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Evaluation of exclusion grids to reduce the bycatch of dolphins, turtles, sharks and rays in the Pilbara trawl fishery

DBIF funded Project

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Fish for the future

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Cover picture:

With the camera positioned upstream of the grid, facing the cod-end, a leopard shark can be seen shortly before it exits through the escape opening.

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Evaluation of exclusion grids to reduce the bycatch of dolphins, turtles, sharks and rays in Pilbara Trawl Fishery

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Non technical summary

Outcomes

The semi-flexible exclusion grid constructed from a combination of braided stainless wire and pipe appears to reduce the bycatch of dolphins by almost half. Dolphins are able to swim out the mouth of the net, or exit through the escape opening, after interacting with the grid. However, an undetermined number of dolphins may exit the net underwater in poor condition with unknown chances of survival.

The semi-flexible exclusion grid also reduces the bycatch of turtles, large sharks and large rays.

Recommendations

An observer program with 22% coverage of the fishery should continue to gather ongoing information on the catch of dolphins, turtles and sharks. Video footage should be collected to gain information on the fate of dolphins that encounter the grid.

Acknowledgements

The authors are grateful to the skippers and crew of the fishing vessels in the Pilbara Trawl Fishery, for their help in facilitating recording of bycatch. The observers on the vessels; Travis Hurley, Carol Sutherland, Chris Lalas, and the staff of Pelagicus are thanked for their valuable contributions.

1.0 Background

Considerable research on the documention of the bycatch of cetaceans, seals, turtles, and sea lions during trawl fishing operations has been undertaken worldwide. These include the Argentinean squid and hake trawl fisheries (Crespo *et al*., 1997; Fertl & Leatherwood, 1997), the Dutch pelagic trawl fishery (Couperus, 1997), the NE Atlantic pelagic trawl fishery (Tregenza & Collet, 1998) and the New Zealand squid fishery (Fishing News International, 2005).

In the Pilbara Fish Trawl Fishery, operating off the coast of Western Australia protected species including dolphins, turtles, sawfish, sea snakes as well as numerous sharks and ray species have been recorded as bycatch (Stephenson and Chidlow, 2003). This observer onboard study recorded 4 bottlenosed dolphins (*Tursiops truncates*) caught during 100 days at sea and 473 shots (1/13 of the annual trawl time allocation) in 2002.

Conditions set by the Australian Government's Department of Environment and Heritage state that the Pilbara Trawl Fishery must address the bycatch of protected species, particularly dolphins, if it is to maintain Wildlife Trade Operation certification under the *Environmental Protection and Biodiversity Conservation Act 1999* and continue to be able to export product. In 2004 the W.A. Department of Fisheries established the Pilbara Fish Trawl Dolphin Reference group to provide advice and recommendations on strategies to reduce the frequency and intensity of interactions with dolphins.

In 2004/05 an FRDC funded project into the "Evaluation of the effectiveness of reducing dolphin catches with pingers and exclusion grids in the Pilbara trawl fishery" (Stephenson & Wells, 2006) was initiated to establish how dolphins and other protected species interacted with the trawl net, whilst determining the effectiveness of exclusion devices used in other trawl fisheries around the world.

The captures of dolphins during trawl operations in Australia and overseas was reviewed by Stephenson and Wells (2006). Since this report, there have been a number of developments in dolphin catch mitigation.

Grids have been implemented successfully in New Zealand and in the Australian South East Trawl Fishery to reduce capture of seals and sea lions in trawl gear (Fishing News International, 2005).

In Europe, one fishery with a significant cetacean catch is the pelagic pair trawl fishery for sea bass off the United Kingdom (UK) (Northridge, 2003a; Northridge, 2003b) and off the French coast. In recent years considerable progress has been made documenting cetacean catch and trialing mitigation devices. Selection grids have been used with mixed success, to reduce the catch of common dolphins and trials with acoustic pingers are continuing.

The Centre for Environment, Fisheries & Aquaculture Science (CEFAS) oversees the project European Union (EU) funded project "NECESSITY". This project involves 22 partners from 13 different countries and aims to develop ways of modifying trawls to reduce cetacean bycatch, by the study of the behavioural characteristics that make small cetaceans vulnerable to capture in trawl fisheries, developing alternative fishing strategies, or fishing gear modifications, to reduce the bycatch, and transferring the information to other fisheries.

The Sea Mammal Research Unit (SMRU) at St Andrews University, Scotland, has been working with UK pelagic sea-bass trawl fishery on this project since 2001 (Northridge 2003a, 2003b, 2004, Northridge et al. 2005, Northridge 2006). The common dolphin catches in this fishery are shown in Table 1 (Northridge 2006). In the 2004–2005 season, modifications were made to the placement of the steel grid to midway between the "shark's teeth" (where the 4 m meshes begin) and the start of the extension, roughly 30 m from each. In addition, modifications were made to the escape opening. As a result, 9 dolphins (out of 41) have been observed exiting through the escape opening. However the reduced catch in 2004–2005 season is not necessarily attributable to gear modification as it could also be due to the effort being half that in the previous season (Northridge et al. 2006) and also the ban on UK trawlers fishing for sea bass within 12 nmiles of the coast of England in the Western English Channel (Press release by Ben Bradshaw, Minister for Local Environment, UK Parliament, March 16, 2006).

Future trials hope to investigate a large mesh barrier in place of the steel grid and further modification to the escape openings that are more transparent and easier to open (Northridge et al. 2005).

Table 1. Common dolphin catches in the UK pelagic sea-bass pair trawl fishery.

Season	Dolphin catch rate number per shot	Estimated catch	catch 95% CI
2000–2001	0.57	190	172–265
2001–2002	0.10	38	23–84
2002–2003	0.23	115	88–202
2003–2004	1.27	503*	491–592
2004–2005	0.63	139	139–146
2005–2006	1.45	84	84–85

* probably too high as the observer coverage was only in the start of the season when catches are usually high. An estimated mortality of 440 is more likely correct.

The quantification of cetacean catch by European trawlers is the aim of the EU funded "PETRACET" project. In a collaborative effort by UK, France, Denmark and Netherlands, around 1000 fishing tows were observed between December 2003 and May 2005. The UK sea-bass pair trawl fishery was excluded from the study as the catch estimates were obtained from the "NECESSITY" project (Northridge 2005). Common dolphins were caught in three of the six trawl fisheries (sea-bass VIII, sea-bass VII, and tuna). If the data is stratified by fishery, the estimated catches per annum were 427 (95% CI 30–1954), 62 (1–409), and 133 (13–542) respectively. With the data stratified by time and area, the catch is estimated as 1567 (55–8544) in sea-bass fishery and 192 (20–767) the tuna fishery.

The data for the common dolphin catches in sea-bass fishery were obtained from the French trawl fleet with the location of the trawls monitored being shown in Figure 1. The common dolphin catch rate in the French sea-bass fleet was 0.27 per tow (Northridge et al. 2006) which appears to be considerably lower than that for the UK fleet which are working on the UK side of the English Channel only tens of km from the French fleet.

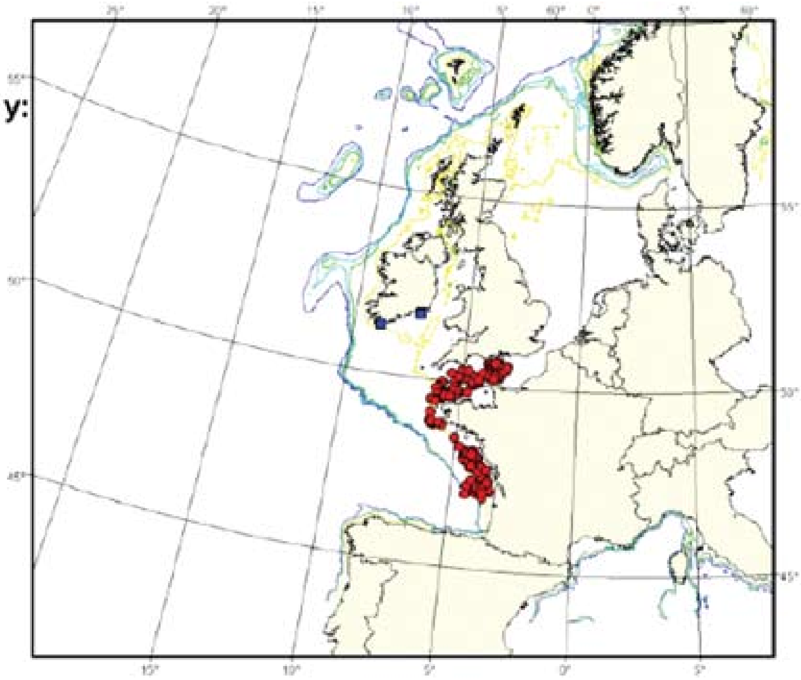

Figure 1. Location of sea-bass pelagic trawls by the non UK fleets in 2003–2004.

If the results of the two studies are combined, it suggests a catch of less than 1000 common dolphins per year (Northridge et al. 2006). Recent ICES advice (ICES 2005) suggests that there may be 500,000 common dolphins in the waters of NW Europe. At this population size, and a mortality level of 1.7% set in the "Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas" (ASCOBANS 1997), a catch of greater than 8500 is a cause for concern (Northridge et al. 2006, Northridge 2006). However there are other types of fisheries in the region whose bycatch have not been quantified (Northridge 2006).

Of the 93 dolphins recorded in the "NECESSITY" programme, 42 were measured and the sex determined for 26 (Northridge et al. 2006). The male:female sex ratio was 0.27:0.73 and most of the animals (69%) were immature (less than 200 mm). There is some suggestion that common dolphin catch might be higher at night (Northridge et al. 2006) but the long trawl duration and the unknown time of capture of the dolphins make the interpretation of the data difficult.

Institut Français de Recherche pour l'exploitation de la Mer (IFREMER), the French public company for marine research, is investigating dolphin catch mitigation methods in the French sea-bass trawl fleet, under the NECESSITY project. A flexible grid, called the EVAFLEX grid (Figure 2) which is constructed from polyurethane with a stiffness of "shore 50D" (Loaec et al. 2006) was trialed by sea-bass fishers in 2006. It was set in the net extension and was rigid while trawling, easily handled due its lightness, and retained it shape even after several days on the net drum (pers. comm. Pascal Larnaud, IFREMER, September 2006). Pascal Larnaud commented that the location of the grid, far back in the net, would probably mean that any common dolphins reaching the grid would have little chance of survival.

The French are still trialing cargo net barriers set at the "sharks teeth", as these appear to be more effective in reducing dolphin catches than the "Evaflex" grid (pers. comm. Pascal Larnaud, IFREMER, September 2006).

Figure 2. “Evaflex” grid being hauled aboard a French sea-bass trawler.

Figure 3. “Evaflex” grid in operation on a French sea-bass trawler.

In the “NECESSITY” programme, acoustic pingers were trialed by IFREMER in 2006. A prototype pinger for trawlers has been developed by IFREMER and Ixtrawl (Figure 4) which appears to successfully deter common dolphins in the wild (Yvon Morizur, IFREMER, pers. comm. September 2005). Field trials will commence in 2006. Results on the trials of pingers on trawl vessels is expected in April 2007.

Figure 4. "Cetasaver" acoustic pinger being trialed on sea-bass trawlers in 2006.

Pilbara Trawl Fishery

In Western Australia, in a FRDC funded project (Stephenson and Wells 2006), pingers were found to be ineffective in keeping dolphins out of the trawl net in the Pilbara Trawl Fishery and were rejected as a dolphin bycatch mitigation method. However, the report concluded that exclusion grids appeared to be effective in the reduction of catches of dolphins and turtles, though the effectiveness could not be evaluated due to the small number of shots observed and limited information about the nature of the interactions.

There appeared to be a difference between the reported catch of dolphins with and without observers on-board the vessels during the project. Between January 2004 and June 2005 the catch rate reported by observers was 13.3 dolphins per 1000 shots compared to 5.6 dolphins per 1000 shots reported by the skippers when observers were not on board. The discrepancy between the observer catch rate and the skipper's logbook catch rate decreased throughout the program from a factor of 2.7 in the first half of 2004 (18.5 compared to 6.9) to a factor of 1.5 in the first half of 2005 (13.3 compared to 8.9) (Table 1). There was some discussion amongst the vessels crew and license holders as to whether the observers were counting dolphin deaths that the skipper could not reasonably be expected to observe, eg when a dead dolphin is seen to fall out of the grid escape opening when the net comes to the surface. This situation would account for a discrepancy of one dolphin during the project.

Table 1. Dolphin catch per 1000 shots during non-observed and observed trips during the FRDC project.

	First half of 2004	Second half of 2004	First half of 2005	Overall
No Observer	6.9	3.2	8.9	5.6
Observer	18.5	12.6	13.3	13.3

The FRDC project found no significant difference in the dolphin catches between fishery areas, and no relationship between depth and dolphin catch rates. The dolphins were generally caught in daylight hours, with 92% of the dolphins caught between 7am and 8pm. The temporal pattern of dolphin catch was not related to the timing of fishing activity as fishing and winch-up occurred fairly uniformly over a 24-hour period (Stephenson and Wells 2006).

2.0 Need

The Pilbara Trawl Fishery captures approximately 70 dolphins per year (Stephenson & Wells, 2006), nearly always deceased. A digital video camera was mounted downstream and upstream of the grid for 112 trawl shots, with video footage being recorded for the first 1.5 hours before the tape expired. Video footage of dolphins in the net was obtained on about half of these recordings. On one of the shots with the camera deployed, a dead dolphin was found in the retrieved net but the dolphins demise was not recorded on video footage, probably because it died after the tape expired (Stephenson & Wells, 2006). In all cases, the skipper reported the dead dolphins were found drowned in the cod-end and were never found tangled in the net. There is a need for increased camera coverage to determine the circumstances of the dolphin deaths.

Stephenson & Wells (2006) reported that during the first half of 2005, there was no significant reduction in dolphin catches with the grid deployed (3 in 292 shots with the grid, and 29 in 2587 shots without the grid). There was considerable uncertainty about whether the grid could be expected to reduce the dolphin catch. On the two vessels with the most experience using grids in this fishery, only one dolphin was caught in 2005 when the grid was deployed, suggesting that grids may reduce dolphin catches.

3.0 Objectives

- To determine the occurrence of dolphin deaths in the trawl net when it has a grid installed compared to when the net does not have a grid installed.
- To determine the behavior and fate of the dolphins (using underwater digital cameras) with and without a grid installed in the net.

4.0 Methods

The grid trial program was planned to run from January 1, 2006 to July 31, 2006 with an proposed observer coverage of 400 shots with grids and 400 shots without grids, totaling approximately 160 days at sea. This large number of shots was planned so that the experiment would have sufficient power to determine if the grid reduced the dolphin catch. On March 1, 2006 the use of exclusion grids became compulsory in the Pilbara Trawl Fishery. Thereafter the project reverted to comparing the catch rates of protected species, rays and sharks to results from the observer programme conducted in 2005, the results of which are shown in Table 2.

Table 2. Dolphin and turtle catches and catch rates for observed shots in 2005 without grids.

	Dolphins		Turtles	
No of shots	Number caught	Catch per 1000 shots	Number caught	Catch per 1000 shots
659	10	15.2	11	16.7

4.1 Selection Grid

The semi-rigid grid with a bar spacing of 15.5cm, trialed in the 2004/05 FRDC project (Stephenson & Wells, 2006) was used as the selection grid in this project. The grid was flexible enough to be retrieved onto the net drum. The selection grid was placed at the beginning of the extension, 10 m from the end of the net (Figure 5). The mesh sizes of the net are shown in Figure 6 e.g. # 150 denotes single mesh of 150 mm and ## 100 denotes double mesh of 100 mm. The photograph of the grid in situ in the net is shown in Figure 7.

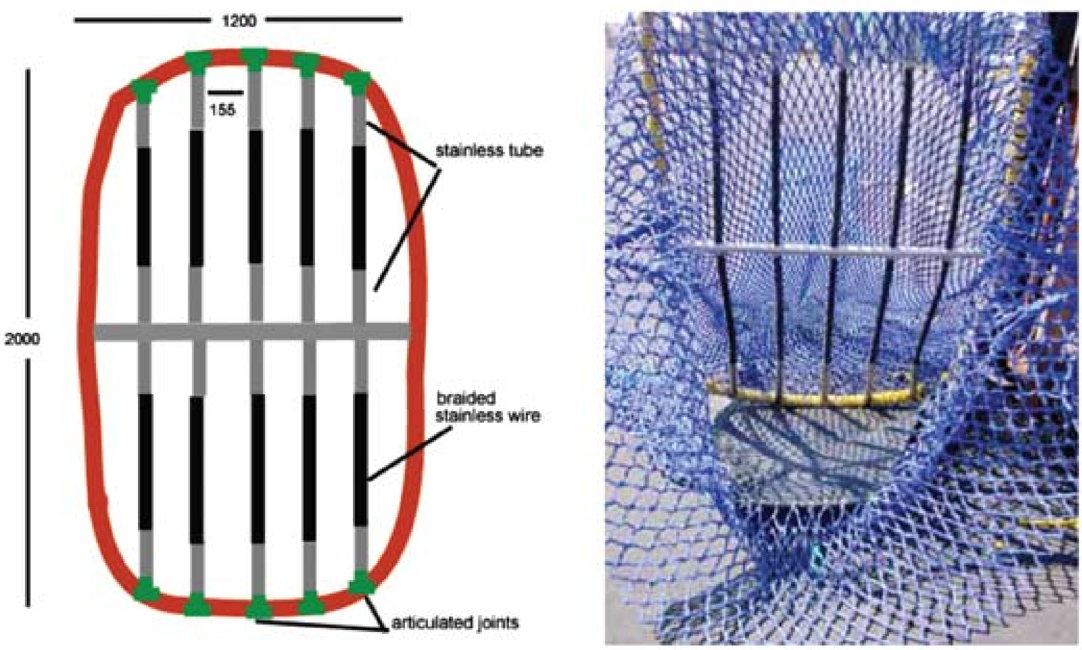

Figure 5. Semi-flexible grid constructed from stainless tube and braided stainless wire.

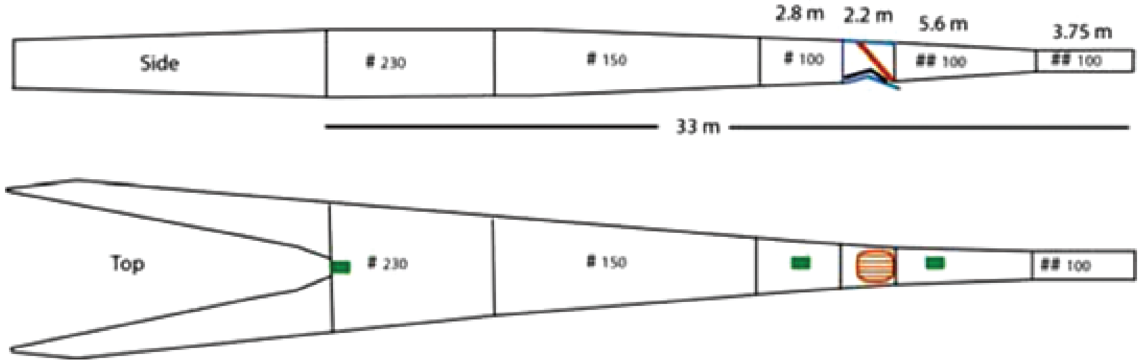

Figure 6. The design of the net used during the selection grid trials showing the grid (red), cover net at the bottom opening escape (blue), the Kevlar flap (black), and the location of the cameras (green) as well as the mesh sizes (## denoted double mesh) for the different panels of the net.

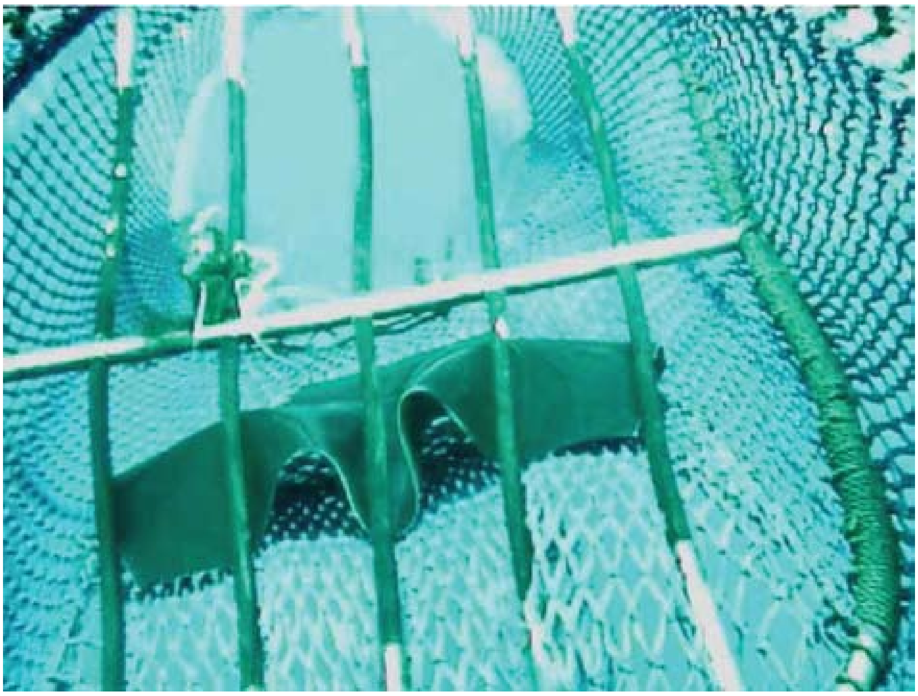

Figure 7. Semi-flexible grid in operation in the trawl net (from Stephenson & Wells, 2006).

4.2 Video Footage

Video footage was recorded on a Sony HC15E DCR set to long play, wide angle, fixed focus on infinity, and night shot. The DCR was placed in either an aluminum or a PVC underwater housing which was mounted on the mesh with four 8 mm cable ties. It was deployed in 3 positions.

- 4 m upstream of the grid and facing upstream
- 4 m upstream of the grid and facing downstream
- 4 m downstream of the grid and facing upstream

Video tape footage was captured as a Quicktime uncompressed video file in "BTVPro" on a Power Macintosh G5 computer and stored on an external Macintosh server. The video file was edited in Quicktime Version 6.5.2 to include only footage when dolphins, sharks, rays, seasnakes or other protected species were visible. The individual video clips were compiled using the Macintosh editing program 'LiveType' and rendered into one video stream. The video stream was compressed to mpeg2 using 'IDVD' in PAL format and saved to a single layer DVD. The video stream was also compressed to mpeg2 using Apple Quick Time Pro then copied to 700mb CD using 'Toast Titanium'.

4.3 Observer coverage

The observer coverage was achieved through a combination of industry-funded observers, a Department of Fisheries-funded observer, and DBIF funded grid trial coordinators. Between the December 27, 2005 and the July 31, 2006 a total of 1384 shots were observed, 1156 with grids and 229 with no grids. The DBIF grid trial observers covered 56% of these shots, 28% were covered by industry-funded observers and 16% by Department of Fisheries funded observers (Table 3). The catch of protected species was recorded for dolphins (sex and total length), turtles (carapace length), sharks (total length) and rays (width). The proportion of sharks and rays in each size class was compared when the grid was deployed and not deployed in order to determine the size selectivity of the selection grid.

Table 3. Shots observed on each vessel between December 27, 2005 and July 31, 2006 by the observers funded from Department of Fisheries, DBIF grid trial project, and industry.

Vessel	DFWA Observer	DBIF Grid Trial	Industry Observer	Total Observed	% Total Shots
A	31	145	37	213	26%
B	27	121	0	148	38%
C	74	319	161	554	61%
D	78	49	191	318	35%
E	0	134	0	134	28%
F	17	0	0	17	33%
Total	227	768	389	1384	39%
% Shots	16%	55%	28%	100%	

5.0 Results

5.1 Bycatch of protected species

Between December 27 2005 and July 31 2006, The bycatch reported by skippers and observers during the study period is shown in Table 4. The observer coverage was 1384 shots out of the total number for the period of the survey of 2719 shots.

Table 4. Bycatch of protected species reported by observers and also by skippers when no observer was on board between December 27th 2005 and July 31st 2006.

Common Name	Scientific Name	Skipper	Observer
dolphin	*Tursiops truncatus*	18	14
pipefish	*Sygnathids*	51	34
sawfish, green	*Pristis zijsron*	12	14
sawfish, narrow	*Anoxypristis cuspidata*	9	5
seahorse	*Sygnathids*	3	1
seasnake	*Hydrophiidae*	51	68
turtle, green	*Chelonia mydas*	7	4
turtle, loggerhead	*Caretta caretta*	2	1
turtle, olive ridley	*Lepidochelys olivacea*	0	2

5.2 Comparison of dolphin catches reported by observers and skippers when the grid was deployed

The observer reported catch rates of dolphins were higher than that reported by skippers when no observer was on board, for all vessels except vessel E (Table 5). The catch rate of dolphins reported by skippers (no observer on board) in 2006 (1.9 per 1000 shots) was similar to that in 2005 (2.1 per 1000 shots). Vessels A and D reported no catches of dolphins without observers on board in 894 shots (55% of all the unobserved shots. The license holders considered there was some confusion about what the skippers were expected to report. There was no doubt that the skippers knew they were expected to report dolphins landed on the deck and those seen to fall out of the net when the net was pulled out of the water. In the seven months of the programme, there was only one case where an observer reported a dolphin falling out of the net and the skipper and crew, for whatever reason, did not report it.

Table 5. The reported dolphin catch for observed and unobserved with the grid deployed between December 27, 2005 and July 31, 2006.

	Number of shots (grid deployed)		Dolphin catch (grid deployed)		Catch per 1000 shots (grid deployed)	
Vessel	Observed	Not observed	Observed	Not observed	Observed	Not observed
A	207	435	1	0	4.8	0.0
B	148	136	2	1	13.5	7.4
C	417	315	5	1	12.0	3.2
D	260	459	1	0	3.8	0.0
E	107	259	0	1	0.0	3.9
F	17	1	0	0	0.0	0.0
Total	1156	1605	9	3	7.8	1.9

5.3 Comparison of dolphin catches for grid and no-grid when observers were onboard

The observer catch rate of dolphins is considered more reliable than that reported by skippers and will be used to determine the impact of deployment of grids on the dolphin catch rates. With selection grids deployed, the observer reported catch rate in 2006 (7.8 per 1000 shots) was considerably lower than the observer reported catch rates of dolphins without the grid in 2006 (21.8 per 1000 shots) (Table 6) and 2005 (15.2 per 1000 shots) (Table 2). There were also differences in the observer reported catch rates of dolphins between vessels, with vessels B and C having much higher catch rates with grids deployed than vessels A, D and E.

Table 6. Dolphin catch and catch rates for shots **with onboard observer** for all vessels between December 27, 2005 and July 31, 2006.

	Dolphins Caught			Number of Shots			Catch per 1000 shots		
Vessel	**Grid**	**No Grid**	**Total**	**Grid**	**No Grid**	**Total**	**Grid**	**No Grid**	**Total**
A	1	0	1	207	6	213	4.8	0	4.7
B	2	0	2	148	0	148	13.5	–	13.5
C	5	2	7	417	137	554	12.0	14.6	12.6
D	1	3	4	260	59	319	3.8	50.8	12.5
E	0	0	0	107	27	134	0	0	0
F	0	0	0	17	0	17	0	–	0
Total	9	5	14	1156	229	1385	7.8	21.8	10.1

5.4 Evaluation of the success of the grid

In the current project, with the grid deployed the dolphin catch was 9 in 1156 shots. The poisson distribution of the catches, indicates the catch of 9 dolphins is inconsistent with a catch rate of > 14.4 per 1000 shots, or < 3.5 per 1000 shots at the 95% level of confidence. As dolphin catch rate in 2005 without grids was 15.2 per 1000 shots, **we should reject the hypothesis that the grid has not reduced the catch rate.**

5.5 Dolphin catches vs time of day

The dolphins were generally caught in daylight hours, with 84% of the dolphins caught between 7:00 and 20:00 (Figure 8). This temporal pattern was not related to the time of winch-up as fishing and winch-up occurred over the whole 24 hour period.

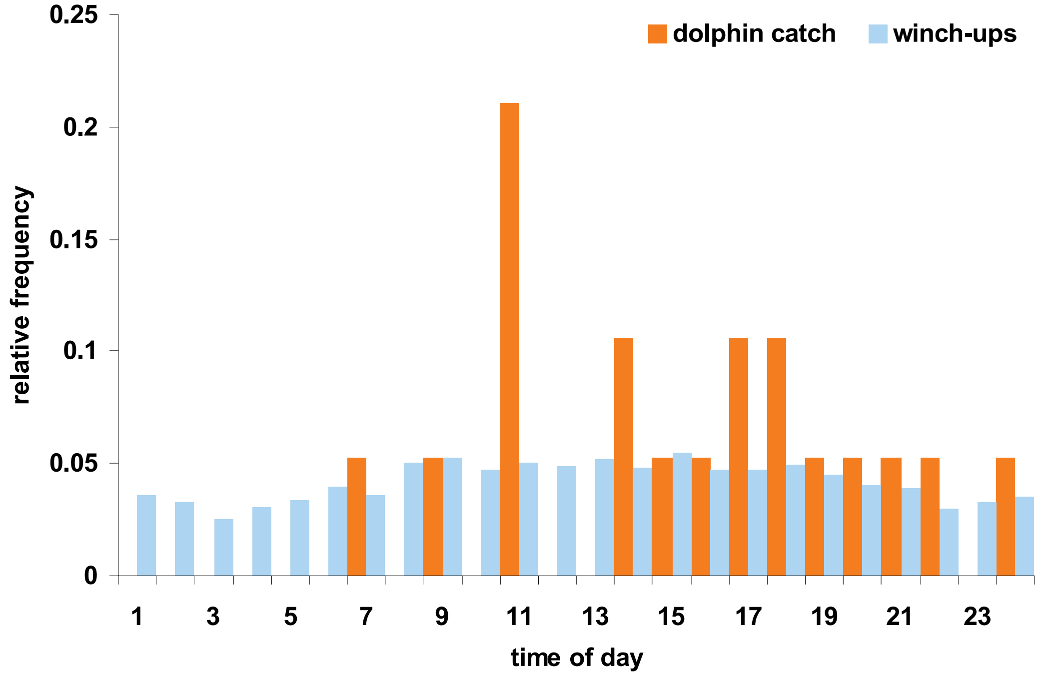

Figure 8. The relative frequency of dolphins caught in each time period between December 27, 2005 and July 31, 2006 (n=19) by time of day (orange) and the proportion of winch-ups by time-of-day (blue) (n=2,719).

5.6 Spatial distribution of dolphin catches

The spatial distribution of dolphin catches (Figure 9) recorded from December 27, 2005 to July 31, 2006 during the current project (orange) and recorded from January 1 2004 and June 30 2005 during the FRDC project 2004/68 (green). There are more dolphin catches in area 1 and less in area 2 but this is a reflection of the effort allocation, as illustrated in Figure 10.

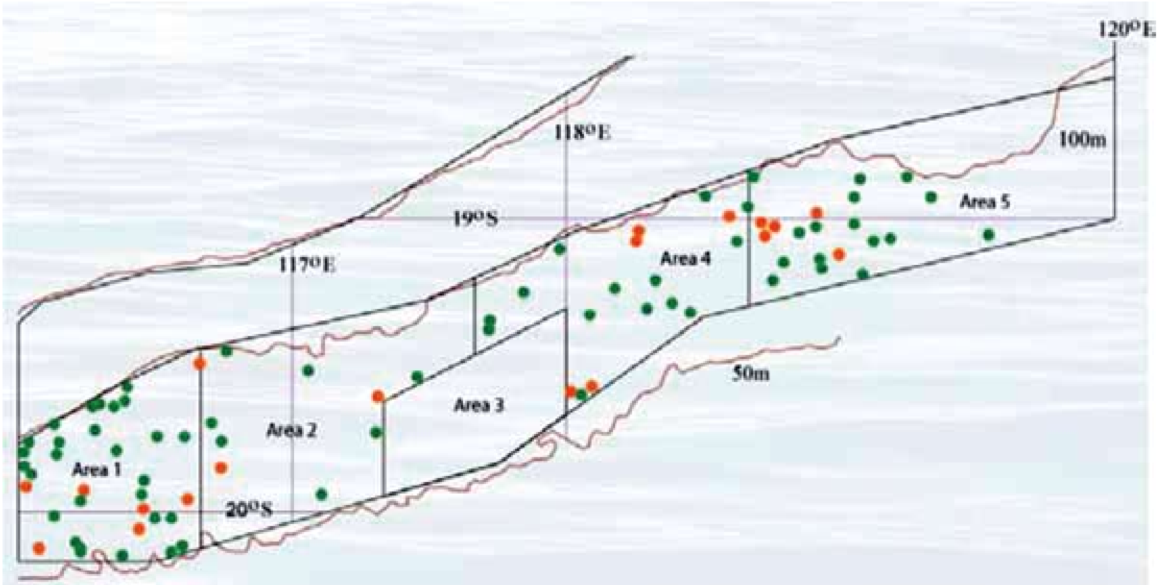

Figure 9. Spatial distribution of dolphin catches reported by observers and skippers between December 27, 2005 and July 31, 2006 (orange) and between January 1, 2004 and June 30, 2005 (green).

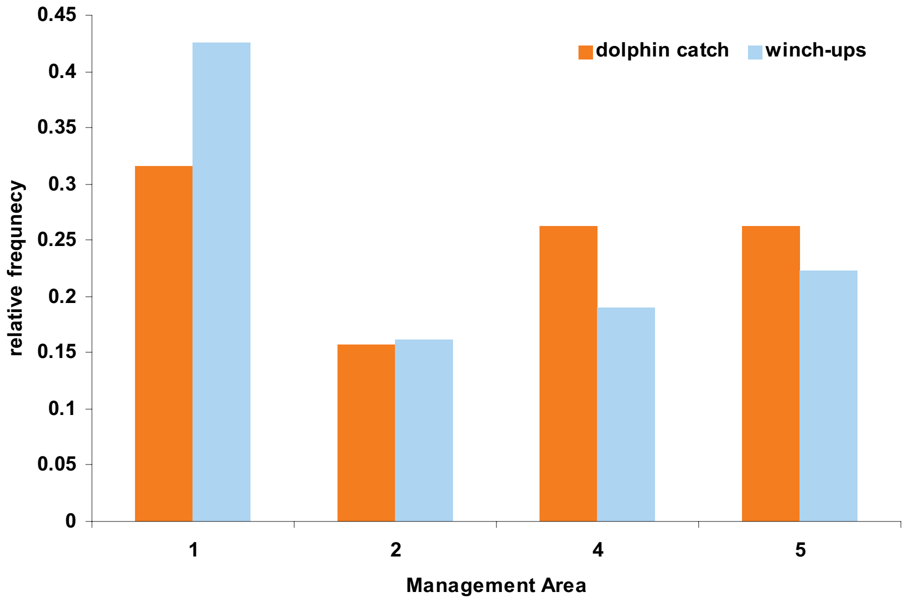

Figure 10. The relative frequencies of dolphins caught (orange) in each management area between December 27, 2005 and July 31, 2006 and winch-ups (blue).

There were no differences in the catch rates of dolphins between 10 m depth categories (Figure 11). The higher relative frequencies of dolphin captures in shallower water were related to the effort expended.

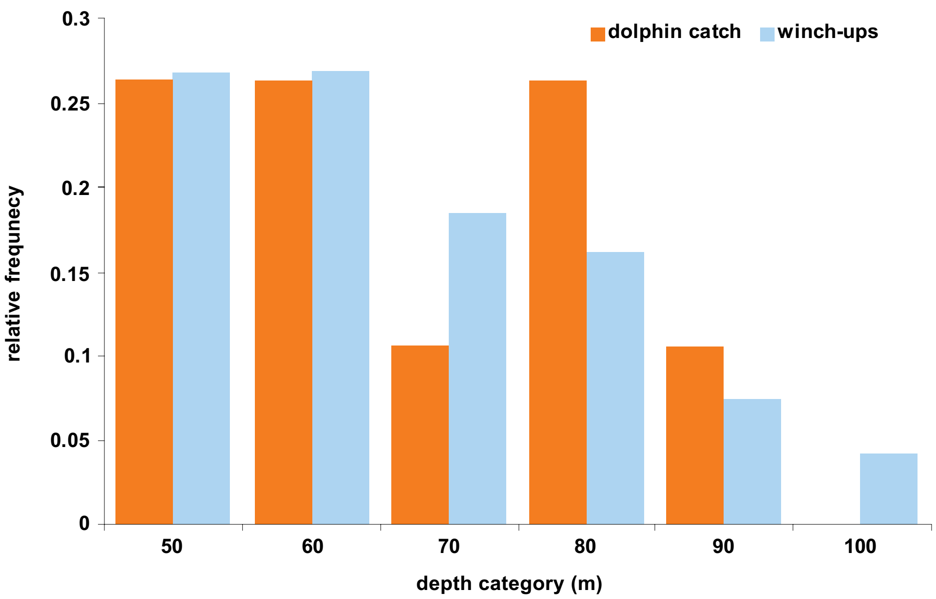

Figure 11. The relative frequency of dolphins caught in each depth category between December 27, 2005 and July 31, 2006 by depth (orange) and the proportion of winch-ups by depth (blue).

In 2005 and 2005, 21 captured dolphins were measured and the length frequency distribution by sex is illustrated in Figure 12.

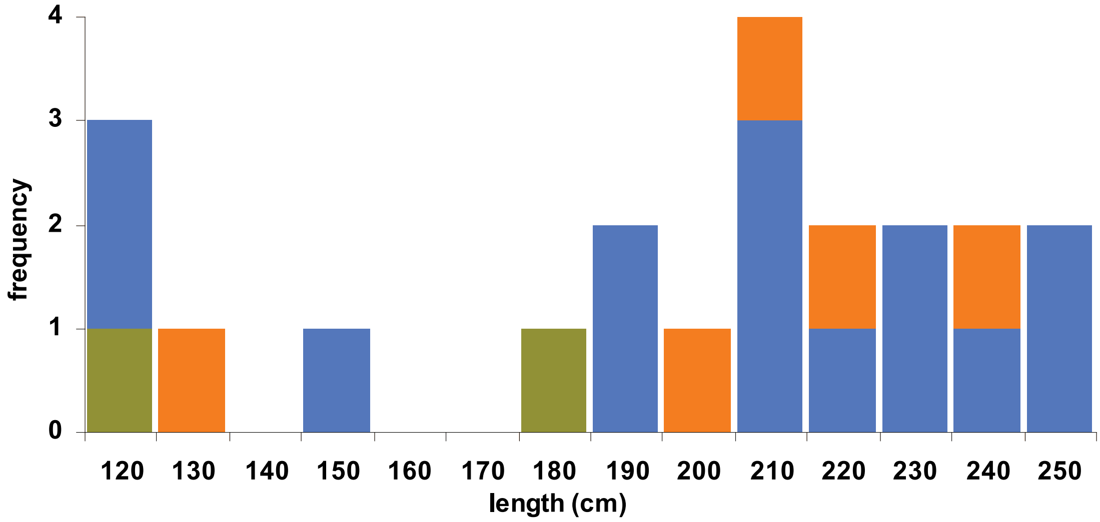

Figure 12. Length frequency distribution of dolphins measured between January 1 2005 and June 30 2006. Males (blue), females (orange), and unknown sex (green).

5.7 Bycatch of turtles

The observed catch of turtles, between December 27 2005 and July 31 2006, with the semi-rigid grid was deployed was 1 in 1156 shots (0.9 per 1000 shots). This is much lower than the catch of 6 in 229 shots when the grid was not deployed (26.2 per 1000 shots) (Table 7).

Table 7. Turtle catch and catch rates for observed shots on all vessels between December 27, 2005 and July 31, 2006.

	Turtles Caught			Number of Shots			Catch per 1000 shots		
Vessel	**Grid**	**No Grid**	**Total**	**Grid**	**No Grid**	**Total**	**Grid**	**No Grid**	**Total**
A	0	0	0	207	6	213	0.0	0.0	0.0
B	0	0	0	148	0	148	0.0	–	0.0
C	0	3	3	417	137	554	0.0	21.9	5.4
D	0	2	2	260	59	319	0.0	33.9	6.3
E	0	1	1	107	27	134	0.0	37.0	7.5
F	1	0	1	17	0	17	58.8	–	58.8
Total	1	6	7	1156	229	1385	0.9	26.2	5.1

5.8 Bycatch of sharks and rays

To increase the dataset, all observer data collected between July 1, 2005 and July 31, 2006 was used for this analysis. When the selection grid, with bar spacing of 15.5 cm, was deployed, large rays selectively made their way out of the escape opening. No rays of width greater than 120 cm passed through the grid into the cod-end. Although the grid reduced the number of captured rays between 90 cm and 120 cm (Figure 13), this was in contrast with the results of the previous trials (Stephenson and Wells 2006) where no rays above 80 cm were captured. The observers reported a small number of large rays on the grid when the net was retrieved.

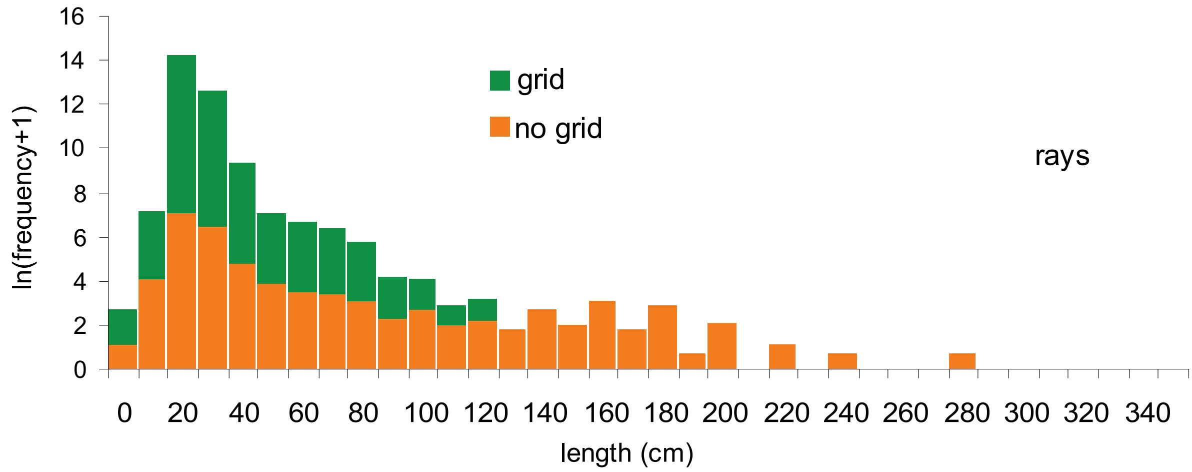

Figure 13. Natural logarithm of the frequency of capture of rays for each width class, with and without the selection grid deployed.

The grid reduced the captured number of sharks with total lengths above 100 cm, with a larger reduction occurring for sharks over 180 cm (Figure 14). This result is in contrast with previous trials (Stephenson and Wells 2006) where no sharks over 180 cm were landed with grids deployed. Some large sharks were landed after becoming stuck in, or in front of, the grid.

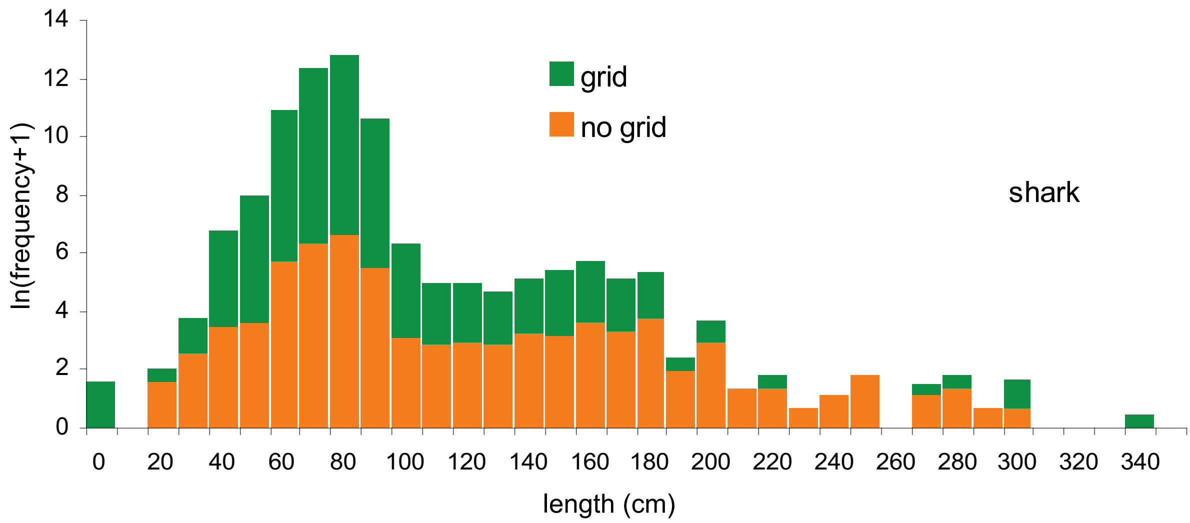

Figure 14. Natural logarithm of the frequency of capture of sharks for each total length class, with and without the selection grid deployed.

The catch of sandbar sharks with lengths between 100 cm and 150 cm total length was reduced when the grid was deployed but it appears that the catch of large sandbar sharks is not reduced by the grid. This is very different to the results of Stephenson and Wells (2006) where 55 sandbar sharks were caught in 558 shots with no grid deployed and only one small sandbar shark caught in 69 shots with the grid deployed.

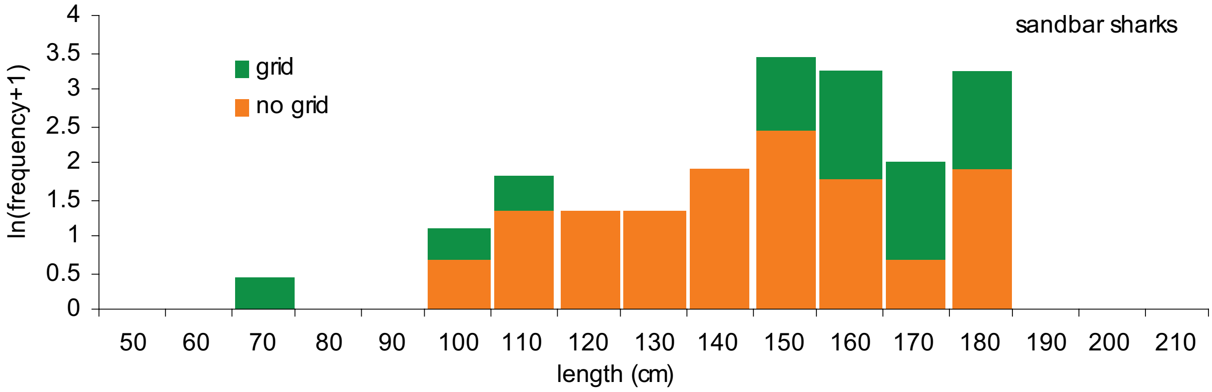

Figure 15. Natural logarithm of the frequency of capture of sandbar sharks for each width class, with and without the selection grid deployed.

5.9 Video footage of animal-grid interactions and dolphin behavior

In the NHT project (Stephenson and Chidlow (2003) and the FRDC project (Stephenson and Wells 2006) the video footage obtained with the cameras on the head-rope facing downstream showed dolphins swimming into the mouth of the net and then turning to face upstream just inside the net to feed on incoming fish. Some dolphins were seen to back down into the net and occasionally dolphins were seen swimming forwards into the net. When the camera was mounted near the grid, the dolphins observed always backed down towards the grid (Stephenson and Wells 2006).

In this project, during the 1384 shots observed, video footage was obtained for 446 shots, with most of the footage obtained by grid trial staff. The footage revealed interactions of scalefish, sharks, rays, dolphins and sea snakes with the grid. The footage showed images of behavior of dolphins entering and exiting the net or on the outside of the net in nearly all of the 446 tapes.

The video footage indicated that in almost all cases the dolphins backed down into the net to a position about 3 m from the grid and later swam upstream out of the net. Very few dolphins were seen swimming head-first towards the grid, and those that did turned around before reaching the grid and swam out the mouth of the net. Seven dolphins were recorded interacting with the grid or escape opening (Table 9). Two dolphins were observed exiting the net through the escape opening underwater (case 1 and 2, Table 9). One dolphin came into contact with the grid and then swam towards the net mouth, presumably escaping as it was not in the net on winch up (case 3, Table 9). A distressed dolphin was in view for three minutes before exiting through the escape opening and was assumed dead (case 4, Table 9). A further dolphin fell through the escape opening when the net came to the surface, assumed dead (case 5, Table 9). Another dolphin was seen to float towards the grid in distress but its fate was unknown due to fading light but it was considered unlikely to survive (case 5, Table 9). Two further dolphins were seen near the grid in a distressed condition and are assumed to have died (case 6 and 7, Table 9).

Table 9. Description and predicted life status of dolphins recorded interacting with the net on underwater video.

	Description of Dolphin Interaction	Type of Exit from Net	Predicted Life Status
1	Dolphin approached net head-first, exited head-first through the escape opening approximately 40 seconds later.	Swam out escape opening	Alive
2	Dolphin approached grid head-first, exited approximately one minute later.	Swam out escape opening	Alive
3	Dolphin approached the grid tail first, came to rest on the grid, then swam towards the mouth of the net two minutes later.	Swam out the mouth of net	Alive
4	Dolphin appeared in view already distressed, slowly approached grid tail first, exited through escape opening approximately three minutes later.	Fell out escape opening underwater	Dead
5	Dolphin floated into view already distressed, appeared lifeless at net/grid junction approximately four minutes later.	Fell out escape opening at surface when winched up	Dead
6	Dolphin floated tail first toward the grid already in distress, before the light faded.	Unknown	Dead
7	Dolphin appeared in view already distressed and approached the grid tail first. Seen resting upon the grid approximately five minutes later.	Unknown	Dead

The video footage also showed the interactions of approximately six turtles with the grid. On all but one occasion the turtles exited the net through the escape opening alive. In one instance a turtle became lodged in the grid for the duration of the video and was presumed dead. It is not known whether this turtle was landed on the deck of the vessel or exited the net unseen.

The video footage showed large sharks, including leopard sharks and sandbar sharks, and large rays entering the net head-first and exiting through the escape opening. A small number of large sharks did not exit through the escape opening and became stuck in the grid, forced their way through the grid or came to rest on the grid. Likewise a small number of large rays did not exit through the bottom escape opening but remained resting on the grid and were landed on the deck on winchup.

6.0 Discussion

The semi-rigid exclusion grid, manufactured in Fremantle, and used in this study appears to be successful in reducing bottlenose dolphin catches in the Pilbara Trawl Fishery. The catch rate of dolphins recorded by observers was approximately halved when grids were deployed in 2006 compared to the observer catch rate when grids were not deployed in 2005. The observer catch rate of 7.8 dolphins per 1,000 shots with grids deployed, is half the catch rate recorded by observers without the grid deployed in 2005. The catch rate in 2006 equates to an annual bycatch of approximately 43 dolphins per year.

Although the reduction is encouraging, the survival of dolphins exiting through the escape opening remains unknown. Of the 466 shots with video observations, 7 showed a dolphin interacting with the grid and of these 7, about half appeared distressed and may have died before exiting through the escape opening.

The underwater video footage of the behavior of the dolphins, showing them backing towards the grid, appears to indicate that the dolphins readily detect the selection grid. The pressure wave generated by the grid is probably effective in allowing the dolphin to detect its proximity to the grid. This is consistent with trials with selection grids in the UK where the number of dolphin deaths were reduced when a solid metal grid was deployed, and further reduced with deployment of a metal tubing grid, where the bars have a larger surface area (Northridge, 2004).

The observed behaviour of dolphins consistently backing down towards the grid, appears to be a very positive feature of their interaction with the selection grid. This behavior would reduce their risk of entanglement, as they do not need to turn around when they get close to the grid. A danger associated with this behavior is that the dolphins may back too close to the grid and get the tail fluke caught between the bars of the grid (Richard Conner, University of Massachuetts, Dartmouth, North Carolina, pers. comm., June 2005). In the Pilbara Trawl Fishery, one dolphin has been reported to have had its tail fluke caught in the grid by an observer and another by a skipper. Reducing the bar spacing, to less than the present 155 mm, may reduce the likelihood of this occurring.

There was a temporal pattern in the dolphin catch rates with most being caught in daylight hours. This pattern is not useful for dolphin catch mitigation as daytime closure of the fishery would severely disrupt the fishing operation and greatly reduce scalefish catches. The lack of spatial patterns in dolphin catches in 2004–05 and 2006 indicate that area closures will probably be ineffective in reducing dolphin catches.

There was a significant difference in dolphin catches between vessels when the grid was deployed. Vessels B and C had a catch rate more than 3 times the rest of the fleet. There are differences in net size, net material and winch-up between vessels. Vessels A and C used a grey net material called “magnet” which is stronger but the same diameter as the standard green material used by the rest of the fleet. The “magnet” material nets are about 5.8 m longer in the area just upsteam of the grid. Although it would appear that a longer net just forward of the grid would put the dolphins at more risk, vessel A had a low catch rate. In addition there are differences in operation of the hydraulics that can alter the speed of the net through the water during winch up. Vessel B has slow winch-up which may be reducing the risk of dolphin capture. During future observer programs, these vessel differences should be documented so that fishing methods and net designs with the lowest dolphin catch rates can be adopted as standards in the fishery.

The reporting of dolphins in logbooks appears to have improved in 2006, but it is still not conclusive whether dolphin catches are under-reported when observers are not onboard. The skipper reported dolphin catch rates in 2006 are similar to those of 2005, but the observer reported catch rate declined in 2006, indicating that the skippers may be reporting a higher proportion of dolphin interactions than previously.

The mortality rate of dolphins that exit through the escape opening is unknown. Of the seven dolphins that were seen on video footage interacting with the grid, three appeared to have a high chance of survival, with the other four appearing to have little chance of survival. During the observer programme, video footage should be obtained to gather information of the likely mortality rate caused by dolphin interaction with the grid when will add to the dolphin numbers observed when the net is retrieved.

The catch rate of turtle species was also significantly reduced in 2006 with the deployment of the exclusion grid and the video footage suggests that turtles are able to exit the net through the escape opening alive.

The reduction in the catch of large sharks and rays when the grid is deployed is an important secondary benefit of the selection grid. The catch rate of sandbar sharks, which are over-exploited in Western Australia, was greatly reduced when grids were deployed in 2005 (Stephenson and Wells 2006). In the current project, it appears that the catch of large sandbar sharks was not reduced with the grid deployed. The difference between the results in the two projects is most likely related to the greater sample size in the current project. This discrepancy may be resolved by catch rate data collected by observers in 2006 and 2007. The present trawl bycatch of this species is now at a level that is probably sustainable (pers. comm. Rory McAuley, Department of Fisheries WA, December 2006).

The largest catch rate of sharks and rays occurred on the two vessels with consistently high dolphin catch rates. With increased experience tuning the fishing gear, especially the grid, the catch of large sharks and rays may be further reduced.

7.0 Conclusion

The semi-flexible grid appeared to be effective in reducing the bycatch of dolphins, turtles, and large sharks and rays.

The observer program should be continued at 22% coverage, to quantify the dolphin and turtle catch. Video cameras should continue to be used to determine the number and survival rates of dolphins and turtles that encounter the grid.

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