed during the periods 1970–1989 and 1990–2009.

	Period		Overall
	1970–1989	1990–2009	
Countries reporting consumption:	107	114	125
Number of species consumed:			
Large cetaceans	12	12	14
Small cetaceans <sup>a</sup>	45 <sup>a</sup>	51 <sup>a</sup>	54 <sup>a</sup>
Pinnipeds	16	16	16
Sirenians	4	4	4
Fissipeds	1	2	2
Total species <sup>a</sup>	78 <sup>a</sup>	85 <sup>a</sup>	90 <sup>a</sup>

<sup>a</sup> *Delphinus*, *Tursiops*, and *Neophocaena* are each counted as one species for comparisons between periods.

consumed 15 or more species of marine mammals; six of these countries were in Asia, four in the Arctic, one in South America, and one in West Africa (Table 6). About two thirds of all marine mammal species have been subject to consumption in at least one country since 1990, the primary exceptions being several protected species of large cetaceans, some species (e.g. beaked whales) that occur far offshore and are rarely observed, and the Antarctic seals.

With respect to categories of acquisition since 1990 (Tables 2 and 3), only 16 countries were exclusively in our Non-Targeted-Salvage category, reflecting the predominance of intentional killing in the other 98 (86%) countries reporting consumption. In at least 50 countries, products were distributed into markets and other commodity chains, sometimes including exports to other countries (Table 6). We discuss these attributes below, starting with modes of acquisition, and then how products have been exchanged.

### 3.2. Non-Targeted-Salvage acquisition of marine mammals

Non-Targeted-Salvage acquisition is characterized by the lack of intent (and usually a lack of incentives) to capture or kill the animal, which is usually found (a) stranded, or (b) inadvertently drowned in a net, trap, or line.

#### 3.2.1. Strandings

Strandings were historically regarded as divine 'gifts' and gained cultural significance in places such as Brazil (Castilho, 2008), Tierra Del Fuego (Piana, 2005), southern and western Africa (Findlay et al., 1992; Weir, 2010), North Sulawesi (Mous and DeVantier, 2001), and New Zealand (Cawthorn, 1997). Elsewhere, times of hardship and food scarcity encouraged the scavenging of stranded animals to alleviate hunger. The Makah (United States) historically hunted both gray and humpback whales, but used beached gray whales for food during the Great Depression of the 1930s, and anecdotal reports suggest the practice continued at least to the 1980s (Sepez, 2008). We confirmed Non-Targeted-Salvage acquisition and consumption of strandings in 26 countries since 1990 (Table 6).

#### 3.2.2. Inadvertent captures in fishing gear

In the former German Democratic Republic, marine mammals (including common minke whales) drowned in fishing nets were reported to be utilized in government food programs (Heidbrink, pers. comm., 19 January 2010). Similar distribution of marine mammal products derived from animals inadvertently drowned in fishing gear continues in Greenland and many Asian countries (but see below on the targeted nature of some of these catches). In developing regions, marine mammals may have been released or broken free from traditional gear in the past, but they rarely are able to escape after being caught in nylon and other synthetic

nets that proliferated around the world after their introduction in the 1950s (Leatherwood and Reeves, 1989; Valdemarsen, 2001). Some fishermen, such as at Kakinada in India, report that they have always retained and often consumed cetaceans drowned inadvertently in fishing nets, but deny deliberately killing them (Yousuf et al., 2009). Evidence of consumption of Non-Targeted-Salvaged marine mammals caught in fishing gear was found in 76 countries since 1990 (Table 6).

### 3.3. Non-Targeted-Deliberate acquisition of marine mammals

Whereas Non-Targeted-Salvage involves the use of inadvertently killed marine mammals, Non-Targeted-Deliberate acquisition reflects the intentional killing of marine mammals when they are (a) found live-stranded on beaches, (b) entrapped by sea ice in high latitudes, or (c) caught alive in fishing gear. Only 10 of the 57 countries with Non-Targeted-Deliberate acquisition of marine mammals did not also have evidence of Targeted hunting.

#### 3.3.1. Strandings

Deliberate killing of stranded animals for food is reported in relatively few (10) countries around the world since 1990 (Table 6).

#### 3.3.2. Entrapment

Ice entrapments of marine mammals such as narwhals can provide unplanned opportunities for acquisition of marine mammals for food. For example, in 2008, at least 629 narwhals were killed by hunters in Nunavut (Canada) during an ice entrapment (NAM-MCO, 2009). We found evidence for such acquisition only in Canada and Greenland (Table 6) although it may also occur in Alaska (USA) and northern Russia.

#### 3.3.3. Incidental captures in fishing gear

Direct observations or interviews with fishermen and community members provided evidence for the Non-Targeted-Deliberate acquisition of marine mammals by fishermen for food in 54 countries since 1990 (Table 6).

Use of non-targeted marine mammals killed in fishing gear (excluding set and trap nets which we regard as targeted and are described below) for public food programs has been a consistent practice in Japan since the mid-1900s (Endo and Yamao, 2007), and in both Japan and Korea the food produced from these non-targeted animals is also now distributed into commercial markets (Ishihara and Yoshii, 2000; Kang and Phipps, 2000). Incidentally caught small cetaceans were discarded at Selinog Island in the Philippines until the 1960s when a dolphin was incidentally caught by fishermen, cooked, and found palatable; this led to increased demand for and commerce in cetacean meat, with small cetaceans caught in gear increasingly killed by fishermen (Dolar et al., 1994; Dolar, 1999). In Sri Lanka, small cetaceans incidentally caught in small-scale fisheries have been used for human consumption since at least the 1950s (Dayaratne and Joseph, 1993; Leatherwood and Reeves, 1989). Small cetaceans captured in Sri Lanka's industrial fisheries were generally not utilized until the early 1990s, at which time the non-targeted (and targeted) acquisition of cetaceans in fishing nets increased (Ilangakoon et al., 2000). In Peru, dolphins and porpoises captured in fishing nets have been kept and consumed since at least 1960, but by the 1980s, the demand for dolphin meat in the markets of small Peruvian ports was driving the systematic killing and consumption of thousands of small cetaceans in conjunction with fishing activities (Van Waerebeek and Reyes, 1994; Alfaro-Shigueto et al., 2008). Similar trends are reported in Ghana (Van Waerebeek et al., 2009), Madagascar (Andrianarivelo, 2001; Cerchio et al., 2009), and Myanmar (Tun et al., 2006).

**Table 6**

Number of animals and species of marine mammals used for human consumption 1990–2009, classification of the mode of acquisition, and marketing, by country.

Region <sup>a</sup>	Sub-Region <sup>a</sup>	Country <sup>b</sup>	Acquisition: 1990–2009		Type of acquisition <sup>d</sup>			Markets <sup>h</sup>	
			Animals/Year <sup>c</sup>	# Species	Targeted <sup>e</sup>	Non-Targeted-Deliberate <sup>f</sup>	Non-Targeted-Salvage <sup>g</sup>		
Americas	<u>Northern America</u>	Canada	>1000	15	Y	N, E	N	R, E	
		Greenland	>1000	19	Y	N, E	N, S	R	
		United States	>1000	17	Y	S	N	R	
	<u>Central America</u>	Belize	1s	1	Y				
		Costa Rica	Unk.	1	Y				
		Guatemala	10s	1	Y			R	
		Honduras	Unk.	1	Y	N			
		Mexico	Unk.	1	Y				
		Nicaragua	10s	1	Y	N		R	
		Panama	1s	1	Y				
		Cuba	1s	1	Y				
	<u>Caribbean</u>	Dominican Republic	10s	1	Y				
		Haiti	Unk. <sup>†</sup>	1 <sup>†</sup>	Y				
		Jamaica	Unk.	1	Y				
		Puerto Rico	<1	1	Y		N	R	
		St. Lucia	100s	11	Y			R	
		St. Vincent and the Grenadines	100s	14	Y		S	R	
		Trinidad and Tobago	Unk.	3	Y	N	N	R	
		Argentina	Unk.	4		N	N		
		<u>South America</u>	Bolivia	Unk.	1	Y			
			Brazil	100s	14	Y	N, S	N, S	
	Chile		Unk.	6	Y	N	N		
	Colombia		1s	3	Y		N	R	
	Ecuador		1s	1	Y				
	French Guiana		Unk.	2	Y		N		
	Peru		>1000	16	Y	N, S	N, S	R	
Suriname	Unk.		1	Y					
Venezuela	>1000		7	Y		N			
Europe	<u>Northern Europe</u>		Denmark <sup>‡</sup>	Unk.	9 <sup>†</sup>	‡	‡	‡	I
		Estonia	10s	2	Y	N	N		
		Faeroe Islands	>1000	7	Y		S	R, I	
		Finland	Unk.	1	Y			R	
		Iceland	100s	8 <sup>†</sup>	Y		N	R, I, E	
		Norway	100s	7	Y			R, I, E	
		Sweden	100s	2	Y			R	
	<u>Western Europe</u>	France	Unk.	3		N	N	i	
		Bulgaria	Unk.	3			N	R	
	<u>Eastern Europe</u>	Georgia	Unk.	1			S		
		Russian Federation	>1000	16	Y			R	
		Ukraine	Unk.	3			N	R	
		Italy	Unk.	5	Y			R	
	<u>Southern Europe</u>	Portugal	Unk.	1			N		
		Spain	Unk.	3			N		
		Egypt, Arab Rep.	1s	1			N		
	Africa	<u>Northern Africa</u>	Sudan	<1	1			N	
Benin			Unk.	1	Y	N	N		
<u>Western Africa</u>		Cape Verde	1s	3	Y	S	S	R	
		Côte d'Ivoire	Unk.	2	Y	N	N		
		Gambia, The	10s <sup>†</sup>	3	Y	N	N	R	
		Ghana	>1000	18	Y	N	N, S	R	
		Guinea	Unk.	5	Y	N	N, S		
		Guinea-Bissau	10s	2	Y	N	N		
		Liberia	Unk.	1	Y	N	N		
		Mali	Unk.	1	Y			I	
		Mauritania	Unk.	2	Y		N		
		Niger	Unk.	1	Y	N	N	I	
		Nigeria	Unk.	2	Y	N	N	R	
		Senegal	10s <sup>†</sup>	9	Y	N, S	N, S	R	
		Sierra Leone	10s	2	Y	N	N	R	
		Togo	10s <sup>†</sup>	3	Y		N, S	R, E	
		<u>Middle Africa</u>	Angola	Unk. <sup>†</sup>	1	Y	N	N	
			Cameroon	100s <sup>†</sup>	4	Y	N, S	N, S	R, I, E
Chad			Unk.	1	Y	N	N	R, I, E	
Congo, Dem. Rep.			Unk.	1	Y	N	N		
Congo, Rep.	Unk. <sup>†</sup>		3	Y	N	N	R		
Equatorial Guinea	Unk.		2	Y	N	N			
Gabon	10s		4	Y	N, S	N	R		

(continued on next page)

Table 6 (continued)

Region <sup>a</sup>	Sub-Region <sup>a</sup>	Country <sup>b</sup>	Acquisition: 1990–2009		Type of acquisition <sup>d</sup>			Markets <sup>h</sup>
			Animals/Year <sup>c</sup>	# Species	Targeted <sup>e</sup>	Non-Targeted-Deliberate <sup>f</sup>	Non-Targeted-Salvage <sup>g</sup>	
		São Tomé and Príncipe	Unk.	1 <sup>†</sup>			N	
	<u>Southern Africa</u>	Namibia	Unk.	1	Y			R
		South Africa	1s	5 <sup>†</sup>		S	N, S	
	<u>Eastern Africa</u>	Comoros	1s	1	Y	N	N	
		Djibouti	Unk.	1		N	N	
		Eritrea	Unk.	1		N	N	
		Kenya	10s	1		N	N	
		Madagascar	100s	10	Y	N, S	N, S	R
		Mayotte	1s	1	Y	N	N	R
		Mozambique	Unk.	2	Y	N	N	
		Seychelles	Unk.	2	Y		N	
		Somalia	Unk.	1			N	
		Tanzania	10s	8		N	N, S	
Asia	<u>Western Asia</u>	Bahrain	Unk.	1			N	
		Georgia	Unk.	3			N	
		Oman	Unk.	4	Y	N	N	R
		Qatar	1s	1			N	
		Saudi Arabia	1s	1		N	N	
		Turkey	<1	1			N	
		United Arab Emirates	10s	1		N	N	R
		Yemen, Rep.	Unk.	1			N	
	<u>Eastern Asia</u>	China	Unk.	6 <sup>†</sup>	Y	N	N	R, I
		Japan	>1000	32	Y	N	N, S	R, I
		Korea, Rep.	10s <sup>†</sup>	18 <sup>†</sup>	Y	N	N	R, I
		Taiwan	>1000	17	Y	N	N	R, I
	<u>South-Eastern Asia</u>	Cambodia	1s	3	Y	N	N, S	
		Indonesia	100s	19	Y	N	N, S	R
		Malaysia	>1000	6	Y	N	N	R, E
		Myanmar	100s	6	Y	N	N, S	R
		Philippines	100s	17	Y	N	N, S	R, I
		Thailand	Unk.	3	Y		N, S	R
		Vietnam	1s	2	Y	N	N	R
	<u>Southern Asia</u>	Bangladesh	Unk.	1		N	N	
		India	100s	8	Y	N	N, S	R
		Pakistan	<1	1	Y			
		Sri Lanka	>1000	15	Y	N	N	R
Oceania	<u>Australia and New Zealand</u>	Australia	>1000	1	Y			
		New Zealand	<1	Unk.			S	
	<u>Melanesia</u>	New Caledonia	10s	2	Y		S	
		Papua New Guinea	100s	1	Y	N, S	N, S	R
		Solomon Islands	>1000	7	Y			R
		Vanuatu	1s	1	Y			
	<u>Micronesia</u>	Kiribati	Unk.	2	Y			
		Marshall Islands	1s	2	Y		S	
		Micronesia, Fed. Sts.	1s	1	Y			
		Palau	1s	1	Y			
	<u>Polynesia</u>	Tonga	<1	1			C	

<sup>a</sup> United Nations Statistics Division standard country and geographical regions recommended for statistical use.

<sup>b</sup> Countries are places with a two-letter United States Federal Information Processing Standard (FIPS) 10-4 code; encompassing independent states, dependencies, and areas of special sovereignty.

<sup>c</sup> Recognizing the vagaries in reporting, we only differentiate by orders-of-magnitude the maximum reported or estimated number of marine mammals killed or collected for human consumption in a year. These represent minimum estimates. We do not scale data from individual locations to country-wide estimates unless such extrapolations are given in the source. We have not used 10,000s because of uncertainty with respect to the extent of actual consumption from the largest acquisitions which usually involve seals. Where animals per year are denoted as unknown (Unk.), we expect most of these instances to involve few animals based on our review and communications with regional experts.

<sup>d</sup> Blank cells reflect a lack of evidence for a specific type of acquisition.

<sup>e</sup> Yes indicates a situation where the animal is intentionally pursued (i.e., targeted and killed in drives or nets, or by shooting or harpooning). Operations where fishermen switch from targeting fish to targeting marine mammals during a single outing are classified as Targeted acquisition.

<sup>f</sup> Non-Targeted-Deliberate acquisition refers to instances where the animal is not directly targeted but is deliberately killed. Three primary sources for this type of acquisition are Nets, Strandings, and natural Entrapments (usually by ice). We have been cautious in our attribution of this category, so net-caught animals are classified as Non-Targeted-Salvage unless there is evidence that the killing was purposeful. Such evidence would include direct observation or the presence and use of weaponry such as harpoons to kill or retrieve entrapped/stranded animals. We have also considered the incentives to capture and kill marine mammals such as markets (see text).

<sup>g</sup> Non-Targeted-Salvage acquisition refers to instances where there was no deliberate attempt to increase the chances of animal deaths, although people may try to increase their own chances of finding dead animals. Primary drivers for making animals available for non-targeted salvage are Nets; Strandings; and Collisions with ships.

<sup>h</sup> Consumption was considered local if by the person who acquired the animal or by that person's kin and close social networks. If the carcass was traded or sold into wider commodity chains and destined for more distant consumption, it was considered exchanged. We differentiated marketing within a Region from transboundary Imports or Exports. When the consumption was considered as an idiosyncratic event, the letter symbol is lower case.

<sup>†</sup> Numbers are likely higher than indicated, judging by qualitative or anecdotal evidence.

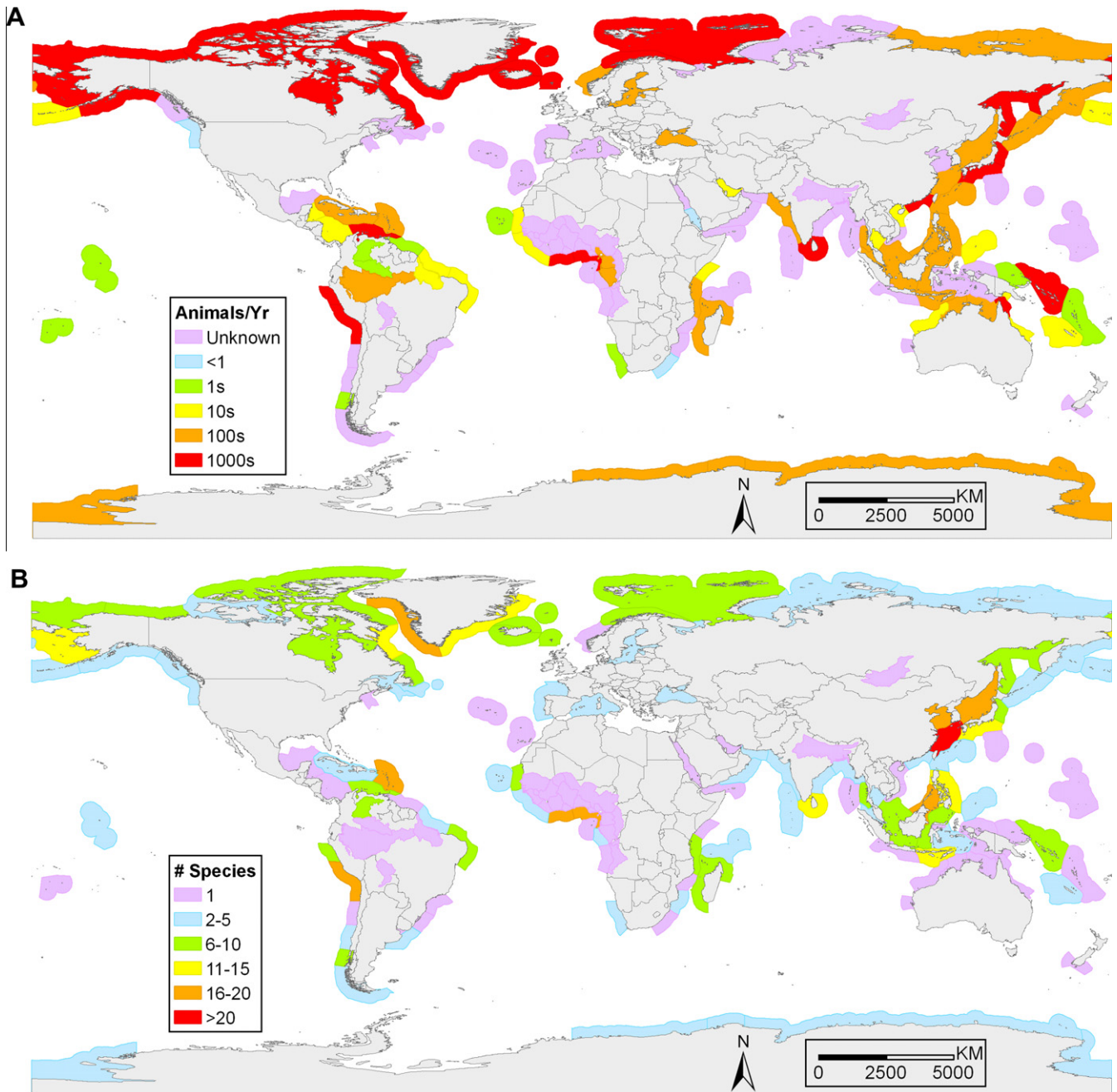
<sup>‡</sup> Consumption results from some small remittances, including of minke whale meat from relatives in Greenland (Horwood, 1990).

Sirenians are widely regarded as a delicious, nutritious source of food in many regions, and often also contribute to a lucrative trade in parts such as tusks, bones, and ‘tears’ for medicines and aphrodisiacs (Marsh et al., 2002; Montoya-Ospina et al., 2001). Consequently, even in areas without targeted hunting, or where food is not the primary motivation to kill them, sirenians are often killed and eaten if found alive, either stranded or captured in fishing gear (Muir et al., 2003; Hines et al., 2008; Tun and Ilangakoon, 2007; Ilangakoon et al., 2008). In some countries such as Cambodia, the scarcity of dugongs makes a targeted hunt impractical, but dugongs are still killed and consumed when incidentally caught in fishing gear (Marsh et al., 2002).

### 3.4. Targeted acquisition of marine mammals

Targeted acquisition of marine mammals has occurred in 87 of the 114 countries where we found evidence of marine mammal consumption since 1990, making this the most widespread acquisition category (Table 6).

Some indigenous communities have hunted marine mammals for millennia, including cetaceans and pinnipeds in the Arctic (McCartney, 1979), dugongs in the Torres Strait region between Australia and Papua New Guinea (Crouch et al., 2007), manatees in West Africa (Jousse et al., 2008), and West Indian manatees in many of the countries bordering the Caribbean (Lefebvre et al.,



**Fig. 1.** Minimum global extent and magnitude (A), and diversity (B) of marine mammal catches for human consumption since 1990.

*Notes:* Data are presented based on ecoregion boundaries developed for marine (Spalding et al., 2007) and freshwater ecosystems (Abell et al., 2008). Catches attributed to a specific ecoregion may be derived from multiple countries, or from only a portion of the catches for a single country. Catches may occur only in a small part of a given ecoregion. Values represent the minimum number of animals or species that are caught. Catches in the Arctic are numerically dominated by pinnipeds and small cetaceans (primarily belugas and narwhals). Catches elsewhere are numerically dominated by small cetaceans and sirenians.



2001). Elsewhere, local hunting of marine mammals for food has developed over hundreds of years, including for small cetaceans in at least the Faeroe Islands (maybe for over 1000 years; Joensen, 1990), Indonesia (Barnes, 1996), Japan (Kasuya, 2007), the Philippines (Acebes, 2009), and probably the Solomon Islands (Takekawa, 1996; Dawbin, 1966). Amazonian manatees have been hunted and consumed for at least many hundreds of years in the Amazon basin (Rosas, 1994). Many of these long-standing hunts include characteristic social attributes such as the sharing of products within social networks and strong traditions associated with the capture and use of the animals.

The origins of some hunts can be traced back to migrations of hunter-gatherers, such as the Thule Eskimo whalers of the Western Arctic (McCartney, 1979), while others developed from Euro-American commercial whaling that introduced new practices in the 1800s, such as at St. Vincent, St. Lucia, Venezuela, and Dominica in the Caribbean (Caldwell and Caldwell, 1971). In other regions, marine mammal consumption has involved the arrival of new cultural groups, including fishermen who used marine mammals for food elsewhere, or inland groups previously unfamiliar with marine mammals and who may regard them as fish (e.g., Beasley and Davidson, 2007). In West Africa, targeting of marine mammals for food had little precedent in some countries prior to the advent of synthetic nets that facilitated capture (Maigret, 1994). In other regions, hunger alone, such as during times of war, has been the initial stimulus to eat marine mammals. In many cases, the development of marine mammal use as food for humans in one community has been followed by diffusion of the practice to neighboring communities and regions.

Regarding the magnitude of current Targeted acquisition, most of the industrial whaling for large cetaceans had ended by the 1980s, but such whaling to obtain food products for humans continues in Japan (100s to >1000/yr), Norway (100s), and Iceland (10s). 'Subsistence' whaling for large mysticetes (baleen whales) persists on a relatively small scale in a few areas, principally Greenland (>100 minke whales, >10 fin and <10 humpback whales per year), Russia (>100 gray whales and a few bowhead whales per year), and Alaska (10s of bowhead whales per year); and for large odontocetes (toothed whales) in Indonesia (10s of sperm whales per year). The large 20th century hunts for small cetaceans in the Black Sea largely ended in the 1980s, with the minimal ongoing consumption now relying on salvage from stranded animals or those incidentally caught in fishing nets (Birkun, pers. comm., 3 December 2009). The largest ongoing Targeted acquisition of small cetaceans is in Japan, where the average annual reported catch exceeded 17,000 animals between 1995 and 2004 (Kasuya, 2007). The next largest annual catch of small cetaceans for any country was rarely more than 10% of the Japanese catch. Large numbers of pinnipeds (sometimes in the 100s of 1000s/year) are hunted primarily for their pelts or to protect fisheries in Scandinavia (Norway, Sweden, and Finland), Canada, and Namibia. These hunts, which do not include the large-scale 'subsistence' hunting of pinnipeds in Alaska, Canada, Greenland, and Russia, also produce, largely as a by-product, some meat that is used for human consumption. Although the demand for this seal meat is reportedly increasing in Scandinavia, demand remains well below the supply of carcasses in Scandinavia, Canada, and Namibia (ECDGE, 2008). Subsistence consumption of seals in Arctic countries is in the 1000s/year, and may exceed 10,000 in some countries, although comprehensive data to establish this are not available. Dugongs are hunted in the 100s to >1000 in some years in Australia. In South America (Quintana-Rizzo and Reynolds, 2007) and West Africa (Keith, pers. comm., 5 April 2010) manatees are caught in at least the low 100s.

We emphasize the Targeted nature of some catches as compared to the benign opportunism by which they are sometimes characterized. For example, in Japan, Endo and Yamao's (2007)

characterization of whale products derived from 'research whaling' as 'byproducts' negates both the targeted nature of acquisition, and the intent to consume products derived from those hunts. Similarly, the catches of cetaceans in Japanese or Korean fixed nets that are erroneously reported to the International Whaling Commission as 'bycatch' reflect Targeted acquisition in a multi-species passive fishery (Kasuya, 2007). The 'tiger nets' set by Taiwanese fishermen in Indonesia were probably the most egregious recent use of such passive fishing gears for large migratory marine life including marine mammals (Perrin et al., 2005).

### 3.5. Exchange of marine mammal products for human consumption

Nearly half of the countries (54 of 114) with evidence of marine mammal consumption since 1990 also had evidence of secondary consumption (Table 3) following the exchange, and sometimes marketing, of food products. Commercialization may be a natural progression from local trade, barter, or exchange, but external markets add incentives to catch marine mammals beyond the immediate nutritional needs of those doing the catching. For example, in Sabah and Sarawak (Malaysia), dugong and dolphin meat is consumed locally, but surplus is sold by fishermen within villages, then between villages, and finally in urban hubs (Jaaman et al., 2005). Meat is increasingly sold outside of Malaita (Solomon Islands) to markets where the economic value of cetacean products is double that found in Malaita itself (Kahn, 2004). Links usually exist between different types of resources. In Greenland, for example, declining sealskin prices increased the importance of small cetaceans to hunters, apparently because they could still sell *muktuk* (whaleskin) at shops for relatively high prices (Heide-Jørgensen, 1990).

Some of the contemporary marine mammal hunting for food consumption and exchange was originally encouraged by outside entities. The Sri Lankan government and Canadian interests jointly sought to develop an industry to utilize dolphins for human consumption to reduce dolphin predation on fish stocks during the 1950s (Alling, 1988). According to Mills et al. (1997), "while whale meat had long been a part of the Japanese diet, consumption increased markedly after World War II, when US occupation forces encouraged whaling in Japan to prevent famine." The Kiwai (Papua New Guinea) were encouraged to kill dugongs, fish, and turtles to supply food to local hospitals, schools, jails, and local markets in Daru during the 1950s and 1960s (Marsh et al., 2002). In 1973, the UN's Food and Agriculture Organization delivered a whaling catcher boat and a Norwegian whaling captain to increase the capacity of whalers and fishermen to catch whales at Lamalera (Indonesia; Barnes, 1984). Roberts (1939) reported the shipping of canned whale meat to West Africa for local consumption, although he didn't indicate origin. New Zealand historically shipped whale meat to the South Pacific Islands (Andrews, 1916).

Some 6000 tons of marine mammal food products are distributed commercially each year in Japan (Endo and Yamao, 2007), from both targeted and non-targeted sources. The Republic of Korea prohibits the targeted hunting of cetaceans, but allows the products from incidentally caught (i.e., Non-Targeted) animals in markets, which are interpreted to include what we categorize here as Targeted marine mammals acquired from the multi-species set-net or trap fisheries. In Chukotka (Russian Federation), cooperative subsistence hunts involve hunters who are paid by the state to hunt marine mammals, but must then purchase products for their own consumption (Eduard Zdor, pers. comm., 21 May 2010). In Greenland, large quantities of marine mammal meat and blubber are sold in local markets (Caulfield, 1997).

Some food products from marine mammals are traded internationally, nominally on terms set by the Convention on Interna-



tional Trade in Endangered Species of Wild Fauna and Flora (CITES). Minke whale meat has been commercially exported from Norway and Iceland, primarily to Japan (Horwood, 1990). Non-commercial exports of cetacean meat from Greenland and the Faeroe Islands to Denmark are common for personal consumption and cultural use by Greenlanders or Faroese residing in Denmark (UNEP-WCMC, 2010). Canadian commercial seal hunting yields over 176 tons of meat annually (ECDGE, 2008), of which some is exported (along with other seal parts), primarily to Asian countries. There is also relatively recent evidence of illegal international trade of cetacean meat in at least Hong Kong, Japan, Norway, the Philippines, Russia, South Korea, Taiwan, and the United States (Baker and Palumbi, 1994; Mills et al., 1997; Kang and Phipps, 2000; Raymakers, 2001; Dalebout et al., 2008; Baker et al., 2010). Illegal transboundary transport of dugong meat for human consumption is reported between Sabah and the Philippines (Rajamani, 2009). In Africa, manatee meat has been illegally transported and sold between Chad and Cameroon (Powell, 1996).

#### 4. Discussion

Japan, followed by several of the Arctic countries (Canada, Greenland, Russian Federation, United States), and then the Faeroes, Australia, and the Solomon Islands, have the largest-scale targeted acquisitions in terms of numbers of animals killed annually (>1000 per year), principally to provide food for people. However, some countries in South America, West Africa, and Asia with Non-Targeted-Salvage, and sometimes Non-Targeted-Deliberate categories of acquisition now kill and consume marine mammals, particularly small cetaceans, at levels comparable to those of the longer-established Targeted hunts in the Faeroe Islands, Australia, and the Solomon Islands (100s to low 1000s; Fig. 1A).

The diversity of marine mammal catches for human consumption largely mirrors the pattern for magnitude (Fig. 1B), with Japan taking the highest diversity of species (32), followed by several of the Arctic countries (Canada, Greenland, Russian Federation, United States), Asian countries (Republic of Korea, Taiwan, Indonesia, Philippines, and Sri Lanka), Ghana in Africa, and Peru in South America with between 15 and 20 species taken. The primary exception to this pattern is Australia, where the only marine mammal species taken by aboriginal hunters is the dugong.

Targeted hunts, particularly of large cetaceans, are generally reduced in extent from those in the nineteenth century and much of the twentieth (Reeves, 2009). In contrast, capture of smaller marine mammals in fishing gear has increased in many coastal regions and is now regarded as perhaps the greatest threat to whales, dolphins, and porpoises (Lewison et al., 2004; Read, 2008). We found evidence for transitions between modes of acquisition, including (a) harpoon or drive hunting to net captures (Cerchio et al., 2009), (b) salvage of stranded animals to targeted drive fisheries that use nets to facilitate capture (Cockcroft et al., 1997), and (c) salvage from nets to targeted net-captures (Clapham and Van Waerebeek, 2007). Whereas the demand for dolphin meat in Taiwan was fulfilled by the Penghu Islands drive hunt (capturing a few 100s to >1000 small cetaceans per year) until its demise in the early 1990s, that demand can now be fulfilled to at least some extent by the use of small cetaceans that are captured in fishing nets (Wang and Yang, 2007).

The routine use and sale of marine mammals killed in fishing gear (Targeted or Non-Targeted-Deliberate acquisition) for food is more widely reported now than it was in the 1970s and 1980s, but it is difficult to know if this reflects factors related to more efficient reporting, new fishing technology, or actual changes in human behavior. For three reasons, we suspect the latter two factors are at least partially responsible. First, synthetic nets have

proliferated around the world, facilitating the capture of marine mammals. Second, distribution networks and economic incentives have developed which can encourage the killing and use of marine mammals caught in fishing gear. Third, given the pervasive declines in global fish catches, increases in human populations (Allison et al., 2009; Pauly et al., 1998, 2005), and the profound impacts of these trends in the coastal regions of developing countries (Hall et al., 2010), we would expect to see changes in consumption and transactions associated with food and economic security.

The lack of alternative forms of protein and the widespread poverty in West Africa were important factors in Brashares et al.'s (2004) analysis linking declines in coastal fish catches with greater use of terrestrial wild meats, although as Clapham and Van Waerebeek (2007) point out, the marine mammal component was not incorporated into Brashares et al.'s model. The prevalence of marine mammal use for human consumption in the West African region that we summarized here is at least correlated with where reductions in fish catches and poverty led to the increased consumption and sale of terrestrial mammals that Brashares et al. (2004) discussed (see also Weir et al., 2011). Similar 'fishing-up-the-food-chain' has been reported in at least Peru (Van Waerebeek and Reyes, 1994), Brazil (Meirelles et al., 2009), Colombia (Montoya-Ospina et al., 2001), Trinidad (Rampersad, 2008), Madagascar (Cerchio et al., 2009), Sri Lanka (Ilangakoon et al., 2000), India (Yousuf et al., 2009), the Philippines (Dolar et al., 1994) and Myanmar (Tun et al., 2006).

Our results suggest that the number of people taking small cetaceans for food has continued to increase since noted by W.R. Martin in the 1970s (foreword to Mitchell, 1975b), and that there is now a trend (as noted by others, e.g., Read, 2008; Clapham and Van Waerebeek, 2007) toward greater use of animals killed in fishing gear, regardless of whether they are the primary targets of the fishing. Although there may be less acquisition of marine mammals by Targeted hunting today than there was 30–40 years ago, the rise of Non-Targeted-Deliberate acquisition is a matter of serious concern. Some of the highest acquisition of marine mammals from fishing gear happens in countries with little or no assessment of marine mammal populations and weak institutions governing use of wild living resources. Even in areas with stronger governance institutions, fishing nets provide an efficient but often relatively inconspicuous means of capturing marine mammals. Most netting operations are, at any rate, less likely to attract controversy than some forms of Targeted acquisition (e.g., drive hunts, specially equipped catcher boats).

Assessing the impacts of human-caused mortality on most marine mammal populations that are exploited for food is hampered by a dearth of key information (stock structure, numbers, trends, etc.). In only a few cases would it be feasible at present to establish scientifically defensible limits on catches sufficient to ensure that removals are sustainable. Consequently, there is a conservation imperative to reduce human-caused mortality of marine mammals in the many areas where proper assessment is lacking and governance is inadequate. Both theory and empirical evidence suggest this will be accomplished most efficiently through providing local incentives and involvement, rather than relying exclusively on higher-order rules that cannot be monitored or enforced at a local scale. One prominent example is the co-management of bowhead whale hunting in Alaska where first, the knowledge and participation of Iñupiat, Siberian Yupik, and Yup'ik whalers were actively incorporated into the management regime, and second, the whaling communities benefited from their active role in conservation of the whale population and its environment (Huntington, 1989). Elsewhere, attempts to impose rules that were perceived as illegitimate or that could not be properly monitored and enforced have often failed to reduce marine mammal mortality as intended, and

in some cases made the situation worse (e.g., Peru – Mangel et al., 2010).

Encouraging more widespread local stewardship of marine mammals will require attention to both the specific socio-economic context and the multi-level institutional conditions that are most influential in determining whether, and how, long-term conservation can be achieved (as suggested by Milner-Gulland et al. (2003) for wild terrestrial food species, and Robinson (2011) more generally). Solutions will need to address the motivations of specific groups of people to catch, kill, and exchange marine mammals, and the drivers for consumption of marine mammal products. In regions where hunger and poverty are causing new consumption patterns that result in greater use of marine mammal products, measures imposed from outside to reduce 'bycatch' in fisheries or prevent the deliberate hunting of marine mammals, without somehow addressing the underlying factors of food and economic security, are unlikely to be effective.

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### Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.biocon.2011.07.034](https://doi.org/10.1016/j.biocon.2011.07.034).

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