THE RAFFLES BULLETIN OF ZOOLOGY 2002 Supplement No. **10**: 115-123

FOOD HABITS OF FINLESS PORPOISES (*NEOPHOCAENA PHOCAENOIDES*) IN HONG KONG WATERS

Nélio B. Barros
Hubbs-Sea World Research Institute, 6295 Sea Harbor Drive, Orlando, FL 32821-8043 USA.
Present address: Center for Marine Mammal and Sea Turtle Research, Mote Marine Laboratory, 1600 Ken Thompson Parkway, Sarasota, FL 34236-1096 USA. Email: nbarros@mote.org

Thomas A. Jefferson
Ocean Park Conservation Foundation, Ocean Park, Aberdeen, Hong Kong.
Present address: Southwest Fisheries Science Center, NOAA, National Marine Fisheries Service, P.O. Box 271, La Jolla, CA 92038, USA. Email: sclymene@aol.com

E. C. M. Parsons
The Swire Institute of Marine Science, The University of Hong Kong, Cape d'Aguilar, Shek O, Hong Kong.
Present address: SEAQUEST, 28 Main Street, Tobermory, Isle of Mull, Argyll PA75 6NU United Kingdom. Email: hwdt@sol.co.uk

ABSTRACT. – This study provides information on food habits and insights into habitat use of finless porpoises (*Neophocaena phocaenoides*) in Hong Kong waters through the analysis of stomach contents of 31 stranded animals. Finless porpoises preyed upon a minimum of 25 species of fish, 3 genera of cephalopods and one shrimp. The most important prey taxa in numerical terms were the fish families Apogonidae, Sciaenidae, Engraulidae, Leiognathidae among teleosts, and the squid family Loliginidae. Squids (*Loligo*) and cuttlefishes (*Sepia*), followed by anchovies (*Thryssa* spp.), cardinalfishes (*Apogon* spp.) and ponyfishes (*Gazza minuta*) were the most frequently taken prey. These are inshore, bottom-dwelling and mid-water prey, suggesting that finless porpoises feed at different levels in the water column and in reefs and sandy substrates. Prey composition and the presence of undigested fish, squid and shrimp retrieved from several porpoise stomachs suggest possible associations with fisheries, particularly trawlers. Onset of ingestion of solid food takes place at 6-12 mos. (95-100 cm in size). No sex-related or seasonal differences in diet were found. There was some dietary overlap with humpback dolphins, but these animals appear to favour prey species common in estuaries, whereas finless porpoises also exploit more pelagic habitats for food. Prey overlap is greater with offshore bottlenose dolphins, suggesting some competition when these dolphins venture into coastal waters.

KEY WORDS. – Feeding habits, stomach contents, prey, *Neophocaena phocaenoides*, Hong Kong, China

INTRODUCTION

Finless porpoises (*Neophocaena phocaenoides*) occur in inshore waters of the South China Sea, and are common in coastal areas and estuaries (Parsons & Wang, 1998; Kasuya, 1999). Despite their extended range, until recently little research had been carried out on this species (Jefferson & Braulik, 1999). Concerns about human impacts on finless porpoises and Indo-Pacific humpback dolphins (*Sousa chinensis*) in Hong Kong prompted a number of studies on their distribution, status and ecology (Parsons et al., 1995; Leatherwood & Jefferson, 1997; Parsons, 1997; Jefferson & Braulik, 1999; Jefferson, 2000).

There are several threats to dolphins and porpoises around Hong Kong. Recent studies on contaminant levels in the tissues of these animals (Parsons & Chan, 1998; Parsons, 1998a, 1999a; Jefferson & Braulik, 1999; Minh et al., 1999), and in particular neonates (Parsons, 1997), indicated high levels of pollution in the waters they inhabit. Elevated levels of metals (mainly mercury and lead) in fish collected from northern Lantau Island led Parsons (1999b) to hypothesize harmful effects on humpback dolphins potentially preying upon those species. Loss of habitat, interactions with fisheries and collisions with vessels have also been implicated as additional mortality factors for Hong Kong cetaceans (Parsons & Jefferson, 2000). Although the impact of these mortalities is not fully understood, it is unlikely that Hong Kong cetaceans can sustain high levels of mortality.

Understanding the feeding ecology of apex predators, such as cetaceans, is crucial for understanding how they accumulate high contaminant burdens. Analyses of prey preferences also provide information on habitat use and movements of the predator as compared with those of its prey. To that end, this study examines the food habits of finless porpoises off Hong Kong through the analyses of stomach contents collected from stranded animals.

MATERIALS AND METHODS

Specimens for this study were collected as strandings in Hong Kong (Jefferson et al., 2002a). Entire stomachs were removed from carcasses and examined in the laboratory for presence of food matter. Stomach contents were washed and strained in a sieve, and wet weight was recorded in grams. The hard structures of prey, such as fish otoliths and squid beaks, were used for prey identification, with the aid of a preliminary reference collection of fish otoliths assembled by sampling local fish markets for species commonly found around Hong Kong waters, and published pictorial guides (Zheng, 1981; Clarke, 1986; Härkönen, 1986; Smale et al., 1995). Prey identification was made to the lowest taxonomic level possible (species or genus). Squid beaks found in porpoise stomachs were compared with those removed from selected cephalopod specimens collected from the Hong Kong area, deposited at the Invertebrate Museum of the University of Miami's Rosenstiel School of Marine and Atmospheric Science (RSMAS). From the several species of coastal cephalopods reported from Hong Kong waters (Voss & Williamson, 1971), the following species were examined at RSMAS (classification after Vecchione et al., 1998): Loliginidae: *Loligo edulis*, *Uroteuthis (= Loligo) duvaucelli*, *U. (= Loligo) singhalensis*, and *Sepioteuthis lessoniana*; Sepiidae: *Sepia recurvirostra*, *S. omani*, *S. kobiensis*, and *Sepiella japonica*. Due to the similarity in beak morphology in loliginid squids, sepias and octopuses, and the need for a more comprehensive local reference collection of all species at different ontogenetic stages (Clarke, 1986), no attempts were made in this study to identify cephalopods beyond the level of genus. However, differences in size and colour pattern of loliginid beaks found in this study suggest the existence of two prey species (*Loligo* sp. "A", *Loligo* sp. "B") within this genus. The latter resembles the morphology and coloration of brief squid (*Lolliguncula brevis*) beaks found in the stomachs of bottlenose dolphins (*Tursiops truncatus*) from the southeastern United States (Barros & Odell, 1990) and marine tucuxi (*Sotalia fluviatilis*) off Brazil (Borobia & Barros, 1989). However, the genus *Lolliguncula* is absent from the western Pacific; it is found primarily off the coasts of North and South America (Vecchione et al., 1998).

Undigested fish and squid retrieved from stomachs were measured to the nearest millimeter. Fish otoliths were sorted into left and right, and squid beaks into upper and lower. The highest number of these structures was assumed to represent the total number of specimens consumed of each particular prey. For those eroded otoliths in which the side could not be ascertained, the total number of fish was calculated by dividing in half the total number of otoliths. Samples examined during previous studies (Parsons, 1997) were re-analyzed and incorporated into this study.

The concept of species diversity includes the number of species present in a community (species richness) and the division of individuals among the various species (species evenness) (Krebs, 1999). Because not all prey could be identified to the level of species in this study, the term 'taxa diversity' was used instead. Thus, gender and seasonal comparisons of taxa diversity (H) in diet were made using the following calculations of the Shannon-Wiener index (Krebs, 1999):

$$H = \sum_{i=1}^{s}(p_i)(\log_2 p_i)$$

where:
H = index of taxa diversity
s = number of taxa
p_i = proportion of total sample belonging to i_{th} taxa

Statistical analyses were performed using SYSTAT (version 8.0 for Windows). The calculations of the Shannon-Wiener index in this study were made considering that the prey identified from each porpoise represented different species, even though identification to that level was not always possible. There may also be additional biases when considering distantly related taxa (i.e, fish and squid) as equivalent entities in biodiversity studies (Gaston, 1996).

RESULTS

Stomach contents of 31 finless porpoises (16 males, 9 females, and 6 of unknown sex) were available for examination (Table 1). These animals ranged from 98 to 168 cm in total length. The stomachs of three additional animals (NP95-02/11, 83 cm; NP99-31/08, 88.5 cm; NP99-21/11, 87 cm) were empty.

Finless porpoises around Hong Kong preyed on fish, cephalopods, and occasionally shrimp (Table 1). Fish/cephalopod was the most commonly found prey combination (20 cases, or 64.5%), followed by the fish/cephalopod/shrimp (6 cases, or 19.4%). Four stomachs (12.9%) contained only the remains of fish and a single stomach (3.2%) contained only cephalopod remains. Cephalopods were present in 27 of the 31 stomachs examined (87.1%). The average number of different prey taxa per stomach was 6.0 (± S.D. 3.08), and the number of prey items found per stomach ranged from 1 to 183 (mean= 45.2 ± S.D. 39.24). The wet weight of stomach contents varied considerably (range= 1-411 g, n= 30), with an average value of 88.3 g (± S.D. 106.24). Over 56% (17 of 30) of the stomach contents weighed < 60 g (Table 1).

Altogether, 1,402 prey items were retrieved from all stomachs, of which 1,078 (76.9%) were teleosts, 318 (22.7%) were cephalopods and 6 (0.4%) were shrimp. A minimum of 25 species of fish (within 16 families, 22 genera), 3 cephalopod genera (within 3 families) and one shrimp family

Table 1. Stomach content data from stranded finless porpoises from Hong Kong waters.

Field #	Stranding Season[3]	Sex[4]	Size (cm)	Wet weight[5] (g)	Prey Type[6]	Prey Taxa[7]	Prey Items	Shannon-Wiener Diversity Index (H)
NP94-04/11[1]	Fa	U	137	242	F,C,K	8	15	1.859
NP95-02/11	Fa	F	83	E	—	—	—	—
NP95-28/11[1]	Fa	M	155	271	F,C	5	23	1.145
NP95-25/12[2]	W	F	143	—	F,C	7	21	1.538
NP96-08/01[1]	W	M	138	232	F	11	104	1.611
NP96-11/01	W	M	168	109	F,C	11	57	2.132
NP96-13/01[1]	W	F	150	117	F,C	7	42	1.217
NP96-08/03[1]	Sp	F	137	9	C	1	2	0.000
NP96-13/03[1]	Sp	M	128	261	F,C	7	66	1.250
NP96-23/07	Su	M	144	5	F,C	4	44	0.874
NP97-23/01	W	F	157	25	F,C,K	5	13	1.378
NP97-26/01	W	F	150	<1	F	2	3	0.637
NP97-12/04	Sp	F	140[8]	163	F,C,K	6	21	1.193
NP97-14/08	Fa	U	157	<1	F,C	2	4	0.693
NP97-09/09	Fa	M	U	4	F,C	4	7	1.494
NP97-11/10	Fa	M	137	14	F,C	5	70	1.083
NP98-06/03	Sp	M	158	<1	F,C	2	3	0.637
NP98-09/04	Sp	F	99	<1	F,C	3	5	1.055
NP98-23/06	Su	M	130	76	F,C,K	5	67	1.005
NP98-25/09	Fa	U	161	22	F,C	7	80	0.974
NP98-15/11A	Fa	F	168	45	F,C	10	88	1.907
NP98-29/12	W	U	158[9]	16	F,C	5	38	0.646
NP98-30/01	W	M	160	411	F,C	12	59	1.825
NP99-17/02	W	M	147[10]	125	F,C,K	11	100	1.846
NP99-31/05	Sp	M	165.5	55	F	4	68	0.388
NP99-16/07A	Su	M	154	11	F,C	6	16	1.418
NP99-02/08	Su	M	119	26	F,C	3	46	0.344
NP99-31/08	Su	F	88.5	E	—	—	-	—
NP99-31/10	F	U	140	138	F,C	9	183	1.085
NP99-17/11	Fa	M	163	177	F,C,K	9	23	2.040
NP99-21/11	Fa	F	87	E	—	—	—	—
NP00-04/01	W	F	98	4	F	2	53	0.094
NP00-12/02	W	M	124	83	F,C	8	41	1.422
NP00-26/03	Sp	U	165	4	F,C	4	39	1.085

1 Samples from Parsons (1997).
2 Partial contents.
3 Fa= Fall, W= Winter, Sp= Spring, Su= Summer.
4 U= Unknown.
5 E= stomach empty.
6 F= Fish, C= Cephalopod, K= Crustacean.
7 Lowest taxonomic level (see text for details).
8 Estimated (missing posterior third of the body).
9 Estimated (missing flukes).
10 Underestimated (carcass too decomposed).

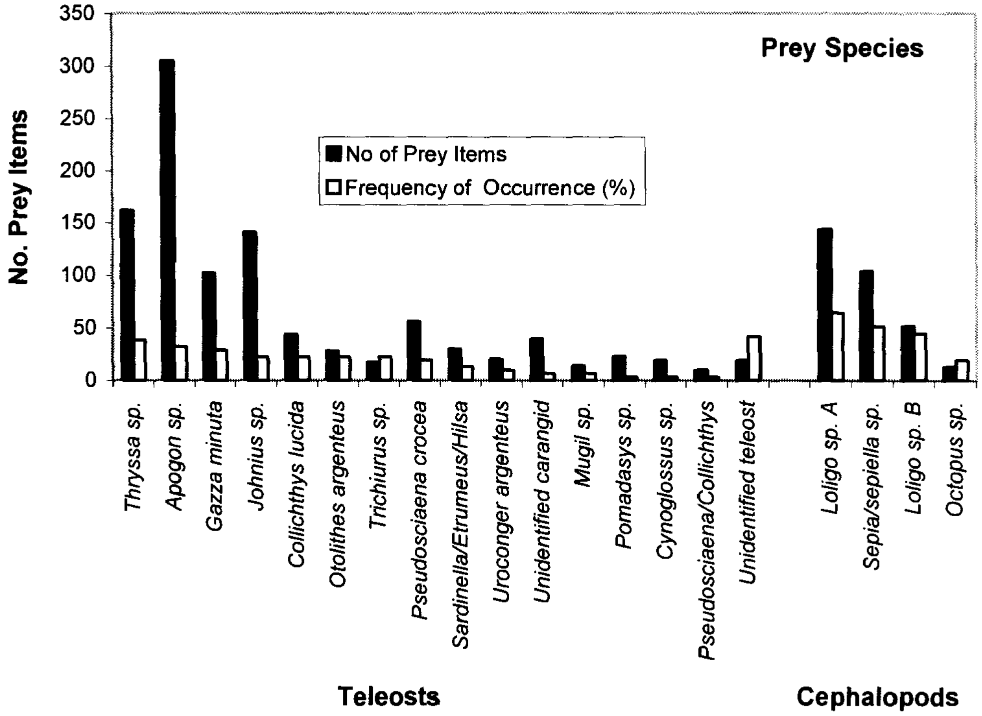

Fig. 1. Prey of finless porpoises (n= 31 stomachs) from Hong Kong waters. Only prey species represented by at least 10 individuals are presented.

were identified (Fig. 1). The most important prey families in numerical terms were the fish families Apogonidae, Sciaenidae, Engraulidae, Leiognathidae among teleosts, and the squid family Loliginidae. These families accounted for 77.7% of all prey taken. The five most frequently taken prey were the squid *Loligo* sp. A (possibly the swordtip squid *L. edulis*), cuttlefishes (*Sepia/Sepiella*), anchovies (*Thryssa* spp.), cardinalfishes (*Apogon* spp.) and the ponyfish *Gazza minuta*. Squids, cuttlefishes and anchovies occurred in 40% of the stomachs examined. The most numerically important species were cardinalfishes (*Apogon* spp.), anchovies (*Thryssa* spp.), the croaker *Johnius* spp., squids (*Loligo* spp.), and ponyfish. Cardinalfishes represented 28.3% of all fish taken, and 21.8% of all combined prey. At least 12 species occurred only once or twice in the samples.

Undigested fish, squid and shrimp, indicative of recent ingestion, were retrieved from several porpoise stomachs (Fig. 2). Cephalopod flesh and buccal mass (from *Loligo* and *Sepia*) were present in at least eight samples. The following undigested fish specimens were measured: a 58.6 cm standard length (SL) congrid eel, from porpoise NP99-31/10; a 5.5 cm SL wrasse, from NP99-17/02; a 16-cm SL *Johnius* croaker, from NP99-31/05; a 23+ cm SL congrid eel and three cardinalfishes (*Apogon*) 8-8.5 cm SL, from NP00-12/02. The mantle lengths (ML) of four squids of the genus *Loligo* found in the stomachs of three porpoises (NP98-23/06, NP99-30/01 and NP99-17/02) were 8.6-11.2 cm. The rostral length of the shrimp shown in Fig. 2 was 3.9 cm.

The seasonal pattern of stomach content parameters is shown in Fig. 3. Data normality was tested with a Kolmogorov-Smirnov one-sample test (Zar, 1999). Since results indicated deviations from normality ($p < 0.001$), a Mann-Whitney U test was used to test differences in taxa diversity in porpoise

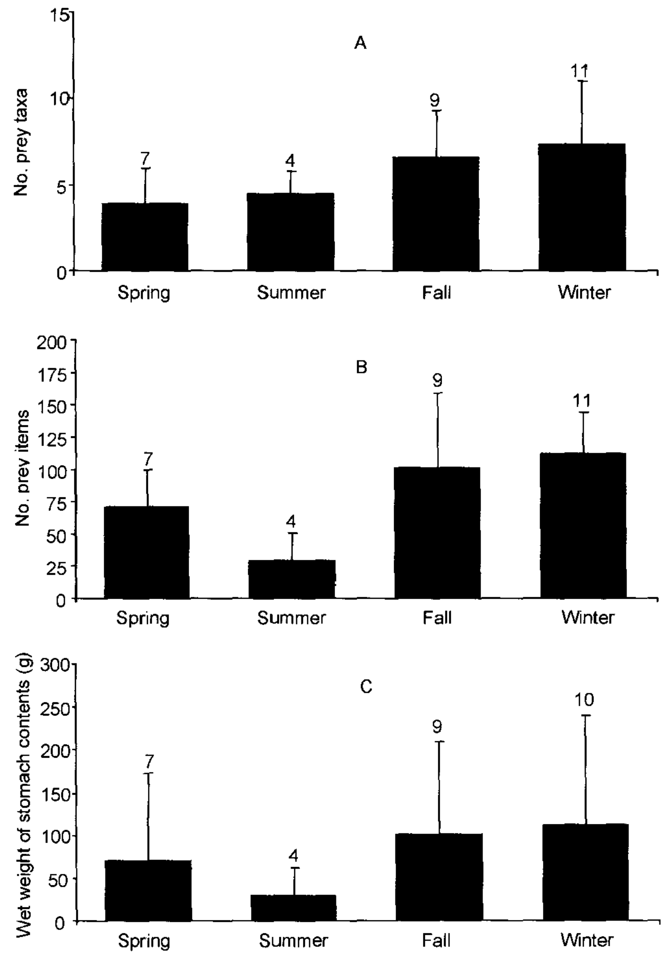

Fig. 3. Seasonality of stomach content data from Hong Kong finless porpoises displaying seasonal differences in: (A) number of prey taxa, (B) number of prey items and (C) wet weight of stomach contents. Values reported are mean ± one standard deviation. Numbers above the histograms reflect the sample sizes available for analysis.

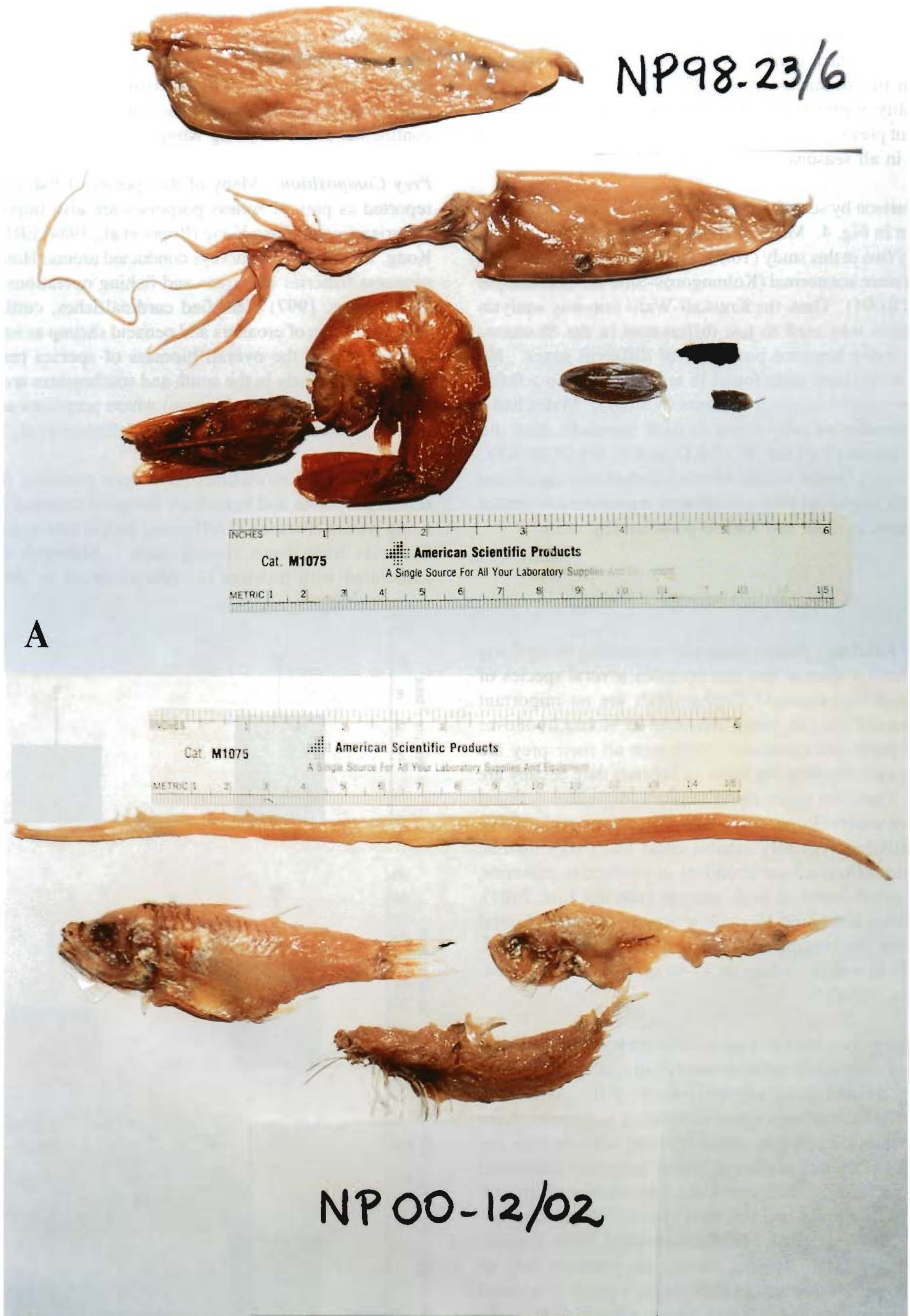

Fig. 2. Undigested fish, squid and shrimp retrieved from the stomachs of finless porpoises from Hong Kong: (A). Squids (*Loligo* sp.), cuttlefish bones from cuttlefish (*Sepia* sp.) and an unidentified shrimp (*Metapenaeopsis* sp.?) retrieved from the stomachs of a 130-cm male finless porpoise, (B). Cardinal fish (*Apogon* sp.) and an unidentified congrid eel from the stomach of a 124-cm long male finless porpoise.

samples collected in different seasons. Taxa diversity calculations (H) are presented in Table 1. Results showed no significant differences in taxa diversity ($p > 0.05$), wet weight of stomach contents ($p > 0.05$) or number of prey items in the stomachs ($p > 0.05$). No obvious trends in seasonality of prey types consumed were noted, as the most important prey (*Loligo*, *Sepia*, *Thryssa*, *Apogon*, *Gazza*) were present in all seasons.

A comparison by sex of the same parameters described above is shown in Fig. 4. Males outnumbered females by a factor of nearly two in this study (16:9). As in the previous analysis, the data were not normal (Kolmogorov-Smirnov one-sample test, $p < 0.001$). Thus, the Kruskall-Walis one-way analysis of variance was used to test differences in the Shannon-Wiener index between porpoises of different sexes. No gender differences were found in taxa diversity ($p > 0.05$) or wet weight of stomach contents ($p > 0.05$). Males had a higher number of prey items in their stomachs than did females (mean of 49.6 ± 30.13 S.D. and 27.6 ± 28.66 S.D., respectively), but the results were not statistically significant ($p > 0.05$). Important prey species were represented in similar proportions in male and female porpoise stomachs.

DISCUSSION

Inshore Feeding - Finless porpoises inhabiting Hong Kong waters have a diverse diet that includes several species of fish, squid and shrimp. Cephalopods are an important component of this diet, being present in the stomachs of over 87% of porpoises examined. Although all their prey are coastal in distribution, the types of habitats they occupy are diverse. Thus, the entire squid family Loliginidae is found in inshore waters (Roper et al., 1984; Vecchione et al., 1998). Cardinalfishes typically inhabit coral and rocky shores. Anchovies (*Thryssa*) are abundant in productive estuaries, and are often found in large schools (van der Elst, 1981). Cuttlefishes are found in shallow waters of tropical coral reefs, over the continental shelf and near oceanic islands, generally in waters as deep as 30-50 m (Roper et al., 1984; Khromov, 1998).

Finless porpoises seem to feed at different levels of the water column. Cuttlefishes, octopuses and most species of croakers (family Sciaenidae) are bottom-dwellers, whereas cardinalfishes, anchovies, and ribbonfish (*Trichiurus*) are mid-water in distribution, often forming schools (van der Elst, 1981). Dietary studies of finless porpoises conducted elsewhere have also reported the importance of coastal species of fish, squid, and shrimp (Pilleri & Gihr, 1972; Chen et al., 1979; Wang, 1984; Mahakunlayanakul, 1996; Kasuya, 1999, Huang et al., 2000). Shrimp are common prey of finless porpoises throughout their range, a preference noted even in earlier studies (Murray, 1884; Allen, 1923).

Findings from this study suggest feeding in nearshore habitats. Results of the present study generally support the conclusions of previous analyses (Parsons, 1997), however finless porpoises apparently do not prey upon deep-water species of fish (e.g., myctophids) as Parsons (1997) previously suggested. His conclusions were based upon misidentified fish otoliths (see Jefferson, 2000). Because myctophids are meso- or benthopelagic in distribution (Hulley, 1989; Huang, 1994; Weitzman, 1997), it is unlikely that finless porpoises would encounter these fish over the continental shelf off Hong Kong.

Prey Composition - Many of the species of fish and squid reported as prey of finless porpoises are also important in fisheries around Hong Kong (Roper et al., 1984; ERM-Hong Kong, 1997). Recent surveys conducted around Hong Kong to assess fisheries resources and fishing operations (ERM-Hong Kong, 1997) identified cardinalfishes, cuttlefishes, several species of croakers and penaeid shrimp as important components of the overall biomass of species present in trawls, particularly in the south and southeastern areas (i.e., south Lantau and south Lamma) where porpoises are often sighted (Jefferson & Braulik, 1999; Jefferson et al., 2002b).

Human-induced mortalities have been recorded for both finless porpoises and humpback dolphins stranded in Hong Kong waters (Parsons & Jefferson, 2000); interactions with fisheries have been among them. Although feeding associated with trawlers is often observed in humpback

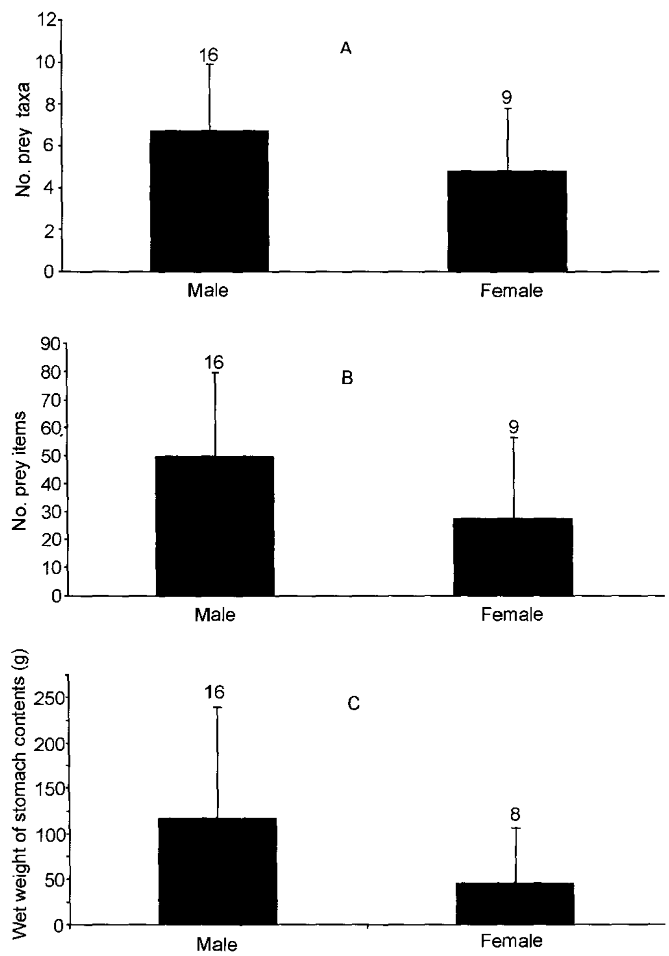

Fig. 4. A comparison between male and female finless porpoise stomach content data for: (A) the number of prey taxa, (B) the number of prey items and (C) the wet weight of stomach contents. Values reported are mean ± one standard deviation. Numbers above the histograms reflect the sample sizes available for analysis.

dolphins in the same area (Leatherwood & Jefferson, 1997; Parsons, 1997, 1998b; see also review in Jefferson, 2000), analyses of stomach contents of stranded humpback dolphins (Barros, 1998) do not generally show evidence of these interactions. It should be pointed out, however, that humpback dolphins show a variety of other feeding behaviors (Parsons, 1998; Jefferson, 2000) and many do not follow trawlers. In addition, results from the analyses of stomach contents (Barros, 1998) were based on the analysis of few samples (n= 8), and may not have included dolphins with different feeding histories; thus, they should be interpreted with caution. Interestingly, however, the prey composition of the porpoises from this study suggests that some animals may feed in association with trawlers, for which there is some anecdotal support from local fishermen (Torey, 2000). Since finless porpoises are less easily detected than humpback dolphins, it is possible that they may also feed near trawlers but have simply been unobserved during visual surveys. Additional research is clearly needed on the spatial and temporal relationships between shrimp and pair trawlers with the two species of cetaceans residing in Hong Kong waters, and the potentially harmful effects of these interactions.

Onset of Feeding/Weaning - The stomachs of the three smallest porpoises (83-88.5 cm in total length) examined in this study were all empty. In at least one of those animals (NP95-02/11), fetal folds were observed. Evidence of curdled milk was present in the stomach of a female, 99-cm long porpoise (NP98-09/04), in addition to remains of solid food (fish, squid, shrimp). Another small animal, a 98-cm female (NP00-04/01), also had remains of both fish and squid in its stomach. Young-of-the-year porpoises (age data presented in Parsons & Jefferson, 2000), excluding neonates, ranged in size from 75 to 94 cm. From the data presented in this study, it seems apparent that porpoises start ingesting solid food at about 95-100 cm in size, corresponding to approximately six months to one year in age (see Jefferson et al., 2002c). Zhang (1992) found solid food in the stomach of a 96-cm porpoise killed in the Yangtze River. From data collected from wild animals and observations of finless porpoises in captivity, Kasuya (1999) estimated that weaning occurred at about 7 months but could be as late as 15 months.

Resource Partitioning with Humpback and Bottlenose Dolphins - Species co-existing in the same general area tend to alleviate competition by occupying different habitats, preying on different species, or by specializing in a particular foraging strategy (Schoener, 1974). The diet of the two cetaceans residing in waters off Hong Kong (humpback dolphins and finless porpoises) overlaps to some extent, as important prey (e.g., *Collichthys*, *Thryssa*, *Trichiurus*) are shared by them. However, humpback dolphins seem to favour those species common in estuarine areas (Parsons, 1997; Barros, 1998), whereas finless porpoises also exploit other coastal, non-estuarine habitats. These prey preferences seem to be reflected in the distribution of the cetaceans around Hong Kong. Finless porpoises occur only in the southern and eastern areas of Hong Kong, where salinities are higher (Jefferson & Braulik, 1999; Jefferson et al., 2002b), and humpback dolphins are seen mostly in northwestern waters, where estuarine conditions prevail under the influence of the Pearl River runoff (Jefferson, 2000). Parsons (1998b) noted that the occurrence of finless porpoises in the southwestern region of Hong Kong was negatively correlated with the occurrence of humpback dolphins (i.e., when finless porpoises were present, humpback dolphins were not). Moreover, the abundance of finless porpoises was significantly correlated with increasing salinity and decreasing water temperature (Parsons, 1998b). These high salinity areas may provide suitable habitat for cephalopods (cuttlefishes, octopuses) and other stenohaline species, which are important food resources for finless porpoises. Resource partitioning between delphinid species (Perrin et al., 1973, Robertson & Chivers, 1997), and dolphins of different ontogenetic stages and reproductive conditions (Bernard & Hohn, 1989; Cockcroft & Ross 1990; Young & Cockcroft, 1995) has been reported for animals with similar distributions.

Although bottlenose dolphins in Hong Kong have a more pelagic distribution than both humpback dolphins and finless porpoises, when they venture into inshore waters they may overlap with the latter in the prey species they take. Of the 12 prey species identified from the stomach contents of four stranded bottlenose dolphins in Hong Kong (Barros et al., 2000), at least eight were shared by finless porpoises. Further research is needed to examine the inter-specific resource partitioning among the cetaceans occurring off Hong Kong.

Seasonality and Sex Differences in Prey Consumption – Seasonal differences in diet, as well as differences between porpoises of different sex, could not be statistically detected in this study. This may have been a result of the small sample sizes available and the large variability in the data obtained. Trends in seasonal variation in diet and gender-associated differences, as they relate to patterns of habitat use, may become more evident with the collection of further samples. Additional studies on distribution and habitat usage, and continuing stranding coverage are recommended to further investigate these possibilities.

Future Research - Seasonal occupation of various areas and habitats probably determines how the two resident cetaceans share common food resources. Research on distribution and abundance has shown strong seasonality for both species in Hong Kong (Jefferson & Leatherwood, 1997; Parsons, 1998b; Jefferson & Braulik, 1999; Jefferson, 2000; Jefferson et al., 2002b). In other areas of the world, there have been unconfirmed reports of finless porpoise seasonal movements correlated to seasonal migrations of prey (Kasuya, 1999 and references therein). Several species of squid and cuttlefish move into inshore waters of Hong Kong during spawning migrations (Roper et al., 1984), and are caught in large numbers in shrimp trawls (ERM-Hong Kong, 1997). This would suggest that the distribution and movements of finless porpoises in Hong Kong waters could be influenced by the seasonal and spatial distribution of their preferred prey.

The high levels of contaminants found in tissues of Hong Kong finless porpoises are a cause for concern (Parsons &

Chan, 1998; Parsons, 1998a, 1999a; Jefferson and Braulik, 1999; Minh et al., 1999; Jefferson et al., 2002a). We recommend the continuation of food habits studies and the monitoring of pollutants in finless porpoises and humpback dolphins (e.g., Parsons 1999a,b), as further development and human population growth around Hong Kong may alter the habitat, distribution and abundance of the cetaceans occurring in the area.

ACKNOWLEDGMENTS

This study was funded by a subcontract of the Finless Porpoise Project, which was in turn supported by the Hong Kong Agriculture, Fisheries and Conservation Department. Logistical support for data collection and analyses was provided by Ocean Park, the Ocean Park Conservation Foundation, SeaWorld Orlando, Hubbs-Sea World Research Institute and Mote Marine Laboratory. We thank those involved in porpoise necropsies, and collection and shipment of samples, particularly Mientje Torey, Lawman Law and Samuel Hung. Prof. Nancy Voss kindly allowed access to cephalopod specimens deposited at the Invertebrate Museum of the University of Miami's Rosenstiel School of Marine and Atmospheric Science. Steve Clark provided statistical support and fruitful insights into data interpretation. We thank him and Gretchen Hurst for the preparation of the figures. Brian Smith, Hiroshi Ohizumi and an anonymous reviewer provided helpful comments on the manuscript.

LITERATURE CITED

Allen, G. M., 1923. The black finless porpoise, *Meomeris*. *Bull. Mus. Comp. Zool.*, **65**: 233-256.

Barros, N. B., 1998. Prey of Indo-Pacific humpback dolphins (*Sousa chinensis*) in Hong Kong waters. *Unpublished contract report to Clymene Enterprises*, 7 pp.

Barros, N. B. & D. K. Odell, 1990. Food habits of bottlenose dolphins from the southeastern United States. In: S. Leatherwood & R.R. Reeves (eds.). *The Bottlenose Dolphin*. Academic Press, San Diego. Pp. 309-328.

Barros, N. B., E. C. M. Parsons & T. A. Jefferson, 2000. Prey of offshore bottlenose dolphins from the South China Sea. *Aquat. Mammals*, **26**: 2-6.

Bernard, H. J. & A. A. Hohn, 1989. Differences in feeding habits between pregnant and lactating spotted dolphins (*Stenella attenuata*). *J. Mammal.*, **70**: 211-215.

Borobia, M. & N. B. Barros, 1989. Notes on the diet of marine *Sotalia fluviatilis*. *Mar. Mamm. Sci.*, **5**: 395-399.

Chen, P., P. Liu, R. Liu, L. Kejie & G. Pilleri, 1979. Distribution, ecology, behavior and conservation of the dolphins of the middle reaches of Changjiang (Yangtze) River (Wuhan-Yueyang). *Invest. Cetacea*, **10**: 87-103.

Clarke, M. R. (ed.), 1986. *A Handbook for the Identification of Cephalopod Beaks*. Clarendon Press, Oxford. 273 pp.

Cockcroft, V. G. & G. J. B. Ross, 1990. Food and feeding of the Indian Ocean bottlenose dolphin off southern Natal, South Africa. In: S. Leatherwood & R. R. Reeves (eds.). *The Bottlenose Dolphin*. Academic Press, San Diego. Pp. 295-308.

ERM-Hong Kong, 1997. *Fisheries resources and fishing operations in Hong Kong waters*. Draft Final Report to the Agriculture & Fisheries Department, Hong Kong, 216 pp.

Gaston, K. J., 1996. Species richness: measure and measurement. In: Gaston, K.J. (ed.). *Biodiversity*. Blackwell Science, Oxford. Pp. 77-113.

Härkönen, T., 1986. *Guide to the otoliths of the bony fish of the Northeast Atlantic*. Danbiu ApS. Biological Consultants. Hellerrup, Denmark. 256 pp.

Huang, Z. (ed.), 1994. *Marine species and their distributions in China's seas*. China Ocean Press, Beijing. 134 pp. (in Chinese).

Huang, Z., W. Liu, C. Zheng, C. Li, J. Wang & T. A. Jefferson, 2000. Finless porpoises in the southern coastal waters of Fujian, China. *Acta Oceanol. Sinica*, **22**: 114-119 (in Chinese, English summary).

Hulley, P. A., 1989. Myctophidae. In: Whitehead, P. J. P., M.-L. Bauchot, J.-C. Hureau, J. Nielsen & E. Tortonese (eds.). *Fishes of the north-eastern Atlantic and the Mediterranean. Volume I*. UNESCO, Paris, Pp. 429-483.

Jefferson, T. A., 2000. Population biology of the Indo-Pacific hump-backed dolphin in Hong Kong waters. *Wildl. Monogr.*, **144**: 1-65.

Jefferson, T. A. & G. T. Braulik, 1999. Preliminary report on the ecology of the finless porpoise in Hong Kong waters. *IBI Rep.*, **9**: 41-54.

Jefferson, T. A. & S. Leatherwood, 1997. Distribution and abundance of Indo-Pacific hump-backed dolphins (*Sousa chinensis* Osbeck, 1765) in Hong Kong waters. *Asian Mar. Biol.*, **14**: 93-110.

Jefferson, T. A., B. E. Curry & R. Kinoshita, 2002a. Mortality and morbidity of Hong Kong finless porpoises, with emphasis on the role of environmental contaminants. *Raffles Bull. Zool.*, Supplement **10**: 161-171.

Jefferson, T. A., S. K. Hung, L. Law, M. Torey & N. Tregenza, 2002b. Distribution and abundance of finless porpoises in Hong Kong and adjacent waters of China. *Raffles Bull. Zool.*, Supplement **10**: 43-55.

Jefferson, T. A., K. M. Robertson & J. Y. Wang, 2002c. Growth and reproduction of the finless porpoise in southern China. *Raffles Bull. Zool.*, Supplement **10**: 105-113.

Kasuya, T., 1999. Finless porpoise *Neophocaena phocaenoides* (G. Cuvier, 1829). In: Ridgway, S. H. & R. Harrison (eds.). *Handbook of Marine Mammals. Volume V. The Second Book of Dolphins*. Academic Press, London. Pp. 411-442.

Krebs, C.J. (ed.), 1999. *Ecological Methodology*. Addison Wesley Longman, Inc. Menlo Park, CA. 620 pp.

Khromov, D. N., 1998. Distribution patterns of Sepiidae. In: Voss, N. A., M. Vecchione, R. B. Toll & M. J. Sweeney (eds). *Systematics and Biogeography of Cephalopods*. Volume I. Smithsonian Institution Press, Washington, D.C. Pp: 191-206.

Leatherwood, S. & T. A. Jefferson, 1997. Dolphins and development in Hong Kong: a case study in conflict. *IBI Rep.*, **7**: 57-69.

Mahakunlayanakul, S., 1996. *Species distribution and status of dolphins in the inner Gulf of Thailand*. M.Sc. Thesis. Chulalongkorn University, 130 pp.

Minh, T. B., M. Watanabe, H. Nakata, S. Tanabe & T. A. Jefferson, 1999. Contamination by persistent organochlorines in small cetaceans from Hong Kong coastal waters. *Mar. Poll. Bull.*, **39**: 383-392.

Murray, J. A., 1884. A contribution to the knowledge of marine fauna of Kurrachee. *Ann. Magazine Nat. Hist.*, **13**: 348-352.

Parsons, E. C. M., 1997. Hong Kong's cetaceans: the biology, ecology and behaviour of *Sousa chinensis* and *Neophocaena phocaenoides*. Ph.D. thesis, University of Hong Kong. 257 pp.

Parsons, E. C. M., 1998a. Trace metal pollution in Hong Kong: implications for the health of Hong Kong's Indo-Pacific hump-backed dolphins (*Sousa chinensis*). *Sci. Total Environ.*, **214**: 175-184.

Parsons, E. C. M., 1998b. The behaviour of Hong Kong's resident cetaceans: the Indo-Pacific hump-backed dolphins and the finless porpoise. *Aquat. Mammals*, **24**: 91-110.

Parsons, E. C. M., 1999a. Trace metal concentrations in tissues of cetaceans from Hong Kong's territorial waters. *Environ. Cons.*, **26**: 30-40.

Parsons, E. C. M., 1999b. Trace element concentrations in whole fish from North Lantau waters, Hong Kong. *ICES J. Mar. Sci.*, **56**: 791-794.

Parsons, E. C. M. & H. M. Chan, 1998. Organochlorines in Indo-Pacific hump-backed dolphins (*Sousa chinensis*) and finless porpoises (*Neophocaena phocaenoides*) from Hong Kong. In: Morton, B. (ed.). *The Marine Biology of the South China Sea III.* Hong Kong University Press. Pp. 423-437.

Parsons, E. C. M. & T. A. Jefferson, 2000. Post-mortem investigations on stranded dolphins and porpoises from Hong Kong waters. *J. Wildl. Dis.*, **36**: 342-356.

Parsons, E. C. M. & J. Y. Wang, 1998. A review of finless porpoises (*Neophocaena phocaenoides*) from the South China Sea. In: Morton, B. (ed.). *The Marine Biology of the South China Sea III.* Hong Kong University Press. Pp. 287-306.

Parsons, E. C. M., M. L. Felley & L. J. Porter, 1995. An annotated checklist of cetaceans recorded from Hong Kong's territorial waters. *Asian Mar. Biol.*, **12**: 79-100.

Perrin, W. F., R. R. Warner, C. H. Fiscus & D. B. Holts, 1973. Stomach contents of porpoise, *Stenella* spp., and yellowfin tuna, *Thunnus albacares*, in mixed-species aggregations. *Fish. Bull. U.S.*, **71**: 1077-1092.

Pilleri, G. & M. Gihr, 1972. Contribution to the knowledge of the cetaceans of Pakistan with particular reference to the genera *Neomeris, Sousa, Delphinus* and *Tursiops* and description of a new Chinese porpoise (*Neomeris asiaorientalis*). *Invest. Cetacea*, **4**: 107-162.

Robertson, K. M. & S. J. Chivers, 1997. Prey occurrence in pantropical spotted dolphins, *Stenella attenuata*, from the eastern tropical Pacific. *Fish. Bull. U.S.*, **95**: 334-348.

Roper, C. F. E, M. J. Sweeney & C. E. Nauen, 1984. FAO Species Catalogue. Vol. 3. Cephalopods of the World. An Annotated and Illustrated Catalogue of Species of Interest to Fisheries. *FAO Fish. Synopsis,* **125**(3): 1-277.

Schoener, T. W., 1974. Resource partitioning in ecological communities. *Science*, **185**: 27-39.

Smale, M. J., G. Watson & T. Hecht, 1995. Otolith atlas of southern African marine fishes. *Ichthyological Monographs of the J.L.B. Smith Institution of Ichthyology*, **1**: 1-253.

Torey, M., 2000. *Study on interactions between cetaceans and fisheries in Hong Kong waters: Final report.* Contract report to the Ocean Park Conservation Foundation, Hong Kong, 29 pp. + appends.

Van der Elst, R., 1981. *A Guide to the Common Sea Fishes of Southern Africa.* Struik Publishers Ltd, South Africa. 367 pp.

Vecchione, M., T. F. Brakoniecki, Y. Natsukari & R.T. Hanlon, 1998. A provisional generic classification of the family Loliginidae. In: Voss, N.A., M. Vecchione, R.B. Toll & M.J. Sweeney (eds). *Systematics and Biogeography of Cephalopods.* Volume I. Smithsonian Institution Press, Washington, D.C. Pp: 215-222.

Voss, G.L. & G.R. Williamson, 1971. *Cephalopods of Hong Kong.* Hong Kong Government Press. 138 pp.

Wang, P., 1984. Distribution, ecology and resources conservation of the finless porpoise in Chinese waters. *Trans. Liaoning Zool. Soc.*, **5**: 105-110 (in Chinese).

Weitzman, S. H., 1997. Systematics of deep-sea fishes. In: D.J. Randall & Farrell (eds.). *Deep-sea Fishes.* Academic Press, San Diego, CA. Pp. 43-77.

Young, D. D. & V.G. Cockcroft, 1995. Stomach contents of common dolphins *Delphinus delphis* from the south-east coast of southern Africa. *Z. Saugertierkunde*, **60**: 343-351.

Zar, J.H. (ed.), 1999. *Biostatistical Analysis.* Prentice-Hall. Upper River Saddle, NJ. 663 pp.

Zhang, X., 1992. Studies on the age determination, growth and reproduction of finless porpoises *Neophocaena phocaenoides*. *Acta Hydrobiol. Sinica*, **16**: 289-298 (in Chinese, English summary).

Zheng, W., 1981. Comparative morphological studies of the otoliths of Chinese Carangidae and other fish families. *Trans. Chinese Ichthyol. Soc.*, **2**: 39-54.