台灣南端鄰近海域鯨類之種組成、分布及相對豐度之調查研究暨對保育與生態觀光之重要性

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摘　　要

首先，本文係初步匯整台灣捕鯨史，自過去擱淺資料可能出現的鯨豚種類中，發現此鯨類名單中缺乏小型鯨類紀錄。於 2000 年三月至九月期間以船舶調查的方式進行台灣南端海域首次的海上鯨類生態研究，以了解台灣南端墾丁國家公園鄰近海域的鯨類現況。調查結果總共紀錄到 14 種鯨類和一暫時鑑定的亞種，其中有七種並未出現在初步鯨類表，也無鬚鯨類的紀錄，顯示出捕鯨時期及過去擱淺資料所列的初步鯨類表並無法正確反映出本海域的鯨種組成。鯨類出現於本海域的時間和位置上呈現不均等分布，發現率最高為花紋海豚 *Grampus griseus*， 數量比例最多為弗氏海豚 *Lagenodelphis hosei*。另外，南灣海域發現 10 次印太洋瓶鼻海豚 *Tursiops aduncus* 和一次暫時鑑定的侏儒飛旋海豚 *Stenella longirostris roseiventris* 亞種。最後根據目前之調查結果，針對台灣南端墾丁海域之鯨類保育與生態觀光活動作一討論分析與建言。

關鍵詞：鯨類，種組成，分布，台灣南端墾丁海域，船舶調查。

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Species Composition, Distribution and Relative Abundance of Cetaceans in the Waters of Southern Taiwan: Implications for Conservation and Eco-tourism

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ABSTRACT: A preliminary list of cetacean species occurring in the waters of southern Taiwan based on historic whaling and stranding data seemed to under-represent the small cetacean fauna in the region. Therefore, the first shipboard survey dedicated to understanding the cetaceans in the waters of southern Taiwan was conducted from March to September 2000. The study confirmed that the species list based on whaling records and stranding data did not reflect accurately the present species composition in these waters. In total, 14 species and one tentative subspecies were observed during this survey. Seven of these species were not on the initial species list and no baleen whales were observed. The temporal and spatial distributions of cetaceans were also heterogeneous. The most frequently observed species was Risso's dolphin, *Grampus griseus*, but Fraser's dolphin, *Lagenodelphis hosei,* was more abundant with respect to the total number of individuals counted. In addition, 10 sightings of the Indo-Pacific bottlenose dolphin, *Tursiops aduncus*, and one sighting, identified tentatively as the dwarf spinner dolphin subspecies, *Stenella longirostris roseiventris,* were made in Nan Wan. The implications of the results of the present study for cetacean conservation and eco-tourism in the waters of southern Taiwan are discussed.

KEYWORDS: Cetaceans, Species Composition, Distribution, Southern Taiwan, Shipboard Survey.

Introduction

Review of historical whaling and stranding records in southern Taiwan

Initial information of faunal composition and distribution of cetaceans in most places throughout the world has come from past records of hunted and stranded animals. We compiled catch information from the historic whaling stations that operated from Tapanle and Banana Bay, Kenting (Yang, 1964; Yu, 1995, 1999) and available stranding records (Yang, 1976; Chou et al., 1995; Wang and Chou, 1999; J. Y. Wang, unpublished data) to

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produce a preliminary list of cetaceans occurring in the waters of southern Taiwan. In these waters, the main target species of whalers were the humpback (*Megaptera novaeangliae*) and sperm (*Physeter macrocephalus*) whales. Between 1920 and 1942, Japanese whalers caught 740 humpback, 18 sperm, 15 blue (*Balaenoptera musculus*), 10 sei (*Balaenoptera borealis*) and one finback (*Balaenoptera physalus*) whales (whaling began in 1913 but the data for the earlier years were not available). In addition, from 1957 to 1967, Taiwanese whalers caught a minimum of 30 humpback, 22 sperm and three sei whales. Other species that were in the whaling records included killer (*Orcinus orca*) and ginkgo-toothed beaked (*Mesoplodon ginkgodens*) whales. In the early 1990's, a small Bryde's whale (*Balaenoptera edeni*) was harpooned by a Taiwanese fisherman and landed at Houbihu Harbour. Photographs of this animal were observed during an interview with a fisherman (by J. Y. Wang). In 1997, a juvenile sperm whale about four metres long was landed at Xin Hai harbour on the east coast of Kenting National Park (KTNP) (S.-Y. Chuan, personal communication, Department of Conservation and Research, KTNP). From stranding records, six small to medium sized cetacean species have been recorded: Cuvier's beaked whale, *Ziphius cavirostris*; melon-headed whale, *Peponocephala electra* (identified initially as harbour porpoise, *Phocoena phocoena*, by Yang (1976) but later corrected); false killer whale, *Pseudorca crassidens* (stranded at Che-Cheng on 02 February 2000); pantropical spotted dolphin, *Stenella attenuata*, (recent stranding – J. Y. Wang, unpublished data); Fraser's dolphin, *Lagenodelphis hosei*, (two recent strandings; J. Y. Wang, unpublished data) and Risso's dolphin, *Grampus griseus* (see Yang, 1964, 1976; Yu, 1995, 1999; Wang and Chou, 1999; and J. Y. Wang, unpublished data). In addition, a finless porpoise, *Neophocaena phocaenoides*, was captured incidentally in a gill or trammel net in the waters of northwest Pingtung County in the early 1990's (the capture location may be slightly beyond the present study area but this species may be an inhabitant of some of the waters being studied). Positive species identification of the animal was made (by J. Y. Wang) from a photograph of the carcass.

Even though the strandings and the detection of the species identification error (see above) added four small cetacean species to the list, the available information shows a clear deficiency in the number of small to medium sized species in these waters. The quality of historical data can vary greatly and is usually dependent upon the necessity of accurate information that in turn affects the amount of effort spent and rigor taken in collecting the information. The bias of the whaling information towards large species and the paucity of reliable stranding records provide an incomplete representation of the cetacean fauna in the waters of southern Taiwan. In order to obtain a more complete and representative list of species, their distribution and abundance in these waters, direct observations of cetaceans at sea are necessary.

Features of the study area

Kenting National Park (KTNP) consists of a strip of land (17,731 hectares) that lines most of the coast of the tip of southern Taiwan and includes 14,900 hectares of its associated

coastal waters. Designated on January 1, 1984 as Taiwan's first national park, it still remains the only national park in Taiwan that includes a marine component. As with all national parks in Taiwan, it was designed as a multiple-use park with considerations for both wildlife and human activities (see Fig. 1).

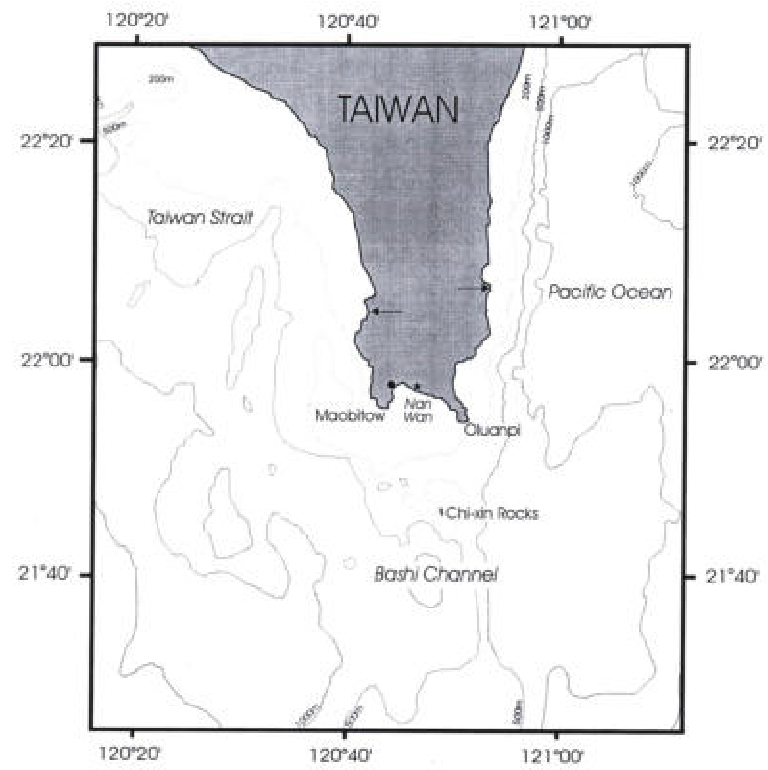

Figure 1. Map of the study location. The large solid circle represents Houbihu Harbour, the star represents the Kenting National Park Administrative Office and the arrows represent the approximate locations of the boundaries of Kenting National Park.

Oceanographic features of the waters of southern Taiwan are very complex. Diverse oceanographic features provide a variety of marine habitats for a multitude of species. There are many complex bathymetric features both on and off the continental shelf. Along the east and northeast coast, the continental shelf is very narrow and the ocean floor drops very steeply into an expansive and deep basin (depth about 1200-1300m) as close as 6 km from shore. The ocean floor southeast of KTNP slopes gradually to a depth of about 1000m. South and west of the southern tip of Taiwan are characterized by a more extensive continental shelf with more complexities in bottom topography and with deep water still remaining fairly close to shore. The region northwest of KTNP is comprised mainly of shallow shelf waters with the exception of a moderately deep trough with gradually sloping sides. Nan Wan is a small, shallow coral reef bay situated at the most southern tip of Taiwan. The greatest depth of this bay is not more than about 100m with the western half being deeper than the east. The wide mouth of the bay faces due south.

The interactions of water currents in southern Taiwan are also very complex. Along the western coast of Taiwan, there is an inshore current of light-coloured water that flows south. Another south-flowing inshore current is found along the east coast. Both coastal currents are turbid and cooler than the Kuroshio Current, which is an immense warm, clear, deep blue body of water. The Kuroshio Current originates east of the Philippines as a branch from the North Equatorial Current and exerts tremendous influence on Taiwan's climate and biota. In general, it flows northward along the east coast of Taiwan towards Japan but intrusions into the Taiwan Strait during summer occur frequently. These three main currents interact in southern Taiwan where the bottom topography is complex. Because tidal forces are also substantial, understanding water movements in this area is not a trivial task. Daily differences in the interactions and strength of these currents, tidal movements and wind can make marine conditions unpredictable and potentially hazardous to mariners especially near Maobitow and Oluanpi.

Eco-tourism, cetaceans and marine conservation

Tourism is substantial in KTNP and boat traffic has been increasing due to the growing number of private pleasure crafts in the waters of KTNP. Because observing cetaceans has increased in popularity in Taiwan, it is likely that local tour operators will also want to offer similar services in or near the waters of KTNP. Prior to the start of any such tours, it is important to have at least a basic understanding of the biology of the local fauna so that vessel operators can be guided in minimizing the impact of their activities on the animals (e.g., avoid visiting cetaceans in areas where they may be sensitive to disturbance). Only by minimizing disturbance to the animals will eco-tours be more likely to succeed and persist. This type of basic biological information also provide a foundation for future research and for monitoring the effects of tourism activities on cetaceans. However, little is known of the species composition, distribution and relative abundance of cetaceans in the waters of Taiwan. Although dedicated shipboard surveys have been conducted recently along the east coast of Taiwan (Chen et al., 1998a; Yeh et al., 1998; Yang et al., 1999), similar surveys elsewhere in coastal waters of Taiwan are limited (see Chen et al., 1998b). Presently, all records of cetaceans in the waters of southern Taiwan are from historic whaling records, stranding reports and interviews with local fishermen. Since most of this information is indirect or biased (e.g., the Japanese whaling records contained mainly large cetaceans), cetaceans of southern Taiwan may not be described accurately.

Much of the conservation-related research in the waters of southern Taiwan has been directed at the coral reef ecosystem. Although a very important part of tropical waters, research effort concentrated solely on this type of environment will overlook a large portion of marine species that are associated with more fluid oceanographic features (e.g., pelagic and deep-sea species). It is not a choice of one over the other but rather the need to obtain a more complete understanding of the marine environment of Taiwan. Because so little is

known of these protected species, which are facing numerous and increasing threats, information is needed urgently.

The purpose of this exploratory study is to use direct observations at sea to provide a more representative description of the present species composition, distribution and relative abundance of cetaceans in the waters of southern Taiwan. Also, by comparing present direct observations with information from historical whaling records, the impact of whaling on the local cetacean fauna may be better understood.

Materials and Methods

Survey equipment and method

The primary survey vessel was a 14 m long fishing boat with a harpooning bowsprit. Average survey speed was about 10-12 km/h. Two to five dedicated observers (including the captain) were situated at the centre of the vessel on a platform that was approximately 3 m high. Observers scanned the waters constantly during active search times that lasted no longer than 5 hours before a rest period. Observers searched with unaided eyes and binoculars (Leica Trinovid 10×32) during daylight hours. For consistency in data collection, one observer (JYW) was present on all trips and recorded all data. Time, position and sighting conditions (weather, glare, Beaufort sea state, swell size, etc.) were recorded frequently and also when the vessel changed course substantially or when sightings (cetaceans or seabirds) or other events were recorded. Sea surface temperature was also measured periodically and at locations where cetaceans were observed. Geographic positions were determined using a handheld Global Positioning System unit (Magellan GPS Tracker). When cetaceans were sighted, we would approach to investigate the animals thoroughly so that species identifications could be confirmed and additional information could be recorded (e.g., group size, water depth - in most cases determined from nautical charts, distance from and bearing with respect to the vessel, and some simple behavioural observations). Animals were approached slowly and cautiously to avoid disturbing or influencing their behaviour or original direction of travel. However, in many cases, this was not possible because the animals approached us to examine our vessel or to surf its bow wake. Also, due to the slow speed of our vessel, it was also not possible to approach some animals closely if they avoided the boat. Whenever possible, sightings were also documented with photographs which were taken mainly with 80-200mm (sometimes with a 1.4 teleconverter) and 300 mm lenses using 35 mm colour slide film (Kodachrome 64 or Fujichrome 100.

Survey design

After the first three survey days, six sectors (NW, W, SW, S, SE and NE) of roughly equal areas were established (Fig. 2) so that survey effort could be monitored and distributed

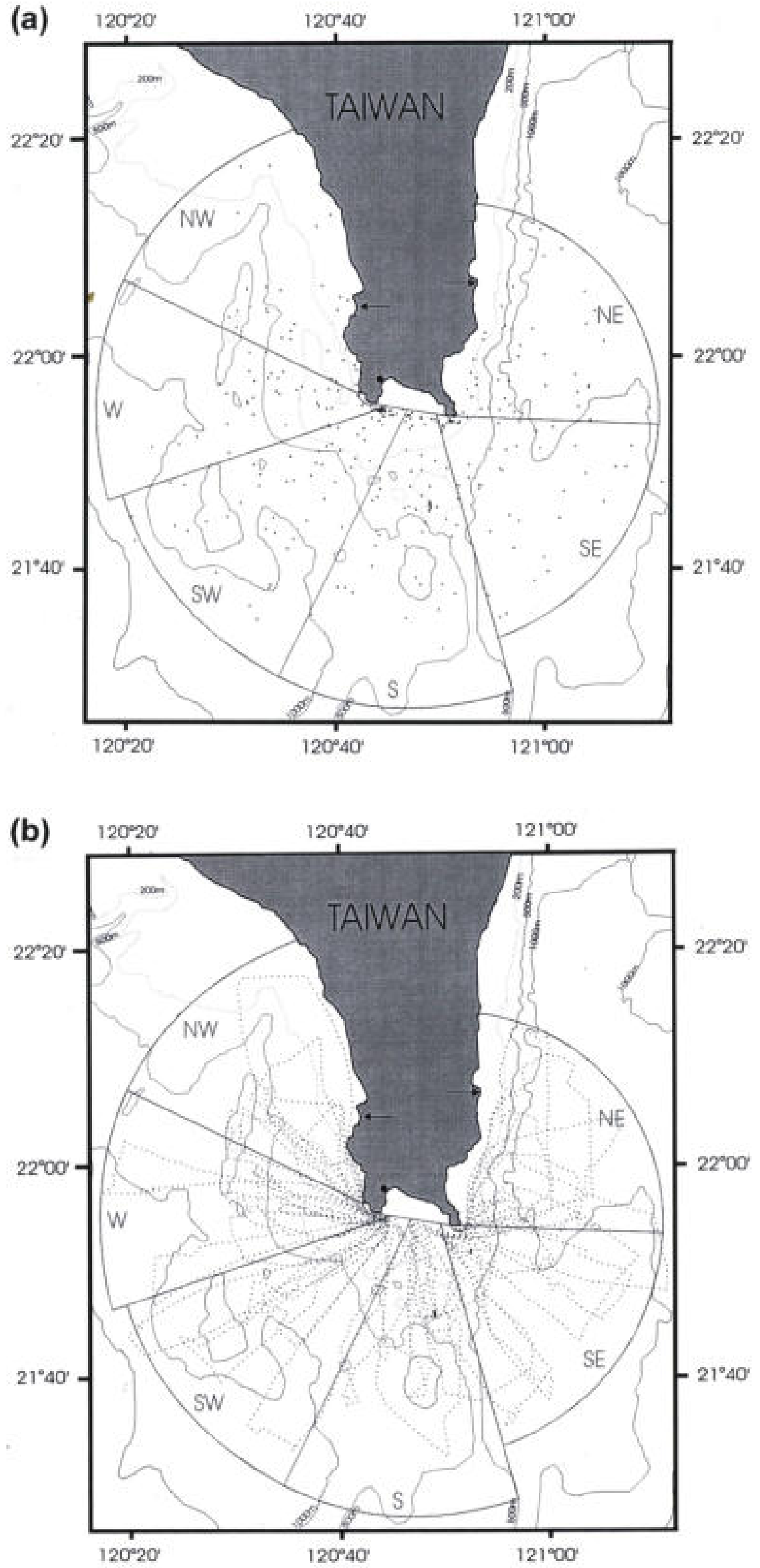

Figure 2. Study location, survey sectors and survey effort. Survey effort allocated to each sector is represented by time (a) and distance (b). Each dot indicates one hour (a) or one kilometre (b). The large solid circle represents Houbihu Harbour and the arrows represent the approximate locations of the boundaries of Kenting National Park.

more uniformly and randomly in the study area. Comparisons of relative abundance and species diversity amongst portions of the study area would also be facilitated with a sector system. The sectors extended out to a maximum radial distance of about 56 km (= 30 nautical miles) from Houbihu Harbour - 56 km is the distance that could be reached within about 2-3 hours by a typical cetacean watch vessel travelling 18-28 km/h. However, all waters north of a straight line connecting Maobitow to Oluanpi and the inshore waters less than 50m deep from Maobitow northwest to Baisha were excluded from the sectors and treated as separate regions, "Nan Wan and adjacent waters". Because we transited through Nan Wan prior to the start of each sector survey, parts of "Nan Wan and adjacent waters" were surveyed on each trip.

All sectors were surveyed between 13 April and 09 September 2000. The order in which the sectors were surveyed was determined randomly without replacement. The random selection process began again only after all six sectors were surveyed. Due to inclement weather or marine conditions, minor adjustments were made to the predetermined random survey order of the sectors to maximize the number of trips that could be conducted (e.g., if a certain sector could not be surveyed because of sea conditions, it was replaced by the next sector in the order that could be surveyed on that day). Because this was primarily an exploratory study, transect-line methodology was not used. Instead, courses were selected to maximize the study area searched while minimizing the overlap of effort.

Data selection and analyses

Only data that were collected in decent sighting conditions (i.e., Beaufort sea state (SS) less than 4, no heavy rain that prevented the use of binoculars, and during daylight hours) were used in the analyses. We felt that cetacean species in Taiwan were easily detectable in these sea conditions which have been used in studies of other species, such as the harbour porpoise, that are not as visible (e.g., Palka 1995).

Most of the analyses in this study were descriptive. For comparisons of the data, survey effort must be constant amongst the categories (i.e., sectors or months) being compared. Therefore, the data were standardized to both survey time and distance surveyed (standardization to time alone may not represent accurately the amount of area surveyed if much time was spent observing animals or searching at different boat speeds while standardization to just survey distance would not represent the amount of effort allocated per unit of distance). This correction for differences in effort is the same principle as catch per unit effort or CPUE (see Caughley, 1977; Gulland, 1983).

To determine if cetaceans were distributed homogeneously throughout the study area, chi-square analyses were performed to test the observed frequencies of sightings and individuals in each sector against expected frequencies. The expected frequencies of the sectors were calculated based on the proportion of the total survey effort allocated to each sector. Similarly, chi-square analyses were also performed to determine if cetaceans were distributed homogeneously throughout the study period (i.e., amongst the months).

Results

Effort

Six (day) trips were made in April, seven trips each in May, June and July, 8 trips in August and 3 in September for a total of 38 survey trips in the sectors. Because many trips spanned more than one sector, it was not possible to count trips per sector. In addition, one day was spent completely in "Nan Wan and adjacent waters" observing a school of Indo-Pacific bottlenose dolphins, *Tursiops aduncus,* and one day was shortened greatly by mechanical problems. Trips surveying the sectors lasted between 2.5 and 11 hours (from exiting to entering port) with data collection periods lasting from 0.3 to 9.1 hours (mean = 6.2; SD = 1.8). The total time spent surveying the sectors was 234.8 hours but only 227.1 hrs had SS < 4 (Table 1; Fig. 2a). The distance surveyed in the sectors during the trips varied from 3.0 km to 110.6 km (mean = 74.6; SD= 23.5). The total distance surveyed was 2834.3 km of which 2723.0 km were during SS < 4 (Table 1; Fig. 2b). The total effort (the product of the survey distance and time for each trip summed over all trips) was 13,760.1 km·hrs and the effort in SS < 4 was 12,888.3 km·hrs (Table 1).

Table 1. Survey effort (time, distance and distance•time) spent in the sectors and in "Nan Wan and adjacent waters" (only time was recorded systematically). SS = Beaufort Sea State.

		Survey Effort		
		Time (hours)	Distance (kilometres)	Distance × Time (km•hrs)
Sectors				
	Total	234.8	2834.3	13760.1
	Survey in SS<4	227.1	2723.0	12888.3
Nan Wan and adjacent waters	Total	47.3	----	----
	Survey in SS<4	44.3	----	----

Species composition

In total, 14 species and one tentative subspecies of cetaceans were observed. During the survey of the sectors, we encountered 44 different groups of 13 species: Risso's dolphin, *Grampus griseus*; false killer whale, *Pseudorca crassidens*; short-finned pilot whale, *Globicephala macrorhynchus*; pygmy killer whale, *Feresa attenuata*; melon-headed whale, *Peponocephala electra*; common bottlenose dolphin, *Tursiops truncatus*; long-snouted

spinner dolphin, *Stenella longirostris*; pantropical spotted dolphin, *Stenella attenuata*; Fraser's dolphin, *Lagenodelphis hosei*; dwarf sperm whale, *Kogia sima*; Cuvier's beaked whale, *Ziphius cavirostris*; an unidentified beaked whale of the genus *Mesoplodon*; an unidentified large beaked whale that was likely of the genus *Hyperoodon*; also a *Kogia* and a *Tursiops* sighting could not be identified to species (they were not added to the list as different species) (Table 2). In addition, the Indo-Pacific bottlenose dolphin, *T. aduncus* and dwarf subspecies of spinner dolphin, *S. longirostris roseiventris* (see Perrin et al., 1989, 1999) were observed in "Nan Wan and adjacent waters" (positive identification of the latter was not possible due to the quality of the photographs taken at dusk in low light conditions). On several occasions, mixed-species groups were observed. Most mixed-species groups consisted of *G. grampus* and *L. hosei*. One mixed group contained *P. crassidens*, *T. truncatus* and a single *L. hosei*. Although on many occasions it appeared that *G. grampus* was "herding" *L. hosei*, no aggression was witnessed and the nature of the interactions remains unknown.

Distribution

Sightings of *G. grampus* were made in all sectors. Two other species are also likely to occur in all sectors: *Kogia* were observed in all sectors except the SW where only 4 sightings of cetaceans were made during the study period, and although *L. hosei* was observed in only four of the girds (NW and SE sectors had no sightings), stranding records indicate that this species might visit the NW and SE sectors as well. *S. longirostris* appeared to occur in relatively shallow waters close to shore. For other species, there were too few sightings for generalizations to be made (Fig. 3).

Most of the sightings were made in the NE and W sectors (Table 3). These sectors also had the highest number of species and number of individuals per 1000 km·hrs (note: "number of individuals" is used in this paper to represent the number of animals counted and may not reflect the actual population size because some animals may have be counted more than once during the study period; however, many distinctly recognizable individuals were observed and photographed but none were seen more than once). Almost all sightings in the NE sector were made in a thin narrow strip of water along the steep slope of the continental shelf (between the 200 and 1000 m isobaths). In the W sector, the sightings were more dispersed. In other sectors, there were too few sightings for any patterns to be detected (see Fig. 3). Chi-square analyses showed that the uneven distribution of sightings and number of individuals amongst the sectors were statistically significant (χ^2 = 16.94, df = 5, p < 0.005; and χ^2 = 1734.3, df = 5, p < 0.001, respectively).

The monthly analyses in this study showed that April and June had the highest number of sightings, species and number of individuals per 1000 km·hrs (Table 4a). Chi-square analyses also showed that the number of sightings and the number of individuals were not distributed uniformly among the months during the study period (χ^2 = 19.34, df = 5, p < 0.002; and χ^2 = 4267.7, df = 5, p < 0.001, respectively).

Table 2. List of cetacean species documented and observed from the waters of southern Taiwan. ? = tentative identification.

Species	Common Names	Historical Whaling Records	Stranding or Other Events	Shipboard Survey
Balaenoptera musculus	Blue whale	X		
Balaenoptera physalus	Finback whale	X		
Balaenoptera borealis	Sei whale	X		
Balaenoptera edeni	Bryde's whale	X	X	
Megaptera novaeangliae	Humpback whale	X		
Physeter macrocephalus	Sperm whale	X	X	
Kogia sima (=*simus*)	Dwarf sperm whale			X
Hyperoodon sp.?	Bottlenose whale			X
Ziphius cavirostris	Cuvier's beaked whale		X	X
Mesoplodon ginkgodens	Ginkgo-toothed beaked whale	X		
Globicephala macrorhynchus	Short-finned pilot whale			X
Orcinus orca	Killer whale	X		
Pseudorca crassidens	False killer whale		X	X
Feresa attenuata	Pygmy killer whale			X
Peponocephala electra	Melon-headed whale		X	X
Stenella attenuata	Pantropical spotted dolphin		X	X
Stenella longirostris	Long-snouted spinner dolphin			X
Stenella longirostris roseiventris ?	Dwarf spinner dolphin			X
Lagenodelphis hosei	Fraser's dolphin		X	X
Grampus griseus	Risso's dolphin		X	X
Tursiops truncatus	Common bottlenose dolphin			X
Tursiops aduncus	Indo-Pacific bottlenose dolphin			X
Neophocaena phocaenoides	Finless porpoise		X	

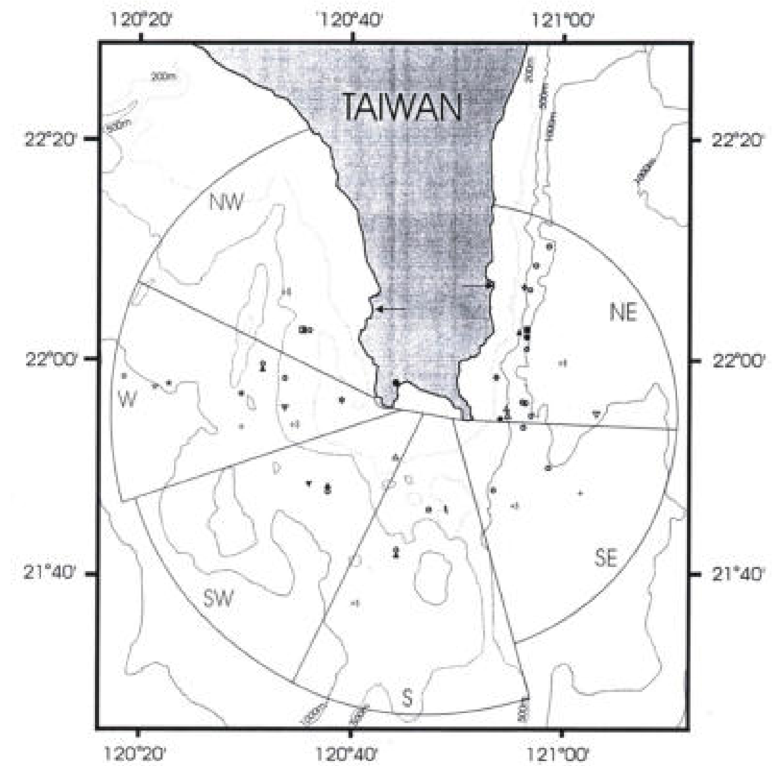

Figure 3. Distribution of the sightings of cetacean species in the waters of southern Taiwan. *Grampus griseus* (open circle); *Lagenodelphis hosei* (solid triangle); *Stenella longirostris* (open diamond); *Stenella attenuata* (open triangle); *Tursiops truncatus* (solid square); *Tursiops* sp.; (half open square); *Kogia sima* (plus sign with "S"); *Kogia* sp. (plus sign); *Peponocephala electra* (solid star); *Feresa attenuata* (asterisk); *Pseudorca crassidens* (solid circle); *Globicephala macrorhynchus* (open star); *Ziphius cavirostris* (solid inverted triangle); *Mesoplodon* sp. (open inverted triangle with dot in centre); *Hyperoodon* (?) sp. (open inverted triangle). The large solid circle represents Houbihu Harbour and the arrows represent the approximate locations of the boundaries of Kenting National Park.

Table 3. Number of cetacean sightings, species and individuals (standardized to unit effort of 1000 km•hrs) observed in each sector of the surveyed area in the waters of southern Taiwan.

Sectors	Survey Effort (km•hrs)	Number of Sightings (per 1000 km•hrs)	Number of Species (per 1000 km•hrs)	Number of Individuals (per 1000 km•hrs)
NW	1712.3	1.75	1.75	5.26
W	2355.4	4.67	3.40	129.91
SW	2963.4	1.35	1.35	71.54
S	1801.3	2.22	1.67	426.37
SE	1694.9	2.95	1.18	20.65
NE	2361.0	7.20	3.39	302.83

In "Nan Wan and adjacent waters", all (n=11) sightings except one were made in the western half of this region. The exceptional sighting was also the only one that was not of *T. aduncus*. The peak in the number of sightings and number of individuals occurred in August (Table 4b). (Note: for "Nan Wan and adjacent waters", the effort correction could only be performed for time alone since detailed positions were not recorded systematically and there were too few sightings to perform statistical analyses).

Table 4a. Number of cetacean sightings, species and individuals (standardized to unit effort of 1000 km•hrs) observed each month during the survey period in the sectors of the study area in the waters of southern Taiwan (Beaufort sea state < 4).

Month	Survey Effort (km•hrs)	Number of Sightings (per 1000 km•hrs)	Number of Species (per 1000 km•hrs)	Number of Individuals (per 1000 km•hrs)
April	1352.5	8.13	4.44	757.15
May	2758.5	3.63	1.81	63.08
June	1725.0	5.80	4.06	118.84
July	2374.5	1.68	1.26	30.32
August	3108.5	0.97	0.64	8.36
September	1569.3	3.82	2.55	346.64

Table 4b. Number of cetacean sightings, species and individuals (standardized to unit effort of 10 hours) observed each month during the survey period in "Nan Wan and adjacent waters" (Beaufort sea state < 4).

Month	Survey Effort (hours)	Number of Sightings (per 10 hours)	Number of Individuals (per 10 hours)
April	4.6	0.00	0.00
May	6.5	0.00	0.00
June	8.4	1.19	17.86
July	8.2	2.44	25.67
August	14.2	4.95	42.40
September	2.4	0.00	0.00

Relative Abundance

Relative abundance can be represented in two ways: the frequency of sighting and the number of individuals observed. By far, there were more sightings of *G. grampus* (16 or 36.4% of all sightings) than any other species. The second most frequently encountered species was *K. sima* with 6 sightings (or 13.6%). There were four sightings of *L.hosei*, three sightings each of *S. attenuata* and *S. longirostris* and two sightings each of *P. crassidens* and *G. macrorhynchus*. The remaining six species were observed only once each (Table 5). The best estimate of the total number of individuals observed in the sectors was 2045 (min.-max. = 1500-2435). We assumed all animals observed were different individuals because we did not encounter any easily identifiable individuals (i.e., scarred, missing or oddly shaped dorsal fins) more than once. However, the validity of this assumption cannot be tested without further studies. *L. hosei* comprised the bulk of the total number of individuals observed (817 or 40.0% of the total number of individuals observed). *S. attenuata* also contributed considerably to the total number of individuals (28.4%). Although *G. grampus* was encountered most often, it comprised only 11.1% of the total number of individuals recorded (Table 5).

Table 5. Number of sightings and individuals of each species in the sectors of the study area in the waters of southern Taiwan. The percentages of the total number of sightings and individuals are shown in parentheses. The number of individuals of each species was the sum of the best estimates of all sightings.

Species	Common Name	Number of Sightings (% of total)	Number of Individuals (% of total)
Grampus griseus	Risso's dolphin	16 (36.4)	226 (11.1)
Lagenodelphis hosei	Fraser's dolphin	4 (9.1)	817 (40.0)
Kogia sima (=*simus*)	Dwarf sperm whale	6 (13.6)	11 (< 1.0)
Kogia sp.	Pygmy or dwarf sperm whale	1 (2.3)	1 (<1.0)
Stenella longirostris	Long-snouted spinner dolphin	3 (6.8)	160 (7.8)
Stenella attenuata	Pantropical spotted dolphin	3 (6.8)	580 (28.4)
Tursiops truncatus	Common bottlenose dolphin	1 (2.3)	25 (1.2)
Tursiops sp.	Bottlenose dolphin	1 (2.3)	1 (<1.0)
Globicephala macrorhynchus	Short-finned pilot whale	2 (4.5)	43 (2.1)
Pseudorca crassidens	False killer whale	2 (4.5)	56 (2.7)
Feresa attenuata	Pygmy killer whale	1 (2.3)	16 (<1.0)
Peponocephala electra	Melon-headed whale	1 (2.3)	100 (4.9)
Ziphius cavirostris	Cuvier's beaked whale	1 (2.3)	1 (<1.0)
Hyperoodon sp. ?	Bottlenose whale	1 (2.3)	5 (<1.0)
Mesoplodon sp.?	Unknown beaked whale	1 (2.3)	3 (<1.0)
	Totals:	44	2045

Of the 11 sightings of cetaceans that were made in "Nan Wan and adjacent waters" (including one sighting that was made in SS>4), only one was of a small group of a very small-bodied, long-snouted spinner dolphin, possibly of the dwarf subspecies *S. l.*

roseiventris. The sum of the best estimates of the number of individuals counted (SS < 4) was 97 (min.-max. = 81-117). However, this was clearly an over-estimate of the number of individuals in this region because most, if not all, of the *T. aduncus* encountered over the study period were of the same individuals. One animal's dorsal fin was uniquely scarred at the tip and as a consequence was named "Nicky". Photographs of this animal and its companions (likely a family group) were taken during many sightings. A quick examination of photographs revealed other recognizable individuals in the group. If all the sightings of *T. aduncus* belonged to the same family group (note: observations made in 2001 support the hypothesis of a single family group in "Nan Wan and adjacent waters" - "Nicky" and about 20 other dolphins (J. Y. Wang, unpublished data)), then the best estimate of the greatest number of different animals (i.e., the largest group) observed in these waters would be 18 *T. aduncus* plus 20 *S. longirostris cf. roseiventris* for a total of only 38 individuals (the group size of Indo-Pacific bottlenose dolphins varied from 1 to 18 individuals (mean = 8.4; SD = 5.83) and the group size of the dwarf spinner dolphins observed was 20 individuals (min.-max. 15-25)). There were far too few data to examine monthly differences in relative abundance in "Nan Wan and adjacent waters".

Discussion

Species composition

Even though survey effort was less than a similar study of cetaceans in Hualien waters (Yang et al., 1999), the number of species found during the present study was higher than that reported from Hualien (Table 6). Three of these species (*T. aduncus*, *F. attenuata* and the tentative genus *Hyperoodon*) have not been recorded in Hualien waters even though the sighting effort there has increased with cetacean watch tours. Because *T. aduncus* inhabits coastal, continental shelf waters, it is highly unlikely that this species exists along the east coast of Taiwan where little shelf water is present. In the waters of southern Taiwan, all sightings of *T. aduncus* (n=10) were made in the western half of "Nan Wan and adjacent waters". Furthermore, during a one-day trip (03 August 2000) dedicated to observing a group of *T. aduncus*, the group never swam east of the midline of Nan Wan (observations in 2001 revealed the same pattern; J. Y. Wang, unpublished data). This apparent barrier to *T. aduncus* movement and distribution is curious and requires further study. It is unclear why *F. attenuata* has not been observed in Hualien waters because it has been observed in the waters of Ilan and Taitung counties which are north and south of Hualien, respectively (see Chen et al., 1998a; Yeh et al., 1998). Although our species identification of a group of large beaked whales as *Hyperoodon* is tentative, sightings of similar animals have not been recorded from Ilan, Hualien or Taitung waters. *Hyperoodon* has been photographed in tropical waters but the species has yet to be confirmed (Leatherwood et al., 1988). Because beaked whales are notoriously difficult to observe and identify in the ocean even by experienced researchers, it is highly possible that this species exists in the deep waters of the east coast but has yet to be observed.

Table 6. Comparison of cetacean sightings, species and number of individuals between Hualien and the waters of southern Taiwan.

	Hours surveyed	Sightings per hour	Species per hour	Individuals per hour
Hualien*	309.25	0.43	0.03	20.4
Southern Taiwan	227.1	0.19	0.06	9.0

*data from Yang et al. (1999)

The diversity of marine habitats provided by the complex oceanographic features of southern Taiwan likely contributes to the high diversity of cetaceans (and other marine organisms) in this region. Species associated with the waters of the Taiwan Strait, South China Sea and Kuroshio Current can co-occur in southern Taiwan where these large bodies of water meet.

Seven of the 14 species of small to medium sized cetaceans observed at sea were not included in the species list that was constructed from whaling and stranding information and two species (killer whale and finless porpoise) that were on the list were not observed at sea. Although the killer whale is a cosmopolitan species, it does not appear to be common or resident anywhere in Taiwan. Each year along the entire east coast of Taiwan, only a few sightings of small groups of individuals are made (Yang et al., 1999). The killer whale also appears not to be a resident or common species in southern Taiwan. The lack of sightings of the finless porpoise in the NW sector (the only region where there appears to be potential habitat for this species - i.e., shallow, coastal waters with a soft ocean floor (Shirakihara et al., 1992, 1994)) may be due to naturally low abundance or reflect a population that has been depleted by human activities (note: the only record near this region was an animal killed incidentally in a gill or trammel net just north of the study area). The difficulty in detecting this species at sea (small size, lacks a dorsal fin, travels in small schools and infrequently displays aerial behaviour) may also contribute to the lack of sightings.

None of the large species hunted historically in these waters were recorded during the survey (Table 2). Commercial whaling has had a lasting impact on the large cetacean fauna of Taiwan. Blue whales of the western North Pacific may have been extirpated (Reeves et al., 1998), humpback whales that were once seasonally abundant in the waters of southern Taiwan have essentially vanished and sperm whales are rarely reported in these waters. In March 2000, prior to the start of the present study, three sightings of humpback whales were reported further north near Shih-ti Harbour (Hualien County) on different days; the sightings consisted of two and three individuals while one was of a solitary animal. In the waters of Lan Yu (which is situated east of KTNP beyond the boundaries of our study area), a sighting of three humpback whales was reported. Based on an examination of photographs showing unique natural markings, one of the humpback whales observed near Lan Yu was identified as an individual that had been photographed by researchers based in Okinawa, Japan (L.S. Chou, personal communication, Department of Zoology, National Taiwan University). However, it is most likely that these humpback whales were just travelling through Taiwan waters from their wintering grounds in the northern Philippines (Yaptinchay, 1999) to their feeding grounds in high latitudes (Evans, 1987). It is possible that some humpback whales also moved through the waters of the study area prior to the start of our survey but it is clear from interviews with fishermen that none have been seen in the waters of southern Taiwan (where they were once abundant) for many years.

Our observations confirm the poor representation of small to medium sized cetaceans in the whaling and stranding records. Direct observations at sea have added greatly to our understanding of the species composition of cetaceans in the waters of southern Taiwan. Furthermore, we suspect that as survey effort increases, more cetaceans will be added to the list of species inhabiting the waters of southern Taiwan. The most likely species include: rough-toothed dolphin (*Steno bredanensis*), striped dolphin (*Stenella coeruleoalba*), long-snouted common dolphin (*Delphinus capensis*), pygmy sperm whale (*Kogia breviceps*), Blainville's beaked whale (*Mesoplodon densirostris*) and minke whale (*Balaenoptera acutorostrata*). With the diversity in marine habitats and complex current patterns, the waters of southern Taiwan likely contain the richest species diversity of cetaceans in Taiwan.

Distribution

It is clear that cetaceans are not distributed homogeneously in space or time in our study area. The most attractive region for cetaceans was near or along the steep edge of the continental shelf in the NE sector. This is similar to the high concentration of cetaceans found along the edge of the continental shelf in Hualien waters (Yang et al., 1999). This type of bathymetric feature may concentrate prey species as water from the Kuroshio Current pushes up against the steep face of the continental slope. In the W sector, sightings were fairly dispersed, further away from shore and no association with bottom topography was obvious. The other sectors contained too few sightings for any patterns to be observed. It was surprising that so few sightings were made in the S sector where the bathymetry was complex and productivity appeared high (i.e., many large schools of small scombirds and flocks of feeding seabirds were observed on all trips near the Chi-xin Rocks). Turbulent waters and unpredictable currents in this region may play a role in the avoidance of the area by cetaceans. The NW sector was also surprisingly sparse. Along the coast north of Baisha, there are many threats to cetaceans: set fish traps have been known to capture cetaceans; pollution and habitat destruction along the west coast; and mariculture impoundments can interfere physically with cetacean distributions and alter habitat by eutrophication.

There were no evident patterns of preference for certain regions by species except that *S. longirostris* tended to be closer to shore than the other species in the sectors and *T. aduncus* preferred the deeper waters of the western half of "Nan Wan and adjacent waters". The reason for the restriction of *T. aduncus* to the western half of "Nan Wan and adjacent waters" is unknown but may be related to differences in water depth, temperature, chemistry or the

availability of their prey.

Relative Abundance

Although the waters of southern Taiwan was more diverse, there were far fewer sightings and individuals compared to Hualien (Table 6). (Note: all comparisons with the Hualien study required standardizing data from the present study to survey time only because the Hualien data were not standardized to both distance and time). However, given the state of our present knowledge, any reasons proposed for these differences would be very speculative.

Although there were many fewer sightings in the S sector than NE and W sectors, the number of individuals observed was considerably higher. This inconsistency between the number of sightings and individuals is due to the school size of the species of cetaceans observed. The number of individuals of S sector was influenced greatly by the largest school (500 to 800 Fraser's dolphin) of cetaceans observed during the study period. Because different species have different schooling tendencies, it is important to determine which index of relative abundance is appropriate for the required purpose (e.g., it might be important that schools are sighted frequently rather than infrequent sightings of large numbers of individuals).

There was nothing notably unusual about the cetaceans observed from published accounts of these species except for Fraser's dolphin. With the exception of one large school, all sightings were of small schools including a single large animal amongst a school of false killer whales and common bottlenose dolphins (it is possible that a few other Fraser's dolphins were not observed but it is very unlikely that a large school of Fraser's dolphins in the near vicinity was overlooked). Fraser's dolphins are gregarious and in Hualien waters, most sightings were of large schools over one hundred individuals (mean = 224.4, SE = 60.56; Yang et al., 1999). Very little is known of this species and the difference in school size of Fraser's dolphin between eastern and southern Taiwan cannot be explained until further studies are conducted.

Conservation of Cetaceans

Past threats

The high level of fishing activity in southern Taiwan likely resulted in considerable cetacean mortality as incidental catch. However, due to the lack of monitoring and absence of records, the impact of this threat will never be known.

The harm caused by industrialization of the west coast during the rapid economic growth period of Taiwan is difficult to quantify because of the lack of pre-industrialization data. This threat is more insidious and long-lasting. Only with continued studies will we even begin to understand the full impact of these activities.

Present and future threats

Although commercial whaling is unlikely to resume, it is likely that local, small-scale harpooning of cetaceans will resume if protection is removed or reduced. Not only do most fishermen consider cetaceans as just another consumable fishery resource, but also there are suggestions by some disgruntled fishermen that small cetaceans are increasing in number uncontrollably and should be culled to reduce a perceived competition for marine resources. However, preliminary analyses of the prey of small cetaceans in Taiwan show that most of the species consumed are of minor to no commercial importance (J.Y. Wang, unpublished data) and there is no evidence that the numbers of small cetaceans are increasing (in fact, many older fishermen claim that like fish, there are many fewer cetaceans today than in the past). Thus, there is no support for culling cetaceans. Such management actions would be irresponsible and may have serious effects on the continued existence of some species.

Habitat destruction and pollution are very serious threats to cetaceans. Direct habitat destruction is evident in Nan Wan with seriously damaged coral reefs. Physical damage, sedimentation (from rapid development with little concern for soil erosion) and warm water discharged from a nuclear power plant are responsible for most of the problems. Pollution may not be as visible but is more insidious and may have very long-lasting effects. As long-living, top trophic level predators, cetaceans bio-accumulate and bio-magnify contaminants such as heavy metals and organochlorines. Much of the pollution in southern Taiwan waters is carried there from industries along the west coast of Taiwan. However, the continued development of tourism in southern Taiwan without adequate treatment of solid and liquid waste can only further burden the ocean. Eutrophication from mariculture activities is also contributing to the degradation of the health of the marine ecosystem but presently, little attention is given to the environmental problems of this industry. Operators of commercial and fishing vessels pollute the oceans with poorly maintained engines and their bad habits of discarding oil, paint and other toxic compounds and solid waste into Taiwan waters. Marine debris was very visible during our survey trips. Plastic debris has been found in the digestive system of many stranded cetaceans in Taiwan (J. Y. Wang, unpublished data) and thus has obvious negative effects.

Although noise pollution is frequently overlooked, it is very important for acoustic organisms such as cetaceans. Most of the anthropogenic noise pollution in southern Taiwan waters originates from high-speed pleasure crafts. In addition, some operators of high-speed pleasure crafts engage in chasing animals. We witnessed this type of intrusive and aggressive behaviour several times. It is highly recommended that commercial or personal pleasure crafts be regulated strictly and all operators undergo comprehensive training.

With the increasing number of aquariums in Taiwan, several companies may request permission to capture cetaceans from Taiwan waters for display. The species most likely to be requested are bottlenose dolphins. There are many reasons why the capture of Taiwan bottlenose dolphins for display should not be allowed presently: 1) there are two species in Taiwan waters (Wang et al., 1999, 2000a,b) and nothing is known of the abundance or basic

biology of either species; 2) both species appear to have been exploited heavily in the recent past (e.g., the Penghu Island drive fishery and harpoon fisheries) so there has been little time for either species to recover; 3) there appears to be a large amount of incidental mortality in Taiwan fisheries; 4) there also appears to be substantial by-catch in the fisheries of the People's Republic of China; and 5) illegal harpooning of bottlenose dolphins still exists in parts of Taiwan. The present and future threats to bottlenose dolphins are many. Permitting further reductions of these species from Taiwan waters (without rectifying existing problems) for any reason is neither responsible nor prudent. Much more needs to be known about the social structure, population structure, size and dynamics of these species before captures for display should even be considered.

Present Protection

All cetaceans are protected under the Wildlife Conservation Law of Taiwan. However, effective enforcement is essential for conservation legislation to succeed. Also, enforcement should be designed to prevent further mortality rather than just punitive actions after the fact. With continued evidence of substantial illegal hunting of dolphins, it is clear that present enforcement of the Wildlife Conservation Law of Taiwan is inadequate to protect cetaceans. Education is also an essential component for long-term success in conserving marine resources.

Marine Protected Area (MPA)

There are not many regions in Taiwan that warrant designation as a MPA. Nan Wan, with its coral reefs and species diversity, is a prime candidate for protection. The small size of this bay also makes enforcement of regulations and management less complicated logistically. Of course, the socio-economic situation of local residents must be considered and much effort should be invested into converting present destructive and exploitative uses of the bay to low impact, low consumptive activities that can be sustained.

Potential for Cetacean Watch Tours in the Waters of Southern Taiwan

According to the sightings data of this study, the only area that might support eco-tourism with cetaceans is a thin strip of water in the NE sector. Most of the cetacean sightings were recorded in this area, which is also very close to shore. However, the weather and marine conditions in waters beyond Nan Wan during much of the summer tourism season do not favour this activity for most people and thus may not be conducive to a viable industry.

Nan Wan is a small, semi-sheltered bay that clearly offers more favourable marine conditions. However, the number of cetaceans that visit the bay presently appears to be limited. Our study showed that dolphins still visit Nan Wan occasionally (possibly seasonally) but local citizens claim that dolphins were once much more plentiful in Nan Wan. Noise and excessive traffic from motorized marine vehicles are deterrents to cetaceans entering the bay. High speed, high-frequency sound producing watercrafts seemed to alter the swimming, diving and surfacing behaviour of these dolphins. On one occasion we witnessed a multi-passenger jet ski violently chasing a small group of spinner dolphins that were only a few hundred meters from the coastline in Nan Wan.

Nan Wan can be an ideal place to offer cetacean-watch tours throughout the year but unless measures are taken to reduce the disturbance to cetaceans and damage to the ecosystem, it is unlikely that Nan Wan will be able to reach its potential in generating revenue from its natural resources. With the present solely profit–making attitudes and activities, it is unlikely the coastal resources can be sustained for future users at the present rate of destruction. Whether this behaviour is due to indifference towards their resources or a lack of education, it is inadvisable to encourage or permit any development of cetacean watch tours in this region until attitudes change.

Future Research

The present study is a mere beginning in understanding the cetaceans of southern Taiwan. Cetacean research in Taiwan is in its infancy and there is much to do. Even with our limited survey, we have already been able to confirm the inadequacy of the previous data. Much more research is needed to further our knowledge of cetaceans and for their conservation. Surveys should be conducted throughout the year to determine if seasonal differences in faunal composition are present. Surveys in the winter season should allow confirmation of the presence or absence of humpback whales from these waters. Regular surveys should be conducted periodically (annually or biannually) to monitor trends in species composition, distribution and relative abundance. Dedicated surveys are needed in Nan Wan to understand the Indo-Pacific bottlenose and spinner dolphins of the bay. This is particularly important because of the close proximity of these species to human activities.

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同類型濕地成立自然公園評估體系之建立

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摘　　要

為建立同類型濕地成立自然公園之評估體系，本研究採用葉昭憲等 (1999) 所歸納之 36 個評估因素，並採用群體決策之概念及分析階層程序法 (AHP)，寄發專家問卷，以瞭解各相關領域專家對因素間相對重要性之看法，並利用幾何平均法取得全體專家之共識值。最後，再以專家之共識值得到各因素於評估體系中之權重值，而同類型濕地成立自然公園之評估體系於此建立完成。為使評估體系能加以實際操作，本研究選擇已成立自然公園之關渡濕地與尚未成立自然公園之香山濕地-兩同類型濕地作為本研究之對照組與實驗組，了解以關渡濕地為基準，香山濕地成立自然公園相較於關渡之價值。本研究由回收之 13 份專家問卷進行資料分析以及分析階層程序法 (AHP)，並利用建立之評估體系得到三項結論：(一) 評估因素相對權重之分析結果呈現二個觀點，一是濕地若要成立自然公園，則其生物之多樣性及稀有性應先達到相當之標準；二是自然公園必須具備社會教育及學術研究之功能。(二) 無論專家學者之背景如何，受訪者在喜好度方面皆一致認為香山濕地在生物狀況中野生動物種類多寡、野生動物之稀有性，以及空氣中之清新度與文化資源中之保留程度等方面皆優於關渡濕地。(三) 最後評估結果顯示，對於同類型濕地而言，關渡濕地與香山濕地成立自然公園之相對評估比值為 1.0579，兩者相差不大，顯示香山濕地亦有成立自然公園之價值。

關鍵詞：濕地自然公園、評估體系、分析階層程序法。

一、前　　言

台灣原本擁有珍貴的濕地資源，但在經濟活動擴張之下，導致濕地逐漸消失。然而，目前台灣各種生態資源重要之量化標準尚未建立，濕地保護之法令、標準尚未成形，且臨近人類聚落之濕地多未能依國家公園法、野生動物保育法及文化資產保存法等法律設置保護區。近來各方學者陸續有提議設立濕地自然公園之方案，以達不破壞珍貴生態環境亦能繁榮地方之雙贏策略，而當前之規劃於自然公園之定位

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