The whale shark tourism industry in Ningaloo Marine Park: summary of the 2001 paying season

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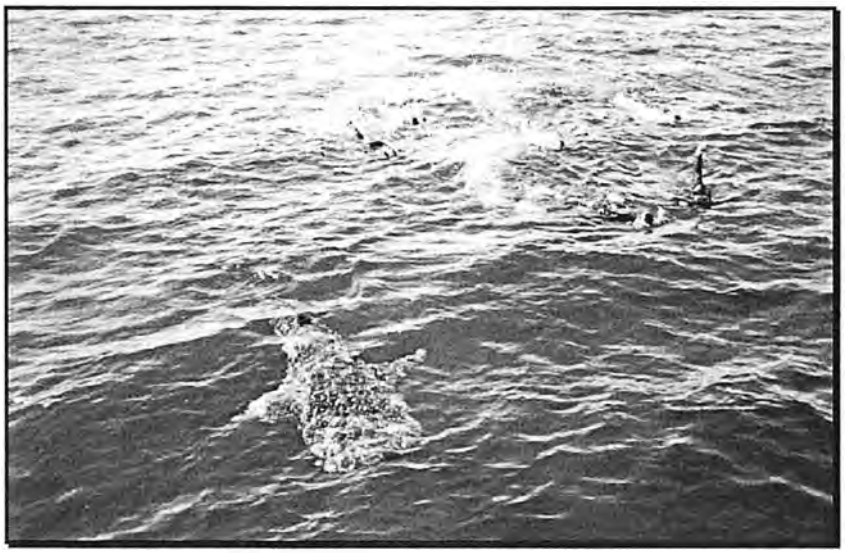

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Summary

Information on whale shark tourism interactions in Ningaloo Marine Park is collected on log sheets which are completed by tour operators. In this report, the log sheet data collected during the 2001 paying season are presented and data collected during the 2000 and 2001 paying seasons are compared. The log sheet design is assessed and a modified log sheet design is suggested.

In 2001, 13 whale shark interaction licences were issued to tour operators by CALM and 10 licence holders conducted tours. A mean of 4.4 vessels operated per day and the industry operated at an overall capacity of 34%. The number of people that participated in whale shark tours was 3,505 and a mean of 13 passengers were carried per tour. In total, 269 tours were conduced and whale sharks were encountered during 211 tours, resulting in an overall strike rate of 78%. Most of the 403 contacts with whale sharks took place between 1000hrs and 1200hrs. The whale shark industry in Ningaloo Marine Park varied little between 2000 and 2001, as the number of vessels operating, tours conducted, encounters and contacts with whale sharks were similar between years.

While the log sheets introduced in 1995 were effective for collecting information on tour duration, passenger and pass numbers, problems occurred with multiple recording of the same sharks and pooling of contact time and number of swimmers per contact. The information collected on shark markings, behaviour and dive quality were also of limited value. A new log sheet is proposed for introduction during the 2002 paying season, which involves recording each shark contacted only once per day, recording contact information in columns to prevent pooling of information and applying standard codes to record the response of whale sharks to swimmers.

A number of recommendations on data collection and management are made.

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1. Introduction

Whale sharks occur in a band around the equator between 30° north and 35° south (Compagno, 1984; Wolfson, 1986; Last and Stevens, 1994) and have been recorded in all tropical and warm seas except the Mediterranean (Wolfson, 1986; Last and Stevens, 1994). Lack of data on the size and distribution of the world's whale shark population makes an estimation of its status and abundance difficult (Wolfson, 1986) and it is listed as 'Data Deficient' on the IUCN Red List of Threatened Animals (IUCN, 1994). Aggregations of an estimated 200-400 whale sharks occur in the northern part of Ningaloo Marine Park between March and June each year, in response to annual mass spawning of corals and other prey organisms (Taylor, 1989; Taylor, 1990; Taylor, 1991; Taylor, 1994a; Taylor, 1994b).

Whale shark interaction tours have been conducted in Ningaloo Marine Park since 1989 and the whale shark tourism industry contributes an estimated $12.8 million per annum to the local community (Colman, 1997a). The rapid expansion of the whale shark tourism industry from 1989-1993 led to the introduction of management controls by CALM in 1993 (Colman, 1997a). Whale shark interactions are managed by CALM with two primary objectives: to conserve whale shark populations by ensuring that they are not subject to an unacceptable level of disturbance; and to facilitate the development of ecologically sustainable whale shark tourism in marine reserves (Colman, 1997a). To achieve the objectives, the whale shark tourism industry is managed by a number of means, including licensing of charter vessels operating in Ningaloo Marine Park and a voluntary code of conduct under the *Wildlife Conservation Act 1950* and *Conservation and Land Management Act 1984* (Colman, 1997a). Under the terms of the licence, a fee of $20 per adult and $10 per child passenger carried is payable to CALM for management purposes (Colman, 1997a). Compliance with licence obligations and the code of conduct is monitored by CALM officers via boat patrols, aerial surveillance and an operator log book (Colman, 1997a).

The log book scheme was introduced during the 1995 paying season with the aim of recording information on the number of vessels and tourists participating in tours and data

on whale shark encounters, interactions and the sharks themselves (Colman, 1997a). The purpose of the log sheets was to record information on the size and status of the industry and to monitor the impact of tours and interactions on whale sharks for management purposes (Colman, 1997a). The log sheets were also intended to provide feedback to commercial operators on tour and passenger information (Colman, 1997a).

Although some of the log sheet data were summarised for research purposes external to CALM (e.g. Norman, 1999; Wilson *et al.*, 2001), they have never been presented in an annual report or compared between years for the purposes of management (A. Meyer pers. comm.). Nor have the data been used to provide feedback to tour operators to assist in the management of their operations. A review of the log sheets is needed because the quality of the data collected in the past has been limited due to the subjective nature of the data collection process, the collection of data by untrained observers and variation in the quality of the data recorded (Colman, 1997a).

The purpose of this report is to: analyse and present a summary of the log sheet data collected during the 2001 paying season, compare data collected during the 2000 and 2001 paying seasons, make an assessment of the effectiveness of the log sheets introduced in 1995, and to modify the log sheet design, ensuring that the data collected can be used to meet management objectives in subsequent paying seasons. A second report, examining changes in tour, passenger, encounter and whale shark information from 1995 to 2001 will be produced in 2002. A glossary of terms used in the whale shark tourism industry is included Appendix I of this report.

2. Methods

2.1 Whale shark tours

The majority of whale shark tour vessels sail from the boat ramp or mooring near Tantabiddi Passage. Most whale sharks are encountered between Tantabiddi Passage and Turquoise Bay (Norman, 1999), but a small number of tour companies operate from Coral Bay and encounter whale sharks north-west of Coral Bay, in the Black Rock region.

On board the vessel, tourists are briefed on safety, the code of conduct and log sheet data to be collected, as part of the requirements as an "ecotourism operation" (Commonwealth Department of Tourism, 1994). A light aircraft is used by tour operators to search for whale sharks west of Ningaloo Reef and when located, the pilot directs the operator toward the whale shark. The vessel moves ahead of the shark and groups of swimmers, which are escorted by vessel staff during each contact, enter the water in front of the approaching shark.

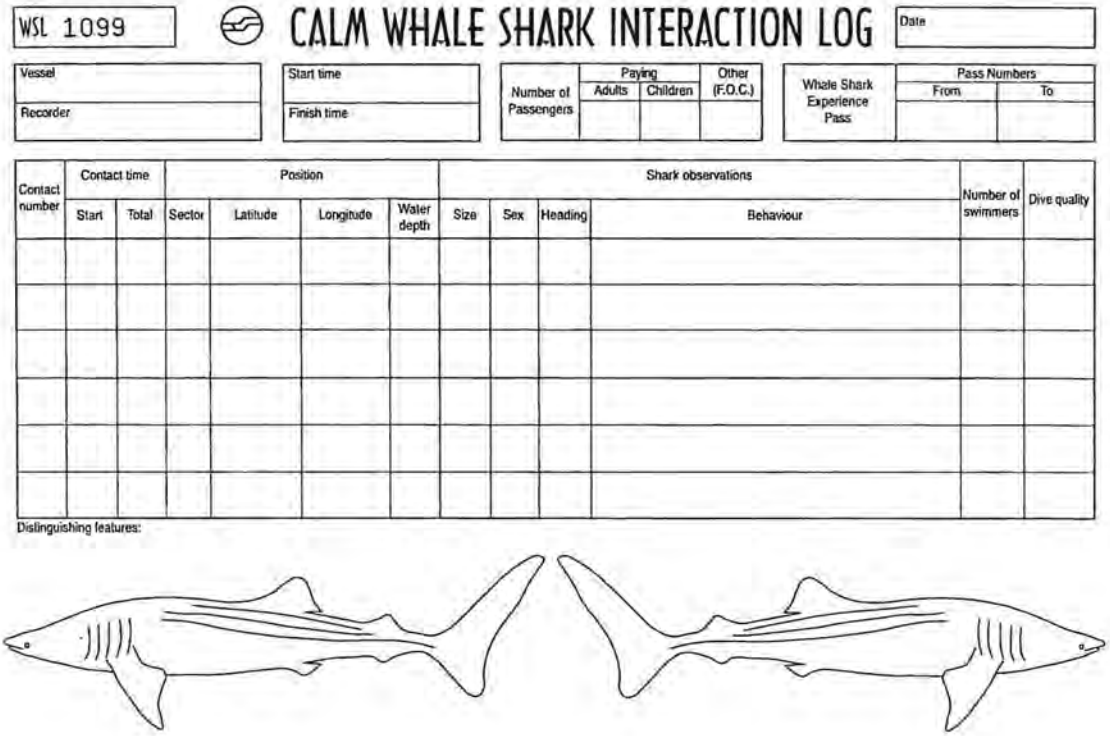
Tourism operators are licenced to conduct whale shark interaction tours under the *Conservation and Land Management Act 1984* and must operate under the legislation set out in the code of conduct for commercial whale shark interaction tours (*Conservation and Land Management Act 1984, Section 101*, *Conservation and Land Management Regulations 1992, Part 5*) and the Wildlife Conservation Close Season for Whale Sharks Notice 1996 (*Wildlife Conservation Act 1950*), which may be summarised as follows:

- One vessel only may operate at a time within the contact zone of a 250m radius around the whale shark, for no more than 90 minutes and at a speed of no more than 8 knots.
- Vessels in the contact zone may approach the shark no closer than 30 metres.
- Swimmers are limited to a maximum of 10 in the water at one time.
- Swimmers must not attempt to touch, ride a shark or impede its movement.
- Swimmers must not approach a shark closer than 3 metres from the head or body and 4 metres from the tail.
- Swimmers must not take flash photography or use motorised propulsion aids.

2.2 Operator log books

Whale shark tourism operators are required to fill out daily log sheets, which were formally introduced in 1995 (Colman, 1997a), to record information on tours, contacts and whale sharks (Figure 2.1). Operators record the following tour information: date, vessel nominated on the licence, recorder of the information (for validating data integrity), time the vessel departed from the jetty/ramp, time the vessel returned to the jetty/ramp, number of passengers and whale shark experience pass numbers, which are used by CALM to calculate fees owing (Figure 2.1). Passengers who do not see a whale shark on a tour may participate in a subsequent tour free of charge and associates of vessel staff

may also participate in a tour of charge. The following data are collected for each whale shark contact for the day: time the shark was first contacted, total time of the contact, sector (corresponding with a grid map in the log book), geographic position using a GPS, water depth using an echo-sounder, number of swimmers and quality of the contact (Figure 2.1). In conjunction with tourists, operators record the following information on each whale shark contacted: length, sex (by the presence claspers for males or absence for females), behaviour and distinguishing features such as marks, scars or tissue damage (Figure 2.1).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CALM WHALE SHARK INTERACTION LOG

Date

Vessel

Recorder

Start time

Finish time

Number of Passengers | Paying: Adults, Children | Other (F.O.C.)

Whale Shark Experience Pass | Pass Numbers: From, To

Contact number	Contact time: Start	Total	Position: Sector	Latitude	Longitude	Water depth	Shark observations: Size	Sex	Heading	Behaviour	Number of swimmers	Dive quality

Distinguishing features:

Figure 2.1 Whale shark interaction log sheet introduced in 1995.

2.3 Data analysis

The data collected on the whale shark interaction log sheets in Ningaloo Marine Park during the 2000 and 2001 paying seasons were entered into a spreadsheet data base, analysed, tabled and charted to summarise tour, passenger, contact and shark information. The 2000 and 2001 paying seasons were compared to determine how the industry varied between the two years.

2.4 Log sheet review

The quality of the data collected during the 2001 paying season was reviewed to determine if the log sheets were appropriate for collecting the information needed to assess compliance with the code of conduct and to manage the industry. The log sheet was re-designed to ensure that the data collected in future seasons are quantitative and that the information collected can be used to meet the needs of the tourism industry, tourists, whale sharks and CALM.

3. Results

3.1 Industry

The Department of Conservation and Land Management issued 13 Whale Shark Interaction Tour Licences for 2001. Of the 13 licence holders, 10 conducted tours and 3 did not conduct any tours during the paying season. Whale shark tour vessels operated every day of the 61 day paying season, the number of tour vessels that operated per day ranged from 1 to 8 and the mean number of vessels that operated per day was 4.4 vessels (s.e. 0.2 vessels, $n = 61$ days).

The whale shark tourism industry operated at between 26% and 45% of total capacity for each of the 9 weeks of the paying season and at 34% of total capacity for the 2001 season (Table 3.1). The industry operated at only 26% capacity in the first week of the season, at its highest capacity (34% to 45% capacity) during weeks 2 to 5 (Table 3.1) and lowest capacity (27% to 33% capacity) during weeks 6 to 9 (Table 3.1).

In total, 269 whale shark tours were conducted during the paying season in 2001, whale sharks were encountered on 211 tours and were not encountered on 58 tours, resulting in an overall strike rate of 78%. During the first week of the paying season, whale sharks were encountered during only around 30% of tours, during weeks 2 and 3, the strike rate was around 60% and the proportion of tours with encounters steadily increased to 100% in the final week of the season (Figure 3.1).

Table 3.1 Maximum number of tours possible, number of tours conducted and the number of tours conducted as a proportion of the maximum number tours possible per week for the 2001 paying season. The maximum number of tours per week was 91 (7 days x 13 licenced vessels) for weeks 1 to 8 and 65 (5 days x 13 licenced vessels) for week 9.

Week	Dates	Maximum number of tours possible	Number tours conducted	Number tours conducted as a proportion of the maximum number of tours possible (%)
1	1-7 April	91	24	26
2	8-14 April	91	38	42
3	15-21 April	91	41	45
4	22-28 April	91	31	34
5	29 April - 5 May	91	34	37
6	6-12 May	91	26	29
7	13-19 May	91	30	33
8	20-26 May	91	25	27
9	27 May - 31 May	65	20	31
All weeks		793	269	34

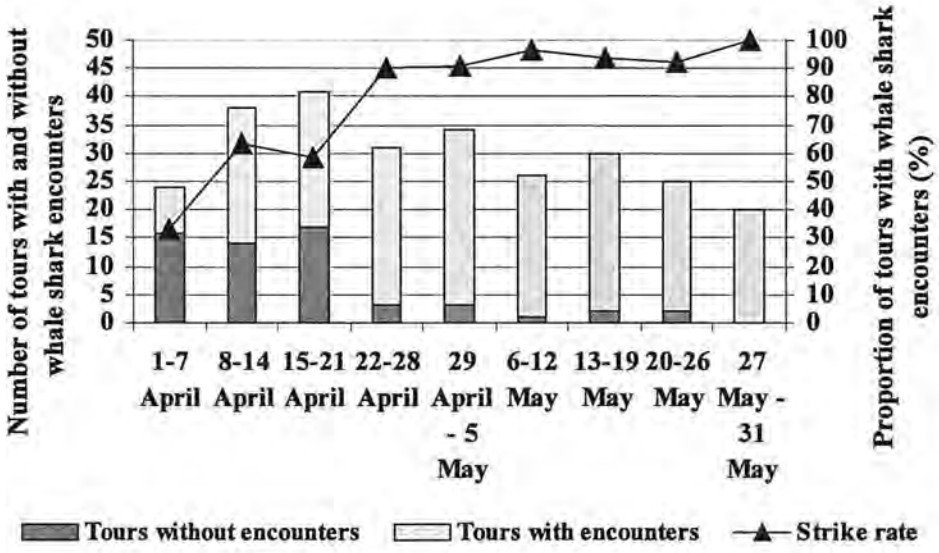


Figure 3.1 Number of tours with and without whale shark encounters and strike rate for each week of the 2001 paying season.

The majority of tours began in the morning between 0900hrs and 1000hrs and were completed in the afternoon between 1530hrs and 1630hrs (Figure 3.2). Mean time of all tours was 5 hours and 44 minutes (s.e. 7 minutes, $n = 238$ records), tours with contacts

averaged 5 hours and 23 minutes (s.e. 8 minutes, $n = 183$ records) and tours without contacts averaged 6 hours and 55 minutes (s.e. 8 minutes, $n = 55$ records).

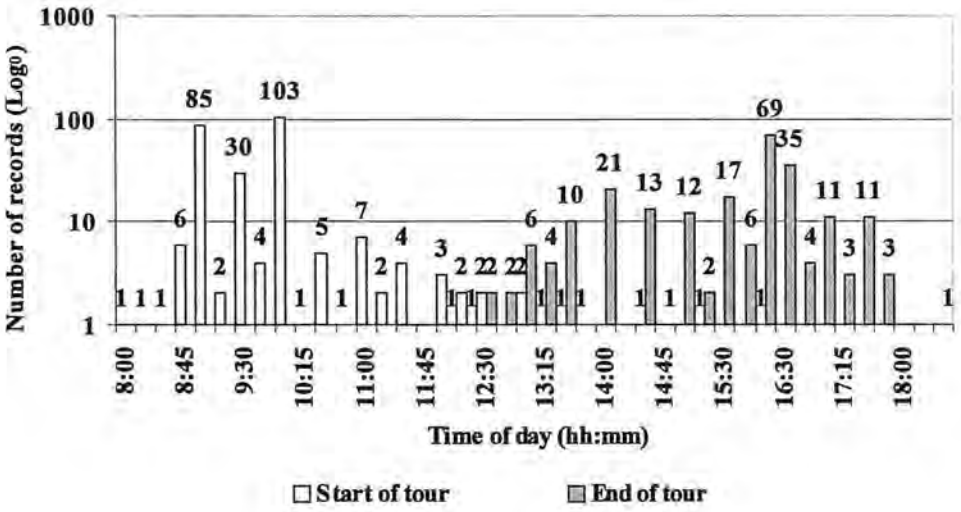


Figure 3.2 Number of records of the time whale shark tours began ($n = 266$ records) and were completed ($n = 235$ records) for 15 minute time periods for the 2001 paying season. Log_{10} scale is used for clarity of the data and actual number of records is shown above bars.

The number of tours conducted each week was closely related to the number of passengers as both were highest in weeks 2-5 of the paying season (Figure 3.3). The number of contacts per week was less closely related to the number of tours and passengers carried (Figure 3.3). The number of contacts per week was low in the first week of the season (17 contacts), very high during the week from 29 April to 5 May (85 contacts) and similar to the season average of 44.8 contacts per week (s.e. 6.4 contacts, $n = 9$ weeks), for all other weeks (Figure 3.3).

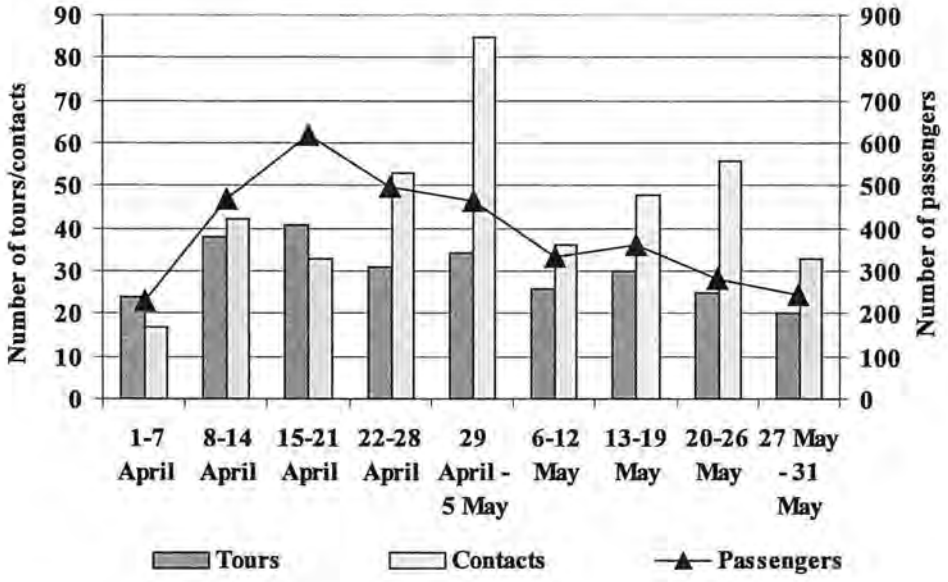


Figure 3.3 Number of tours conducted, number of contacts with whale sharks and number of passengers participating in tours each week for the 2001 paying season.

3.2 Passengers

In total, 3,505 people participated in whale shark tours during the 2001 paying season, including 2,555 adults, 173 children and 483 passengers carried free of charge (the total number of passengers exceeded the sum of adults, children and passengers carried free of charge because on some log sheets, only the total number of passengers was recorded and not the number of passengers in each category). The number of passengers carried per tour varied from 1 to 20 and most commonly numbered 17, 20 and 16 passengers (Figure 3.4). The mean number of passengers carried per tour was 13.1 passengers (s.e. 0.3 passengers, $n = 267$ records).

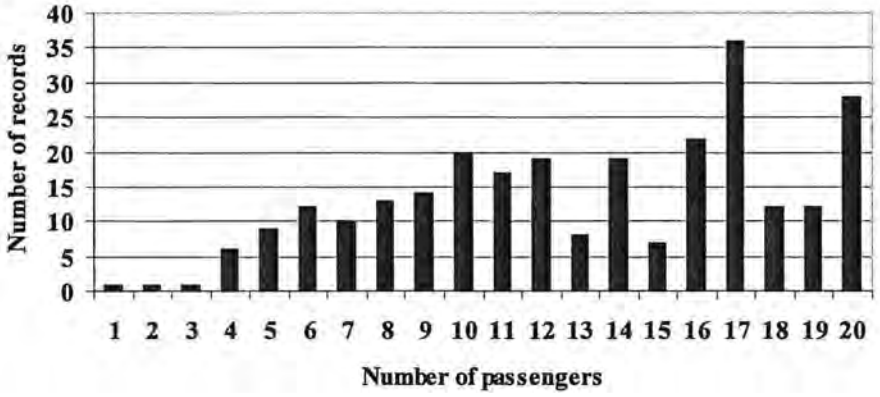


Figure 3.4 Frequency distribution of the total number of passengers carried per tour for the 2001 paying season (n = 267 records).

3.3 Contacts

The total number of contacts with whale sharks was 403, the number of contacts per tour ranged from 1 to 5 and the mean number of contacts per tour was 1.77 contacts (s.e. 0.05 contacts, n = 403 records). Contacts with whale sharks were most common in the morning between 1000hrs and 1200hrs and were least common in the afternoon between 1245 and 1600hrs (Figure 3.5).

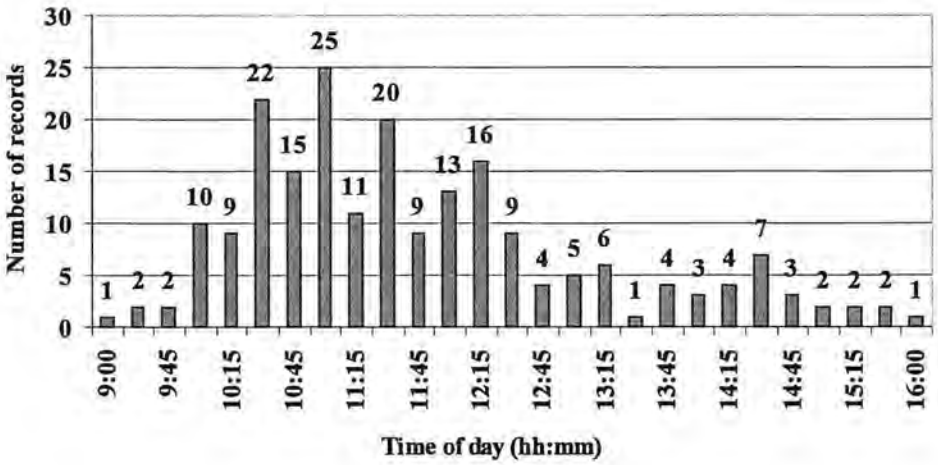


Figure 3.5 Number of contacts with whale sharks for 15 minute time periods throughout the day for the 2001 paying season (n = 208 records).

The duration of contact between swimmers and whale sharks reported ranged from 1 minute to 180 minutes and averaged 29.9 minutes (s.e. 1.5 minutes, $n = 362$ records). The number of swimmers reported per contact ranged from 2 to 23 and averaged 11.9 swimmers (s.e. 0.2 swimmers, $n = 376$ records). Figure 3.6 shows that while the number of swimmers reported remained constant between successive contacts, the time of contact was significantly shorter for contacts 3, 4 and 5 than for contacts 1 and 2. Out of the 356 records relating to the quality of contacts, 49% of contacts were reported to be good (173 records), 24% excellent (86 records) and 21% average (73 out records). Only 7% of contacts (24 records) were considered to be of poor quality by tour operators.

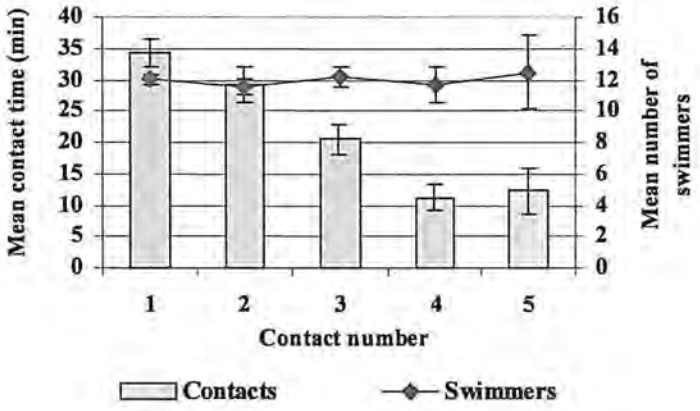


Figure 3.6 Mean duration of contact with whale sharks and mean number of swimmers per contact for successive contacts with whale sharks for the 2001 paying season (bars show standard error).

3.4 Whale sharks

The depth of water in which whale shark contacts took place ranged from 6m to 110m and averaged 39.9m (s.e. 1.1m, $n = 385$ records). The number of male sharks recorded was 180 and the number of female sharks recorded was 86, resulting in a sex ratio of 2.09 males per female. Of the 390 sharks recorded, the sex of 124 sharks could not be determined or was not recorded. The mean length of all sharks was 5.9m (s.e. 0.1m, $n =$ 388 records), females were 0.2m longer than males and the length of animals of undetermined sex was the same as the average length for all whale sharks recorded (Table 3.2).

Table 3.2 Mean length of male, female and whale sharks of undetermined sex recorded for the 2001 paying season (s.e. = standard error).

Sex	Whale shark length (m)			
	Range	Mean	s.e.	*n*
Male	2.5 - 10.0	5.8	0.1	178
Female	3.0 - 9.0	6.0	0.2	86
Undetermined	2.5 - 11.0	5.9	0.2	124
All whale sharks	2.5 - 11.0	5.9	0.1	388

Whale sharks were most commonly recorded moving north, south or circling and the least common directions whale sharks were recorded moving were east, south-east and west (Table 3.3).

Table 3.3 Direction whale sharks were recorded moving for the 2001 paying season.

Direction moving	Number of records
North	130
North-east	22
East	10
South-east	10
South	101
South-west	16
West	10
North-west	19
Circling	50
Total records	368

The map overleaf shows the distribution of whale shark contacts for each week of the 2001 paying season. The majority of contacts with whale sharks occurred between Tantabiddi and Osprey Bay, with a small number of contacts in the Black Rock region. In some weeks, such as 13-19 May and 20-26 May, contacts were spread along the reef, but in other weeks, such as 15-21 April and 29 April to 5 May, contacts were clustered within small areas of the reef.

3.5 Comparison of the 2000 and 2001 paying seasons

The number of licences issued and used, number of days of the season vessels operated, number tours conducted as a proportion of the maximum number of tours possible, mean

tour time and total number of tours conducted were similar in both the 2000 and 2001 paying seasons (Table 3.4). However, the mean number of vessels operating per day was 0.5 greater in 2001 than 2000, while the strike rate was 6% greater in 2000 than 2001 (Table 3.4). The total number of passengers, number of adult and passengers carried free of charge and mean number of passengers per tour was similar in 2000 and 2001, but 67 more child passengers were carried in 2001 than 2000 (Table 3.4).

The mean number of contacts per tour was greater in 2000 than 2001, but the time of day sharks were contacted, mean contact time and number of swimmers per contact were consistent between years (Table 3.4). Around the same number of tours encountered whale sharks each year and the depth of water in which whale sharks were contacted, direction the sharks were moving and number of animals of each sex recorded was similar between years (Table 3.4).

Table 3.4 Comparison of industry, passenger, contact and whale shark data collected by CALM and tour operators for the 2000 and 2001 paying seasons (s.e. = standard error). The number of passengers carried exceeds the total of adults, children and free of charge passengers for 2001 because only total passengers was recorded on some log sheets and not the number of passengers in each category.

	Data	2000	s.e.	*n*	2001	s.e.	*n*
Industry	Licences issued	14			13		
	Licence holders that conducted tours	11			10		
	Days out of 61 days of the season vessels operated	57			61		
	Mean number vessels that operated per day	3.9	0.2	57	4.4	0.2	61
	Maximum number of tours possible	854			793		
	Number tours conducted	255			269		
	Number tours conducted as a proportion of the maximum number of tours possible (%)	30			34		
	Number of tours with encounters	213			211		
	Number of tours without encounters	42			58		
	Strike rate (%)	84			78		
	Mean tour time (hours:mintues)	6:05	0:05	251	5:44	0:07	238
	Mean tour time with an encounter (hours:mintues)	6:01	0:06	211	5:23	0:08	183
	Mean tour time without an encounter (hours:mintues)	6:25	0:07	40	6:55	0:08	55
	Number of whale shark log sheets returned	478			461		
Passengers	Number of adults carried	2444			2555		
	Number of children carried	101			173		
	Number of passengers carried free of charge	516			483		
	Total passengers carried	3061			3505		
	Mean passengers carried per tour	12.2	0.3	251	13.1	0.3	267
Contacts	Number of contacts with whale sharks	436			403		
	Mean number of contacts per tour	2.03	0.06	436	1.77	0.05	403
	Most common time of day of contact with sharks	1200hrs			1100hrs		
	Mean contact time (min)	26.6	1.4	415	29.9	1.5	362
	Mean number of swimmers per contact	9.2	0.2	420	11.9	0.2	376
Whale sharks	Number of whale sharks male	187			180		
	Number of whale sharks female	107			86		
	Number of whale sharks of undetermined sex	134			124		
	Number of male sharks per female shark	1.75			2.09		
	Mean length of male sharks (m)	6.5	0.1	187	5.8	0.1	178
	Mean length of female sharks (m)	5.8	0.1	107	6.0	0.2	86
	Mean length of sharks of undetermined sex (m)	5.5	0.1	130	5.9	0.2	124
	Mean water depth of whale shark contacts (m)	46.7	1.2	403	39.9	1.1	385
	Most common directions whale sharks were moving	North, South			North, South		

4. Discussion and recommendations

4.1 2001 paying season

The data collected by the whale shark tourism industry operators via log books during the 2001 paying season show that the industry operated at a low capacity (34% of maximum capacity). For instance, although a least one vessel operated every day of the 2001 season, out of the 13 licensed vessels, on average, less than half operated on a daily basis. Although up to 20 passengers could be carried per tour, only a mean of 13 passengers were carried per tour.

The whale shark tourism operators were very efficient at locating whale sharks during the 2001 paying season. Most sharks were located in the morning shortly after setting sail, and a high proportion of tours (around 80% of tours) encountered a whale shark. Similar observations were made by Osborne and Williams (1994) who used air surveys to demonstrate that as long as sharks were present in the area, the use of spotter planes enabled tour boats to locate and make contact with the sharks. The high strike rate may be attributed to a number of factors including the habitual behaviour of the sharks, co-operation between industry operators and improvement of skills in locating sharks as the season progressed.

The strike rate was most variable during the first 3 weeks of the season, when the weekly total number of passengers was greatest, and the industry became more efficient at encountering whale sharks as the season progressed and the number of passengers declined. The progressive increase in the strike rate throughout the season may be due to an increase in the number of sharks in the region, the co-operative practice of hand-balling animals to other vessels, or the predictable behaviour of the animals, as they were mostly located in water of medium depth (around 40m) and moved north and south, parallel to the reef in both 2000 and 2001.

Variation in the location of whale shark contacts either along the reef or in clusters on a weekly basis may have been due to variation in the search effort or the extent of 'hand-balling' of sharks. Alternatively, variation in the location of sharks along the reef may

have been due to the behaviour of individual or groups of sharks. For instance, one shark was repeatedly recorded within a small area of the northern part of Ningaloo Reef in 1997 (Norman, 1999). Groups of whale sharks move in response to physical changes in their environment, such as water temperature and currents, wind speed and direction and prey distribution and abundance on a long term basis (Compagno, 1984; Colman, 1997b) and they may also do so on a weekly basis (A. Meyer pers. comm.).

The high number of contacts with whale sharks in the Tantabiddi region may have occurred because most vessels launch from the Tantabiddi boat ramp and thus, the search effort is concentrated in that region. However, data presented in this and other studies (e.g. Osborne and Williams, 1994; Taylor, 1996; Norman, 1999) have shown that the sharks aggregate west of the reef in the region between Tantabiddi and Turquoise Bay, increasing the chances of tour vessels that launch from the Tantabiddi boat ramp encountering a shark. If sharks were not located, vessels apparently spent more time searching for sharks as the time of tours without a whale shark encounter averaged 1hour and 32 minutes longer than tours with an encounter.

The data collected by tour operators during the 2001 paying season showed that the time of contact between swimmers and whale sharks declined significantly with increasing numbers of contacts, which may have occurred due to increasing fatigue of vessel staff, adverse behaviour of sharks with increasing contact, or the dynamics of groups of swimmers. For instance, swimmers may have chosen to spend less time in the water with increasing numbers of contacts due to fatigue or because they were satisfied with the length of time of previous contacts. The large number of contacts during the week 29 April to 5 May probably occurred due to a large number of tourists in Ningaloo Marine Park during that week.

4.2 Comparison of the 2000 and 2001 paying seasons

Comparison of the 2000 and 2001 paying seasons showed that the industry did not change between years as the mean number of vessels that operated per day, total number of tours conducted, mean number of contacts per day, mean contact time and total number of passengers carried was similar between years. The consistency of data between the two

years may indicate that the number of sharks in Ningaloo Marine Park was similar in 2000 and 2001. Other studies, however, have shown that the number of whale sharks may vary greatly between years over the long-term (Taylor, 1996; Colman, 1997a), supporting the need to continue collecting data on tourism operations in Ningaloo Marine Park via log sheets.

4.3 Log sheet review

4.2.1 Log sheet limitations

The log sheet introduced in 1995 was very effective for collecting records of tour duration, the number of passengers carried and for cross referencing of pass numbers for collection of fees by CALM.

One of the main problems with the log sheet was the recording of each whale shark contact in rows, down the form, which resulted in multiple recording of the same sharks. Multiple records of sharks resulted in the inability to determine the number of individual sharks encountered per tour and to estimate the total number of sharks in Ningaloo Marine Park. Multiple records of the same animal also lack independence, so any statistical analyses of the data will lack power and the chances of making an error in testing a null hypotheses will be increased. Repeatedly recording information on the same animal is also cumbersome for tour operators and as a result, on many log sheets, operators ceased recording data on individual contacts and pooled contact time and the number of swimmers per contact. The pooling of data resulted in records of contact time up to 180 minutes and number of swimmers up to 23, so that CALM officers were unable to assess whether operators were complying with the code of conduct.

Problems with sexing of sharks by untrained observers was evident from the 2001 log sheets. The bias of 2 males per female shark recorded in 2001 may have occurred because males are more easily identified due to the presence of claspers. Between 72% and 92% of sharks examined by Norman (1999) could be sexed, but only 70% of sharks were sexed by tour operators, demonstrating that operators are not confident in assigning sex or are not willing to sex some sharks. Alternatively, the male bias may be due to geographic

segregation of sexes which is a common in occurrence shark populations (Klimley, 1987; Bres, 1993). Lack of data on sex or incorrect sexing may limit the quality of the data on the size and behaviour of sharks and should ideally be recorded by trained CALM officers as part of a tagging program where sex can be matched to length measurements.

The information collected on the behaviour of the sharks was of limited value because it was not collected using a quantitative method and was open to interpretation, resulting in subjective observations. Examination of the records of behaviour collected by tour operators from 1995 to 2001 showed that behavioural information was recorded in several different ways, including the depth at which the sharks were swimming (shallow, medium, deep), the speed at which they were moving (slow, medium, fast), their normal behaviours (e.g. dive, porpoise, bank, dive and feeding), and their reaction to the vessel and the swimmers. Records of depth and swim speed were of limited relevance because the information was not collected using standard measurements such as metres and knots. Records of normal behaviour are not required for assessing the affects of tours on whale shark behaviour because the key parameter needed for management purposes is the reaction of the sharks to swimmers. Tour operators occasionally recorded the reaction of the sharks to the vessel and the swimmers, but for the information to be useful, it should be collected by all operators for each shark contacted, using a predetermined set of behaviour options. Quantifying the response of the sharks to swimmers should simplify the process of data collection by tour operators and should ensure that the data collected are standardised so they can be used to make management decisions.

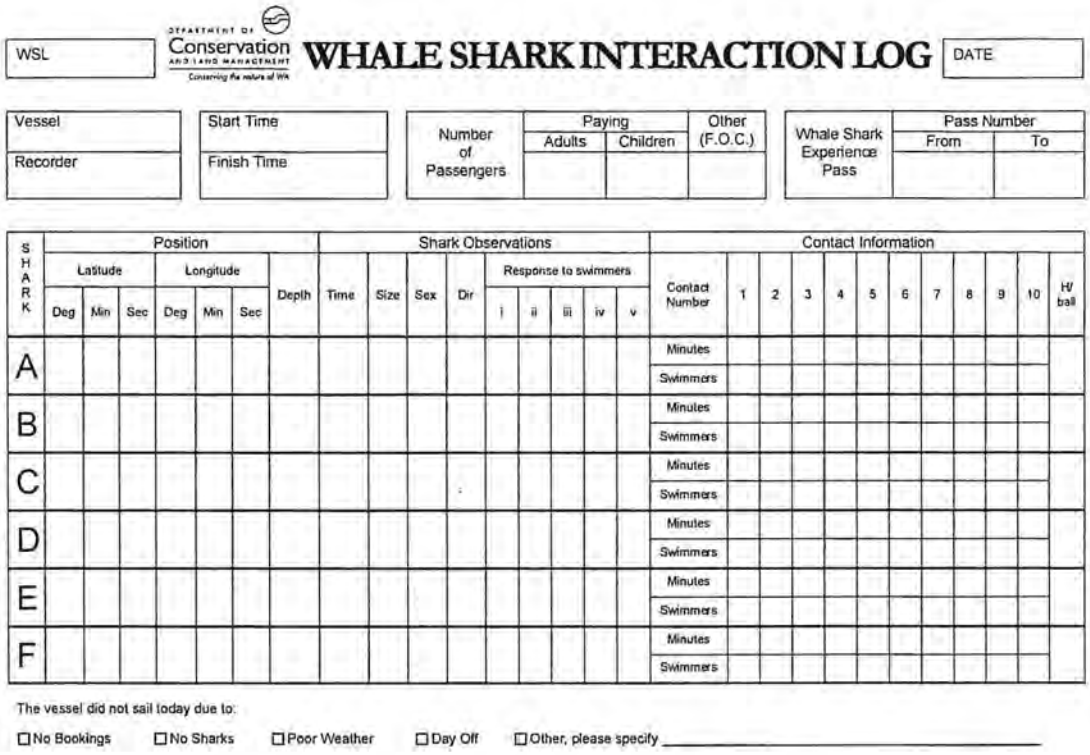
Records of dive quality were incongruous because of the large range of factors to which they may have referred, including water visibility, length of contact time, behaviour of the shark (A. Meyer pers. comm.) and overall 'value for money' of the contact. Notes made on shark markings were also of limited value for identifying individual animals as many animals may have the same injuries and scars (Norman, 1999, A. Meyer pers. comm.) and injuries of fish and sharks can heal in a short period of between 1 and 3 weeks (Anderson and Roberts, 1975; Reif, 1978). Due to the rapid healing properties of whale shark tissue, superficial scarring probably can not be used for identification of individuals between years (Norman, 1999). Records of marks, scars and injuries will probably only be of use

if recorded as part of a tagging program or identification of individual animals by body markings via a photographic library such that compiled by Norman (1999).

4.2.2 Modified log sheet

A new log sheet design, which will be accompanied by detailed instructions in the log book, is proposed for introduction during the 2002 paying season. The method of recording information on tour duration, the number of passengers carried per tour and pass numbers will remain the same (Figure 4.1). Non-quantitative information such as records of dive quality and shark markings will be eliminated from the log sheet and the method of recording shark behaviour will be modified.

On the proposed log sheet, each individual shark seen per day, the time it is first seen, its location, depth of water, size, sex, direction heading and if it is hand-balled to another vessel will be recorded only once, in rows (Figure 4.1). Contact information, including contact time and number of swimmers per contact, will be recorded in columns across the table for up to ten contacts per shark (Figure 4.1), which will provide accurate data on individual contacts and should eliminate the tendency to pool information. The reasons for vessels not sailing on a particular day will also be recorded using a tick-box method (Figure 4.1), as such information may be valuable in determining variation in the number of vessel days lost each year to a range of factors such as poor weather conditions.



WSL | Department of Conservation and Land Management | **WHALE SHARK INTERACTION LOG** | DATE

Vessel	Start Time	Number of Passengers	Paying		Other (F.O.C.)	Whale Shark Experience Pass	Pass Number	
Recorder	Finish Time		Adults	Children			From	To

SHARK	Position							Shark Observations									Contact Information											
	Latitude			Longitude			Depth	Time	Size	Sex	Dir	Response to swimmers					Contact Number	1	2	3	4	5	6	7	8	9	10	H/ ball
	Deg	Min	Sec	Deg	Min	Sec						i	ii	iii	iv	v												
A																	Minutes											
																	Swimmers											
B																	Minutes											
																	Swimmers											
C																	Minutes											
																	Swimmers											
D																	Minutes											
																	Swimmers											
E																	Minutes											
																	Swimmers											
F																	Minutes											
																	Swimmers											

The vessel did not sail today due to:

☐ No Bookings ☐ No Sharks ☐ Poor Weather ☐ Day Off ☐ Other, please specify _____

Figure 4.1 Log sheet designed for introduction during the 2002 paying season.

The information recorded by tour operators from 1995-2001 was used to devise a list of a standard set of responses by whale sharks to swimmers. Tour operators will record up to five principal reactions of sharks to swimmers during all contacts with that shark, using any combination of the codes shown in Table 4.1. Analysis of records of whale shark behaviour should provide data on the most common responses of sharks to swimmers, allowing CALM officers to determine what impact, if any, contact has on whale shark behaviour.

Table 4.1 Codes used to quantify the reaction of whale sharks to groups of swimmers.

Code	Term	Similar terms listed on previous log sheets
AG	Agitated	Intimidated, shy, flighty, reacted adversely, nervous, timid, avoided swimmers, uncomfortable, didn't like swimmers underneath
BA	Banked away	Turned away, swam away
BT	Banked toward	Turned toward, approached, followed
CR	Circled or swam under	Swam around, circled
DV	Dived	Descended
IN	Investigated	Curious, attracted to bubbles, inquisitive, interested, related well to swimmers, checked out swimmers
NO	No reaction	Continued as normal, uninterested, meandered, did nothing, not bothered, took no notice, relaxed, unconcerned, disinterested
PC	Physical contact	Touched, bumped into
SD	Decreased speed	Slowed down on contact with swimmers
SI	Increased speed	Bursts of speed, sped off, sped up on contact with swimmers

4.4 Recommendations

- The modified log sheet should be introduced for the 2002 paying season and its effectiveness should be re-assessed annually.

- An annual report summarising the log sheet data should be produced for management purposes and the information should be made available to tourism operators.

- A summary of each operator's tour, whale shark, contact and passenger information should be produced each year for feedback to individual operators.

- CALM officers should consider developing a program of tagging whale sharks in Ningaloo Marine Park to determine the total number of sharks in the region and the proportion of sharks that return to the park each year. Tagging would also allow CALM officers to collect accurate information on the sex and size of animals and if the tag number were recorded by operators, such information could be matched to behavioural data recorded on the log sheets.

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Appendix I

Glossary of terms used in the whale shark tourism industry in Ningaloo Marine Park.

Term	Definition
Paying season	Period of time (1 April to 31 May) when the whale shark tourism industry comes under the jurisdiction of CALM. During this time, fees per passenger are payable to CALM for management purposes.
Tour time	Time from when the tour vessel left the boat jetty/ramp to the time it returned.
Encounter	Location of a whale shark by a tour vessel.
Strike rate	Proportion of tours with a whale shark encounter.
Contact	Occurs when a group of swimmers from a vessel, enters the water to interact with a whale shark.
Swimmers	Persons in the water during a contact with a whale shark. Under the code of conduct, the number of swimmers in the water at one time should not exceed 10.
Hand-balling	The practice of identifying the location of a whale shark, from a vessel that has competed its contacts, to another vessel.