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Evaluation of the effectiveness of reducing dolphin catches with pingers and exclusion grids in the Pilbara trawl fishery

Final FRDC Report – Project 2004/068

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Fisheries Research and Development Corporation

Fish for the future

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Cover picture:

With the camera positioned downstream of the grid, a dolphin can be seen holding position about 4 m from the grid.

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Evaluation of the effectiveness of reducing dolphin catches with pingers and exclusion grids in the Pilbara trawl fishery

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Non technical summary

"Savewave" acoustic pingers were trialed on one vessel to determine if they would deter dolphins entering the trawl net. During daylight hours, the pingers were deployed on alternate shots in the configuration recommended by the manufacturer. On the other alternate shots, no pingers were deployed. A video camera in an underwater housing was attached to the headrope facing downstream for 18 trawl shots. On the 14 shots where usable video footage was obtained (11 with pingers deployed and 7 with pingers not deployed) the number of dolphins viewed in the camera frame was counted for the 1.5 hours filming time, with no account being taken for double counting. The results indicated there was no reduction in the numbers of dolphins inside the net when pingers were deployed.

A flexible grid, constructed from polypropylene pipe joined by nylon rope was trialed for 5 shots. Although the grid was set according to the manufacturer's recommendations, the catch was almost zero. The digital camera footage showed the water and fish streaming out through the escape opening rather than through the grid. The trials of this grid were consequently abandoned.

A semi-rigid grid, which could be retrieved onto the net drum was trialed. It was constructed from stainless tube joined by braided stainless wire with articulated joints at the top and bottom. It had a bottom escape opening with a Kevlar/rubber mat just upstream of the escape opening. The mat was designed to improve water flow and assist in the escape of large objects. The selection grid was placed at the beginning of the extension, 10 m from the end of the net. During the trials, it was immediately obvious to the skipper and crew that large sharks and rays as well as large sponges were not coming on deck, which they saw as a benefit. They also perceived that scalefish catches has not decreased. The video footage showed large animals passing out through the escape opening and the dolphins backing down to a position about 4 m upstream of the grid and then swimming upstream out of view of the camera. During the period of the project, the dolphin catch with grids not deployed was 29 dolphins in 2616 shots (11 per 1000 shots) compared to 3 dolphins caught in 295 shots with the grid deployed (10 per 1000 shots). Two vessels trialed the grid voluntarily for most of these 295 shots with zero dolphin catch (albeit with no observers on board for most of the shots) and toward the end of the project, a third vessel trialed the grid for one trip and caught all three dolphins.

The grids appear to be successful at reducing dolphin catches on two vessels, but there is a need for trials to be conducted with a power sufficient to detect differences in the dolphin catch

with grids deployed and not deployed. If 400 shots were observed with the grid deployed and 400 shots with the grid not deployed, at the current capture rate 10.2 per 1000 shots, a dolphin catch of 2 or less would indicate, with a power of 0.9, that grids reduce the dolphin catches.

Keywords: Acoustic pingers, exclusion grids, dolphin, turtle.

Outcomes Achieved

"Savewave" acoustic pingers appear to be ineffective in keeping dolphins out of the trawl net in the Pilbara Trawl Fishery.

The flexible grid constructed from polypropylene pipe appears to be impractical, as the net and grid combination did not fish properly, with scalefish catch close to zero.

The semi-flexible selection grid constructed from a combination of braided stainless wire and pipe appears to reduce dolphin catches.

A possible mechanism for reducing dolphin catches in the Pilbara Trawl Fishery has been identified. In 2005, when the grid was deployed, all dolphin captures occurred on the initial trial of the grid and could have been due to initial technical problems.

Acknowledgements

The authors are grateful to the skippers and crew of the fishing vessels in the Pilbara Trawl Fishery, for their help in facilitating the recording of bycatch. Australia Bay Seafoods are acknowledged for the design and construction of the selection grid used in this project. The observers on the vessels, Kim Brooks, Rob Gherardi, and the staff of Pelagicus are thanked for their valuable contributions. Justin King is thanked for data extraction and analysis.

1.0 Background

In the 1970's there was an increasing concern over some marine mammal stocks, which led to the FAO's Advisory Committee on Marine Resources Research, organising a meeting in Bergen in 1976 (Northridge 1984) to determine the extent of mammal interaction with fishing gear.. Concern over marine mammal interaction with fishing gear resulted in the International Union for the Conservation of Marine mammals conducting a meeting in La Jolla in 1981 (Northridge 1984). This lead to changes in fishing practices and use of acoustic devices which have reduced the catches of cetaceans in gill net and purse seine fisheries (Culik et al. 2001, Dawson et al. 1998, Fullilove 1994, Kastelein et al. 2000, Kastelein et al. 2001, Koschinski and Culik 1997, Kraus 1999, McPherson et al. 1999, Stone et al. 1997, Trippel et al. 1999).

In contrast, the deaths of cetaceans, caused by interaction with trawl fishing gear, is not well documented. Considerable information has been documented on the Dutch horse mackerel fishery, French hake fishery, French tuna fishery and especially in recent years the sea bass fishery fished by French and Scottish trawlers. The background information of this report documents the extent of catches and mitigation measures investigated in trawl fisheries.

1.1 Cetacean interactions in the North East Atlantic, North Sea and Baltic Sea

In the pelagic trawl fisheries of the NE Atlantic, observer surveys in the 1990's recorded catches of dolphins in the Dutch horse mackerel fishery, the French hake fishery, the French tuna fishery (Morizur et al. 1999).

Since 2000, surveys have been conducted on thirteen United Kingdom (UK) pelagic trawl vessels for 190 days at sea, covering fisheries for herring, mackerel, sprat, pilchard, blue whiting, anchovy and sea bass. During these surveys, the only observed cetacean bycatch was from the UK sea bass trawl fishery (DEFRA 2003).

The European pelagic sea bass trawl fishery consists of 30 pairs of French vessels, 10 large Dutch vessels (working singly) and between two and six UK trawlers working in pairs (DEFRA 2003). The operators in the U.K pair trawl fishery, in collaboration with the Sea Mammal Research Unit (SMRU) at St Andrews University, determined that approximately 90 common dolphins per year were caught between 2000 and 2003 (Northridge 2003) and then a dramatic increase to 439 common dolphin deaths in the 2003/2004 season (Northridge 2004), and a preliminary estimate of 142 deaths in 2004/2005 (pers. comm. Simon Northridge, 2005). The Whale and Dolphin Conservation Society (WDCS) suggested that common dolphin mortality from the French sea bass trawl fleet could be over 2000 dolphins a year (WDSC 2004).

To address concerns of the level of cetacean bycatch, Belgium, Denmark, Finland, Germany, Lithuania, Netherlands, Poland, Sweden, and UK entered into the "Agreement on the Conservation of Small Cetaceans of the Baltic and North Seas" (ASCOBANS) in 1994 (Figure 1).

In 1997, ASCOBANS defined "unacceptable cetacean interactions" as a total anthropogenic removal above 2% of estimated abundance and in 2000. In agreement with the International Whaling Commission (IWC), recommended that a removal of harbour porpoise of more than 1.7% of the population was unacceptable. In the North Sea and Celtic Sea the harbour porpoise bycatch was estimated at 2.6% and 6.2% respectively (ASCOBANS 2000).

In 2003, the UK Department for Environment, Food and Rural Affairs (DEFRA) suggested that the sea bass trawl fishery catch of common dolphins be reduced to below 1.7% of the population estimate by May 2006. In addition, trials of selection grids should continue in the UK sea bass fishery, together with cetacean catch monitoring in all UK pelagic trawl fisheries (DEFRA 2003). Although selection grids have been criticised for their potential to injure animals exiting through the escape opening (DEFRA 2003), it is not clear whether this is a problem in the UK sea bass fishery (Select Committee on Environment, Food and Rural Affairs 2004).

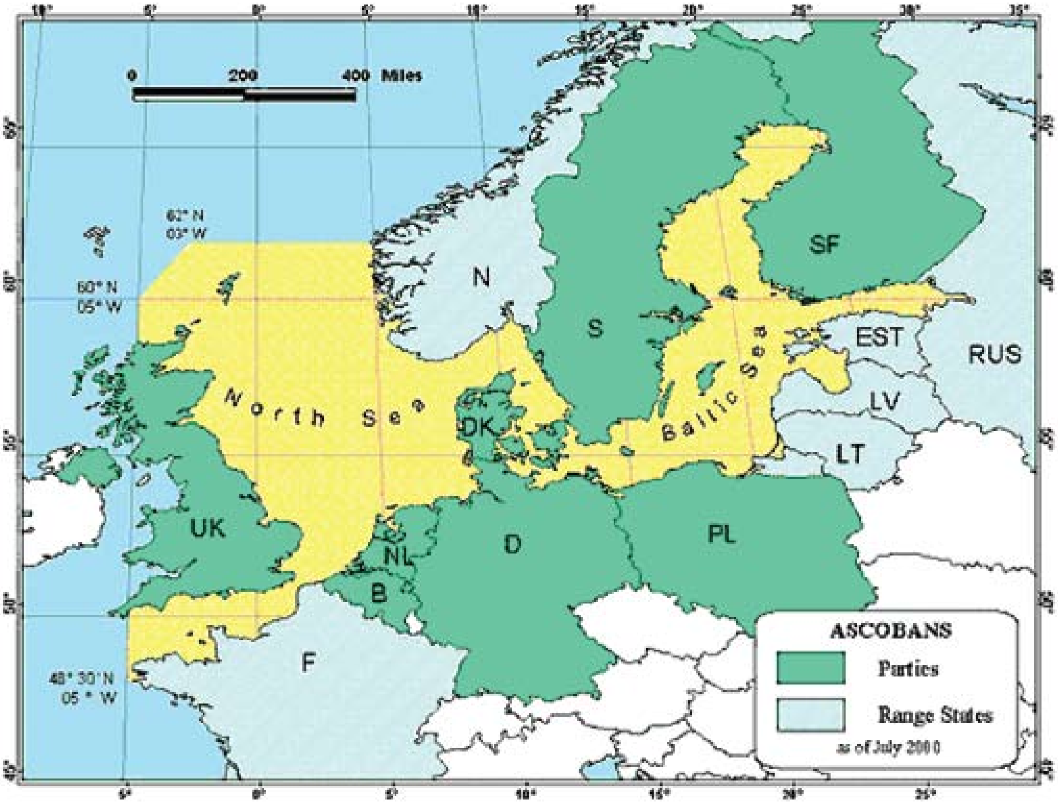

Figure 1. Parties to ASCOBANS: UK, Belgium (B), Denmark (Dk), Finland (SF), Germany (D), Lithuania (LT), Netherlands (NL), Poland (PL), Sweden (S).

1.2 Mitigation measures in the North Sea

Various mitigation measures, to reduce the catch of common dolphins, have been trialed in the UK sea bass pelagic pair trawl fishery, including acoustic pingers, rope barriers, large mesh net panel, and selection grids. Trials of these devices occurred in collaborative work with the Sea Fish Industry Authority and the Sea Mammal Research Unit at St Andrews University.

1.2.1 Acoustic pingers

In the 2001/2002 fishing season, Dukane NetMark pingers (Figure 2) were trialed by placing up to 12 pingers on the head rope and footrope of the trawls. During 52 tows when pingers were deployed the dolphin catch rate was 1.3 per tow compared to 1.1 per tow with pingers not deployed. It was concluded that these pingers were not effective (Northridge 2003).

Figure 2. Dukane Netmark 1000 acoustic pingers.

In 2002, AQUAmark 200 pingers (Figure 3) were deployed further back in the net around the "sharks teeth" section of the net. Up to 6 pingers were used simultaneously but dolphin bycatch was still observed (Northridge 2004). The dolphins appear not to be deterred by the pingers either because they were not loud enough with the trawl associated noise masking the pinger output or because the dolphins are highly motivated to enter the net (Northridge 2004).

Figure 3. AQUAmark100/200 acoustic deterrent devices.

Louder acoustic devices are being developed and tested by Aquatech (Figure 4) in the Irish tuna pair trawl fishery (Northridge 2004). These will be deployed at the sharks-teeth of the trawl net in order to deter the dolphins entering the portion of the net where the mesh is too narrow for the dolphins to escape.

Figure 4. Aquatech pinger designed for the Irish pair trawl fishery and the area of deployment at the shark-teeth position in the net.

1.2.2 Rope barriers

The rope barrier trialed consisted of 60 lengths of polypropylene rope across the 40 m net width at the “sharks teeth”. In addition, 100 plastic reflective floats in two horizontal lines were deployed across the ropes. It was reasoned that the 60 cm spacing between the ropes and the reflective floats would act as a deterrent to dolphins. This device was tested for 4 tows on one trip with no dolphin catches compared to 3 dolphins in 2 tows on the partner vessel. Although this device appeared to be effective in reducing dolphin catches, the fish catch was low and the crew concluded the ropes were tangling and preventing the net fishing effectively. Consequently, this device was discontinued (Northridge 2000).

1.2.3 Large mesh panels

A large mesh cargo-net panel, deployed across the net mouth, was tested by the French Institute for Exploration of the Sea (IFREMER) in March 2004 and installed for one tow on a Scottish trawler at the end of the sea bass season. The crew did not report reduced fish catches and the device will be trialed again in 2005 (Northridge 2004).

1.2.4 Steel Grids

A solid rectangular selection grid (Figure 5) designed by the Institute of Marine Research in Bergen was trialed off Scotland in the 2002/2003 season. The grid had 220 mm bar spacing, a 1.7 m top escape opening and a 22 mm mesh cover flap. The grid was placed at the beginning of the net extension and an underwater camera was deployed, with an umbilical for lighting on the camera. Images were fed via the umbilical to the vessel’s wheelhouse.

Figure 5. Solid metal selection grid used in trials in the UK sea bass pair trawl fishery between 2002 and 2004.

During the trials consisting of 82 hauls with the grid deployed, two dolphins drowned after being jammed in the grid. Elsewhere in the fishery with no grid deployment, 28 dolphin casualties were recorded in 49 hauls (DEFRA 2003). When grids were deployed, the video footage indicated no dolphins exited through the escape opening. The results of these trials were considered encouraging and DEFRA concluded that separation grids were effective in minimizing dolphin mortality, although the mechanism for the catch reduction was not clear (DEFRA 2003). Unexpectedly, during further grid trials in the 2003/2004 season, 45 dolphins were caught in 10 tows.

In an effort to reduce dolphin injuries associated with collisions with selection grids, a flexible grid (Figure 6), with a 2.4 m top opening escape hole and a 22 mm cover mesh, was trialed. In the period February to April 2004, with the grid deployed, 53 dolphins were caught in 30 tows. The crews perceived that there were reduced fish catches with this grid and speculated that the flexible grid may interfere with the proper operation of the net. The crew put various reinforcing rods in the grid to make it more rigid.

Figure 6. Flexi-grid manufactured in Shetland, Scotland.

In the second half of the 2003/2004 season, from December to April, a rectangular rigid tubular steel grid was trialed. The escape opening was 2.4 m with an escape hatch cover of stiff 5 mm mesh. In these trials the dolphin catch was 29 in 30 tows. This tubular steel grid appeared more effective than the solid steel or the flexible grid in reducing the dolphin catch but the reason was not clear. It was speculated that it might be due to the different cover material or the more reflective property of this grid (Northridge 2004).

1.3 Mitigation measures in the United States

In 1972 the Marine Mammal Protection Act aimed to eliminate the incidental mortality and injury of marine mammals during commercial fishing operations. In 1994 the act was amended to require the levels of mortality be reduced to a level approaching zero by 30th April 2001. National Marine Fisheries Service (NMFS) determined that the acceptable threshold catch level would be 10% of the Potential Biological Removal level (PBR see Wade 1998) for each species.

The NMFS classifies commercial fisheries according to their mortality of marine mammals:

Category I ≥ 50% of PBR.

Category II with other fisheries ≥ 10% PBR or individually ≥ 1% of PBR.

Category III with other fisheries ≤ 10% of PBR or individually ≤ 1% of PBR or no information available.

In 2004, the cetacean mortality rates were only available for 6% of the 216 fisheries in US, and PBR's were known for less than half of the marine mammal stocks (NMFS 2004). Thus 175 of these 216 fisheries were classified as Category III and are not required to take mitigation measures to reduce incidental dolphin capture.

Of the trawl fisheries listed in the 2004 US List of Fisheries, only the Alaskan finfish pair trawl fishery was listed as Category II, with all other trawl fisheries listed as Category III. In these Category III trawl fisheries catches of cetaceans have only been recorded in the groundfish trawl fishery, with the average annual catch of Dall's porpoise, Habour porpoise, and Pacific white sided dolphin being 54 in the Bering Sea, 4 in the Gulf of Alaska and 18 in the Washington/Oregon/California area.

A take reduction plan was instigated by the NMFS due to the catch of common, bottlenosed and spotted dolphins in the Atlantic pelagic pair trawl, drift net and longline fisheries. The plan was abandoned in 2001 due to changes in management and operation of the fisheries. The Atlantic pelagic pair trawl is now inactive.

1.4 Mitigation measures in France

The French institute for the exploration of the sea (IFREMER) is currently conducting gear trials (selection grids and acoustic devices) to reduce cetacean catches. This includes an acoustic deterrent incorporated in net sensors, which was successfully trialed on common dolphins during experiments in 2005 and will soon be trialed in a commercial fishing operation (Yvon Morizur, Sciences and Technologies Department, IFEMER, Plouzane, France, pers. comm. September 2005). IFREMER commenced trials of an EVA copolymer exclusion grid in 2005. The initial trials indicated no reduction in fish catch with no dolphin catches (Anonymous 2005).

1.5 Mitigation measures in the Black and Mediterranean Sea's

The Agreement on the Conservation of Cetaceans of the Black and Mediterranean Sea (ACCOBAMS) aims to improve knowledge and reduce anthropogenic mortality of cetaceans. Parties to the agreement (France, Greece, Albania, Bulgaria, Croatia, Georgia, Italy, Lebanon, Libya, Malta, Monaco, Morocco, Portugal, Romania, Syrian Arab Republic, Spain, Tunisia and Ukraine) aim to implement a conservation plan for cetaceans by minimising incidental capture and creating protected breeding and birthing areas. The main threats to common dolphins include deaths in fishing gear, reduced food supplies, habitat degradation, and toxic contaminants.

1.5.1 Black Sea

A small number of common dolphins and bottlenose dolphins are caught in trawl operations off Turkey (Öztürk 1999) and off Georgia, 2 common dolphin captures were recorded during trawling for anchovy (BLASDOL 1999). In Crimea, a small number of common dolphin captures have been reported during pelagic trawling (Birkun and Krivokhizhin, 2001).

1.5.2 Mediterranean Sea

The priority for research in this area is determination of cetacean abundance, identification of critical habitats, and the extent of contaminant induced reproductive disorders, especially in the eastern Mediterranean (Bearzi et al. 2004).

Interactions between trawlers and several cetacean species, mainly bottlenose dolphins, are exacerbating their demise (Bearzi et al. 1999, Casale 1996, Consiglio et al. 1992, Gannier 1995, Goffman et al. 1995, Marini et al. 1995, Mazzanti 2001, Mussi et al. 1998, Northridge 1984, Pace et al. 1998).

Off the coast of Israel, 26 bottlenose dolphin mortalities were reported by Goffman et al. (2001). One third of the annual mortality of bottlenose dolphins is estimated to be due to bottom trawls (Dan Kerem, Israel Marine Mammal Research and Assistance Centre, pers. comm., September 2005).

The Balearic Archipelago, 170 km off the Spanish coast in the western Mediterranean, is an area of operation for 76 Spanish bottom trawlers. Dolphins seek prey around and inside the trawl nets but operators indicate there are no dolphin captures (Silvani et. al. 1992).

In the waters off Greece no pelagic trawls operate and the demersal trawls have a low net opening of 1 – 2 m with no reported cetacean bycatch. Consequently no independent catch monitoring occurs (Chris Smith, Hellenic Centre for Marine Research, Crete, Greece, pers. comm. September 2005). In the eastern Ionian Sea off Greece, the local decline of common dolphins and the low density of bottlenose dolphins have been attributed to fishing induced depletion of prey species (Bearzi 2005).

At Lampedusa Island (Italy), during a five-year study, dolphins were observed to come close to fish trawlers but there have been no reported mortalities (Pace et al. 1999).

From January 2005, pelagic trawl vessels over 15 m in the Black and Mediterranean Sea’s will have on-board observers to record incidental catches of cetaceans (Bearzi et. al. 2004).

1.6 Mitigation measures in Australia

1.6.1 South East Trawl Fishery

In the South East Trawl Fishery of Australia, dolphins commonly occur in the vicinity of trawl operations but there has been only one reported dolphin fatality (AFMA 2005).

1.6.2 Small Pelagic Fishery off Tasmania

In Zone A of the Small Pelagic Fishery, one operator has been targeting red baitfish since 2001 (Figure 7). Initially the operation was pair trawling using midwater gear but in 2003 single vessel midwater trawling commenced. During this period, scientific observers were onboard for 28 trips and no dolphin interactions were recorded.

Exclusion devices were in operation in this fishery from 2001 to 2004. They consist of 170–200 mm square mesh “cargo net” barriers set just before the extension (60 m from the cod end and 140 m from the head rope) with a 1.9 m wide bottom escape opening. This exclusion device was not totally satisfactory as water streamed out of the escape hole with possible loss of catch. In late 2004, the design was changed to a top escape opening. From the period October 2004 to May 2005, 25 dolphins were caught with the “cargo net” selection device deployed.

Between May and July 2005, a low-light self-contained camera system was deployed with the “cargo net” selection device and an escape hatch either open, covered with ribbons of mesh, or covered with a wide section of mesh. During 19 shots, no dolphins appeared on the video (Browne et al. 2005).

In mid 2005, a solid metal grid designed in New Zealand was deployed. It measures 2400 mm by 2100 mm, with 200 mm bar spacing and is hinged horizontally so that it can be wound onto the net drum.

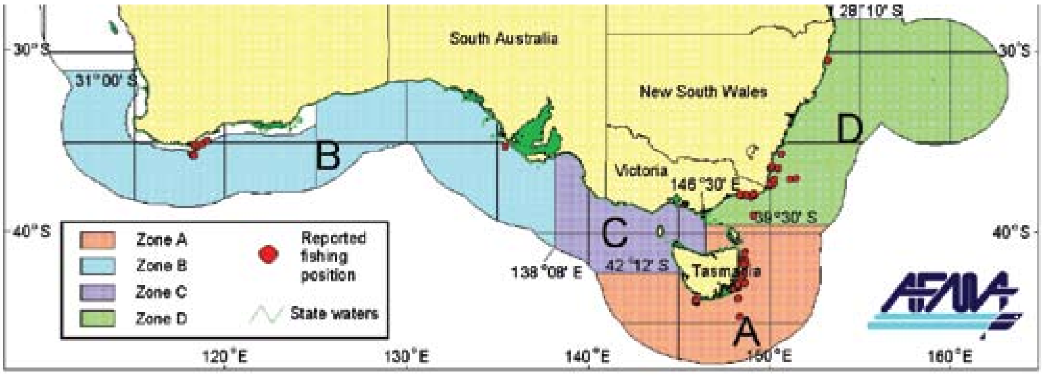

Figure 7. Zones in the Australian Fisheries Management Authority Small Pelagic Fishery in southern Australia.

1.6.3 Pilbara Fish Trawl Fishery

In the Pilbara Fish Trawl Fishery, operating off the coast of Western Australia (Figure 8), on-board observers recorded 4 dolphins caught during 100 days at sea and 473 shots (1/13 of the trawl time allocation). The four dolphins were all caught in daylight hours, in water shallower than 65 m, and in Area 1 of the fishery (Stephenson and Chidlow 2003).

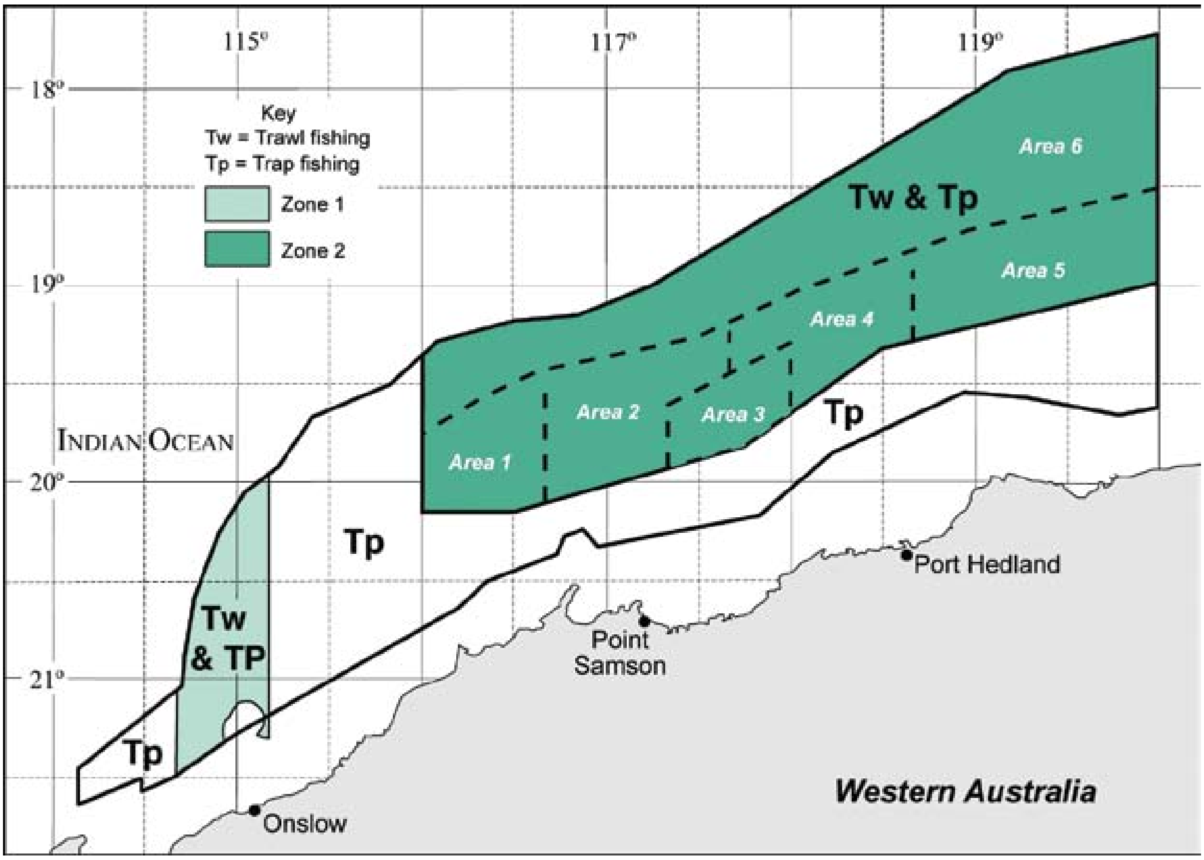

Figure 8. Management areas in the Pilbara trawl and trap fisheries. Management area 3 is closed to trawl fisheries.

In this project, a video camera set on the headrope facing the cod-end (Figure 9), revealed dolphins swimming in the pressure wave of the net and feeding on the incoming fish. The majority of the dolphins observed backed into the net and often stayed within the net about 5 m from the mouth, catching fish as they swam past. Dolphins that swam forwards into the net either turned around and positioned themselves close to the net entry or swam out of sight into the net, returning 2–6 minutes later to swim out of the net mouth.

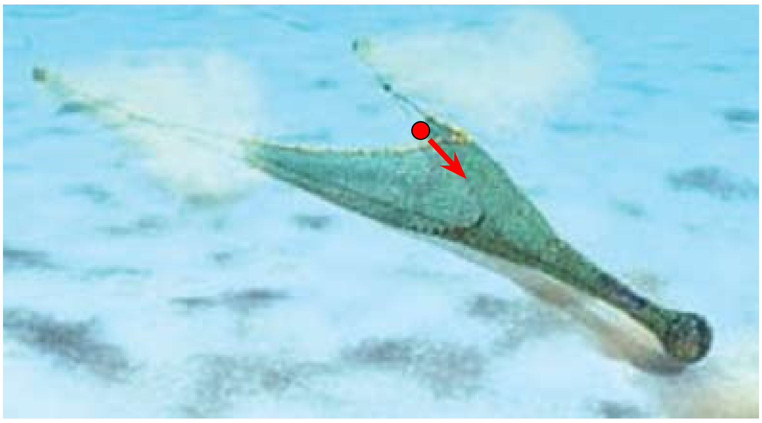

Figure 9. Demersal trawl net showing location of camera and the direction it was facing for filming.

On one occasion a dolphin died in the net when the camera was deployed but there was no recorded footage of the dolphin's death. Copies of the report, Stephenson and Chidlow (2003), and the accompanying video footage are available from the author.

2.0 Need

The Pilbara Trawl Fishery captures approximately 50 dolphins per year (Stephenson and Chidlow 2003), nearly always dead. Trials with a digital camera mounted on the headrope found that video footage of dolphins in the net was obtained on about half the occasions when the camera was deployed. Because of the limited number of trawl shots with the camera deployed, there was no information on how the dolphins drowned in the trawl net. All dead dolphins were found in the cod-end and were never found tangled in the net.

In the North Sea pelagic sea-bass fishery, pingers appeared to be ineffective in reducing the common dolphin catch. Exclusion grids appeared to reduce the common dolphin catch with the most effective design being a hollow tube rigid grid (Northridge 2003). The results from the North Sea are not directly applicable to the Pilbara Trawl fishery which uses demersal trawls and the species caught are bottlenose dolphins. Consequently there is a need to determine the effectiveness of pingers and exclusion grids in this specific fishing operation.

3.0 Objectives

- Determine the occurrence of dolphins swimming into the net on vessels with exclusion grids, compared to vessels without grids, and to determine the behaviour and fate of the animals encountering the grid.
- Determine the occurrence of dolphins swimming into the net on vessels with pingers, compared to vessels without pingers.
- Determine the mortality rate of dolphins on trawls where pingers or grids are deployed compared to trawls without mitigation devices.

4.0 Methods

4.1 Acoustic Pingers

“Savewave” acoustic pingers (www.savewave.net) were trialed to determine if they would deter dolphins from entering the mouth of the trawl net (Figure 10).

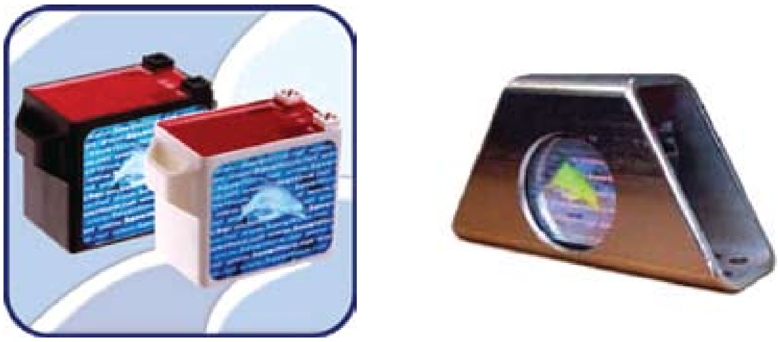

Figure 10. “Savewave” acoustic pingers (left) with the metal protective housing (right).

The pinger units were enclosed in a protective housing of aluminum tubing with circular holes of 3.5 cm diameter cut out of each side, similar to the housing recommended by the manufacturer, shown in Figure 10.

During each shot in daylight hours, the pingers were alternately deployed or not. Prior to deployment, the pingers were immersed in saltwater and tested with a device that converts the pinger output signal into a human audible frequency. Five black and five white pingers (each having different output frequencies) were tied to the bridles, sweeps, and doors with 8 mm cable ties in positions suggested by the supplier (Figure 12).

Video footage was obtained for each shot to determine the presence of dolphins in the net when pingers were deployed or not deployed. The footage was recorded on a Sony HC15E DCR which was set to long play, wide angle, fixed focus on infinity, and night shot. The DCR was placed in an aluminum underwater housing designed and built by the author in conjunction with Cockburn Sheet Metals and DamoWest Plastics (Figure 11). The camera housing was mounted on the mesh with four 8 mm cable ties, close to the centre of the headrope facing towards the cod-end and downwards at an angle of 20 degrees.

Figure 11. Under water video camera housing.

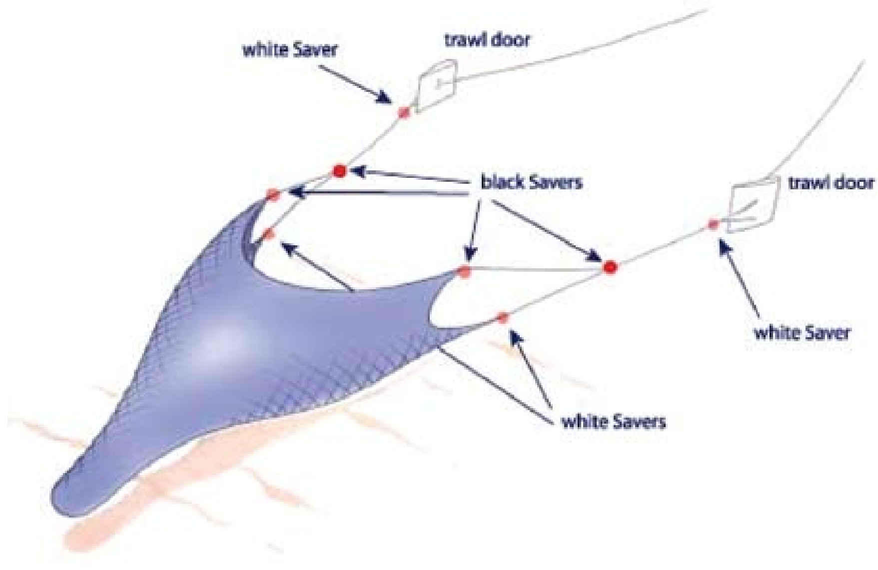

Figure 12. Positions of the pingers on the trawl net as suggested by manufacturer.

At the end of each shot, the pingers were tested to ensure they were operating and then washed in fresh water and shaken to remove excess water until they stopped emitting sound. The camera housing was washed in fresh water, cloth dried, opened and the o-ring and seating groove dried and cleaned.

During the trip, 44 trawl shots were undertaken. Where sufficient light was available for filming, video footage was also obtained for 11 shots with pingers deployed and 7 shots without pingers.

The videotape footage was edited and stored as indicated below.

1. Video tape footage was captured as a Quicktime uncompressed video file in “BTVPro” on a Power Macintosh G5 computer and then stored on an external Macintosh server
2. 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.
3. The individual shot video files were then compiled using the Macintosh editing program ‘LiveType’ and rendered into one video stream.
4. The video stream was compressed to mpeg2 using ‘IDVD’ in PAL format and saved to a single layer DVD
5. The video stream was also compressed to mpeg2 using Apple Quick Time Pro then copied to 700mb CD using ‘Toast Titanium’.

The edited video of the pinger trials was 1hr 20 min long. This video footage was viewed on a Power Macintosh G5 and the number of times a dolphin was sighted in the view of the camera was recorded, with no attempt made to allow for double counting of the same animal.

4.2 Selection Grids

In the Pilbara Trawl Fishery, nets are retrieved onto net drums in two configurations

1. one net drum 2.6 m wide partitioned in the centre and containing two nets, with one net on each side or two net drums 1.3 m wide containing one net each.
2. If one net needs repair or is lost, the second net can be quickly and easily deployed.

In both these configurations, a rigid grid cannot be retrieved on the net drum and it would need to be hauled onboard and then the codend retrieved with a “lazy line”, making the retrieval slow and cumbersome. Consequently it was decided to use a selection grid with some flexibility, which could be wound onto the drum.

4.2.1 Flexible grid

The first selection grid trialed was a flexible grid, constructed from polypropylene pipe joined by nylon rope (Figure 6). The grid was sewn into the net at the beginning of the extension, approximately 10 m from the cod-end, with a 1m by 1m escape opening at the bottom. A net maker set up the grid according to the manufacturer’s recommendations. The digital camera was attached to the net with 8 mm cable ties, 3 m downstream of the grid, facing the grid, and angled downwards at about 20 degrees. The flexible grid was trialed for 5 shots on two separate trips with 1 hour of video footage obtained for each of the last three shots. The scalefish catches from these tows were so low that this grid was abandoned (see section 7.2).

4.2.2 Semi-rigid grid

In order to improve scalefish catches, a semi-rigid grid, that was still flexible enough to be retrieved onto the net drum, was designed and manufactured by Australia Bay Seafoods. This grid was made from stainless tube joined by braided stainless wire with articulated joints at the top and bottom. This grid can fold horizontally because of the braided wire and can flex on a diagonal axis due to the articulated joints (Figure 13). With care, this grid could be wound onto a net drum.

The selection grid has a Kevlar/rubber mat which improves the hydrodynamics of the grid and aids large objects exiting from the net through the escape opening. The selection grid was placed at the beginning of the extension, 10 m from the end of the net. The placement position of the grid in the net, the net plan and mesh sizes (e.g. # 150 denotes single mesh of 150 mm, ## 100 denotes double mesh of 100 mm) are shown in Figure 14.

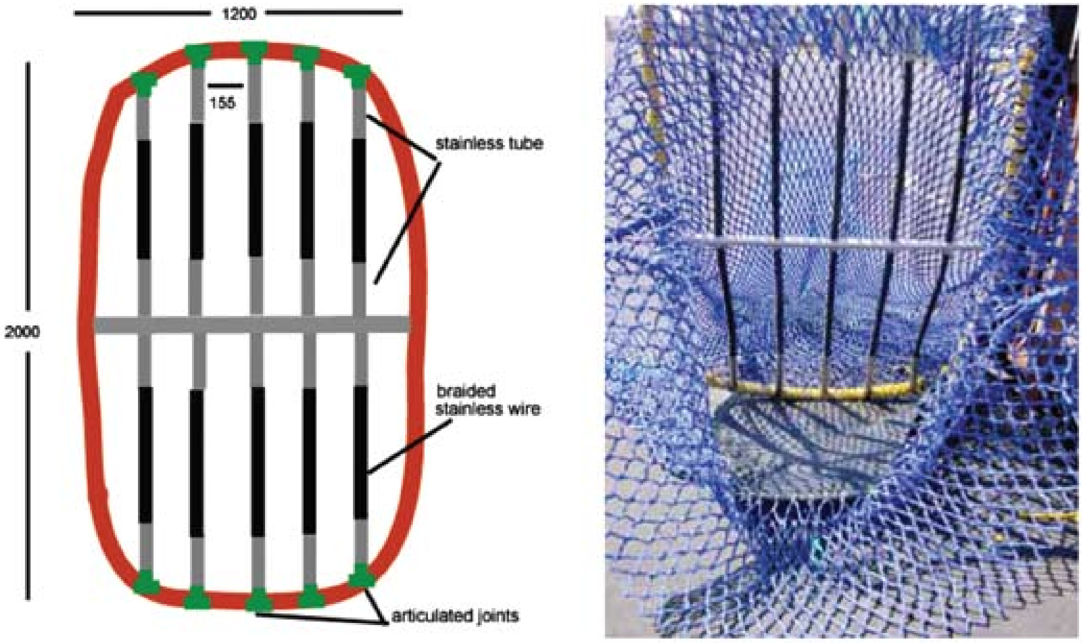

Figure 13. Semi-flexible grid constructed from stainless tube and braided stainless wire.

1. Video cameras were placed at four positions (Figure 14 - in green) in order to view the operation of the grid and net and the behavior of animals in the trawl net.
2. Camera on head rope facing downstream.
3. Camera located 4 m (occasionally 5.5 m) upstream of the grid and facing towards the grid.
4. Camera located 4 m upstream of the grid and facing towards the vessel.
5. Camera located 4 m downstream of the grid facing the grid.

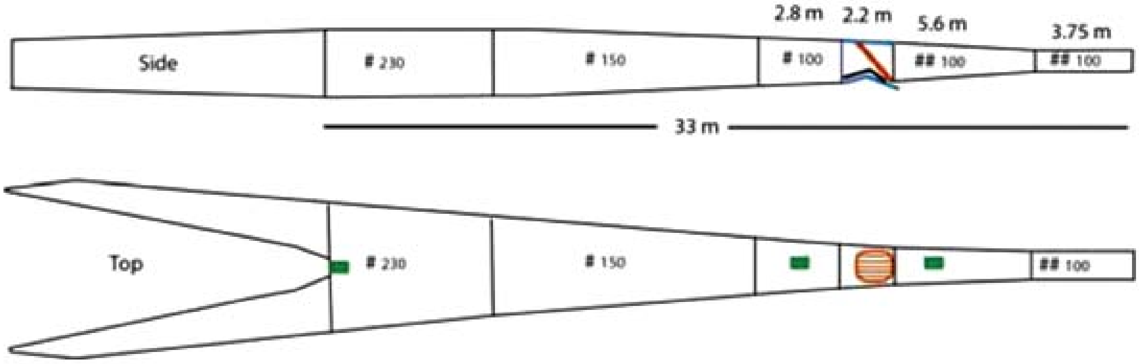

Figure 14. The plan of the net used during the trials of the selection grid showing the grid (brown), opening net cover (blue), Kevlar flap (black), location of the cameras (green) as well as the mesh sizes for the different panels of the net.

4.3 Observer and Logbook data

Concurrent with this study, baseline data on the catches of protected species were being recorded by skippers on logbooks. In addition, an industry funded observer was identifying and recording the quantity of bycatch, the lengths and sex of sharks, dolphins, turtles and rays. The logbook and observer data was transferred to an "Access" database for subsequent analysis.

4.3.1 Differences in dolphin catch between areas, vessels and grids deployment

The dolphin captures were analysed using a chi-square test to determine if there were differences in the dolphin catch rates between vessels, management areas, observer data and logbook data, and deployment or non deployment of the selection grid.

In addition, the logbook data was analysed to determine if the dolphin catches were related to the duration of the trawl shot. Data from 2005 only was used, as reporting of dolphin catches was considered more reliable than in the previous years. Data was used for the four vessels that worked consistently in 2005 and those shots where the grid was deployed were omitted from the analysis. Univariate ANOVAs were carried out on the duration of the trawl shot, with a type III sum of squares used because the data was unbalanced (i.e. the number of shots differed between vessels and for shots with and without dolphin catch). The predictor variables were dolphin catch (1 for shots with dolphin catch and 0 for shots with no dolphin catch), management area (1,2,4 and 5), and vessel (A,B,C, and D).

4.3.2 Differences in the size distribution of sharks and rays with a selection grid deployed and not deployed

The lengths of all sharks and rays were recorded during the observer programme and during the grid trials. The proportion of sharks and rays in each size class was determined with the grid deployed and not deployed in order to determine the length selectivity of the selection grid. The catches with the grid deployed and not deployed was also determined.

4.3.3 Differences in the scalefish catch with the selection grid deployed and not deployed

One vessel consistently deployed the semi-rigid selection grid between February and August 2005. The logbook data was analysed to test for differences in catch per unit effort (CPUE) of scalefish when the grid was deployed and not deployed. Univariate ANOVAs were carried out on the CPUE (kg per trawl hour) of small fish (blue spot emperor (*Lethrinus* sp.), flag fish (*Lutjanus vitta*), threadfin bream (*Pentapodus emeryii*) and frypan snapper (*Argyrops spinifer*)), large fish (red emperor (*Lutjanus sebae*), Rankin cod (*Epinephelus multinotatus*), scarlet perch (*Lutjanus malabaricus*), spangled emperor (*Lethrinus nebulosus*), red snapper (*Lutjanus erythropterus*) and goldband snapper (*Pristipomoides multidens*)) and total catch (all species). A type III sum of squares was used because the data was unbalanced (i.e. the number of shots differed between management areas and with or without the grid deployed). The CPUE for each shot was weighted by the number of trawl hours in each shot. The predictor variables were grid (1 for grid deployed, 0 for grid not deployed) and management area (1,2,4 and 5) due to the differences in abundance of small and large fish between management areas.

5.0 Results

5.1 Acoustic pingers

A DCR on the headrope recorded dolphins entering the net for 11 shots when "Savewave" acoustic pingers were deployed and for 7 shots with no pingers deployed. The number of sightings of a dolphin on the video footage was recorded for 14 of these 18 videos; the results are shown in Table 1. No attempt was made to account for multiple sightings of the same animal. On shot 3 and 5 the video image was too dark and unusable. On shot 31 and 36 the camera housing was hooked on the net and misaligned resulting in no usable footage.

Table 1. The number of dolphins sighted on the video recording of each of 18 shots with eight or zero "Savewave" pingers deployed.

Date	Shot No	Number of Pingers	Dolphin count
2/03/2005	3	8	unavailable
2/03/2005	4	0	31
2/03/2005	5	8	unavailable
3/03/2005	10	0	35
3/03/2005	11	8	48
3/03/2005	12	0	177
4/03/2005	16	8	9
4/03/2005	17	0	63
4/03/2005	18	8	53
5/03/2005	23	0	93
5/03/2005	24	8	20
5/03/2005	25	8	17
6/03/2005	29	8	11
6/03/2005	30	0	168
6/03/2005	31	8	unavailable
7/03/2005	35	0	17
7/03/2005	36	8	unavailable
8/03/2005	42	8	43

The mean number of dolphins recorded with the pingers deployed and not deployed (excluding shots 3, 5, 31, and 36) was 29 and 80 respectively with no significant difference between the means of the Poisson distributions for the two treatments ($t = 1.70$, $p = 0.12$).

5.2 Flexible grid

During the first trial of the flexible grid, consisting of three shots, the catch for each shot was less than 1 kilogram. Measurements of the distance between the warp wires determined that the distance between the trawl doors (Figure 12) was 82 m compared to 68 m with no grid deployed indicating there was reduced net drag. There was no video footage for these three shots so there was no visual information on how the net was operating.

During the second trial, consisting of two shots, video footage showed the grid pushed up to the top of the net, resulting in a gaping hole at the escape opening (Figure 15). The pressure of water inside the net was causing the water to rush out of the escape opening taking the catch with it. This is consistent with the reduced net drag and increased spread of the doors observed in the first three shots. The scalefish catches from these shots were so low, it was concluded that this grid would not work in its present form and its use was discontinued.

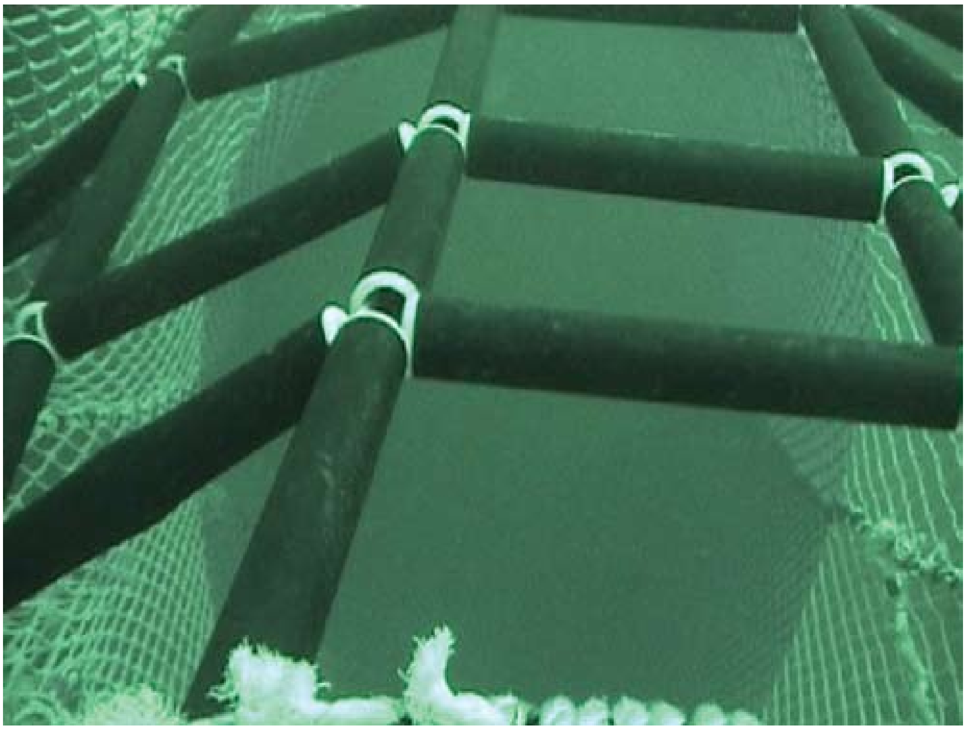

Figure 15. Flexible grid from Shetland, Scotland, with the camera downstream of the grid facing upstream towards the month of the net. The bottom of the grid, bound in rope, is elevated as the water flow is out the escape opening rather than through the grid.

5.3 Semi-rigid grid

The semi rigid grid was first trialed with 5 one-hour shots on January 16, 2005. The catch of scalefish appeared satisfactory and the video footage indicated the grid did not appear to be interfering with the water flow through the net. The kevlar/rubber mat was pushed up against the grid preventing the scale fish exiting through the escape opening (Figure 16) but also reducing the water flow through the grid. Consequently, the Kevlar mat was adjusted to be further downstream. On subsequent days on this trip, the skipper reverted to the normal fishing pattern of 2.5-hour shots with the grid and camera deployed during daylight hours. As the video camera had a recording time of 1.5 hours, footage was available only for the first half of each shot.

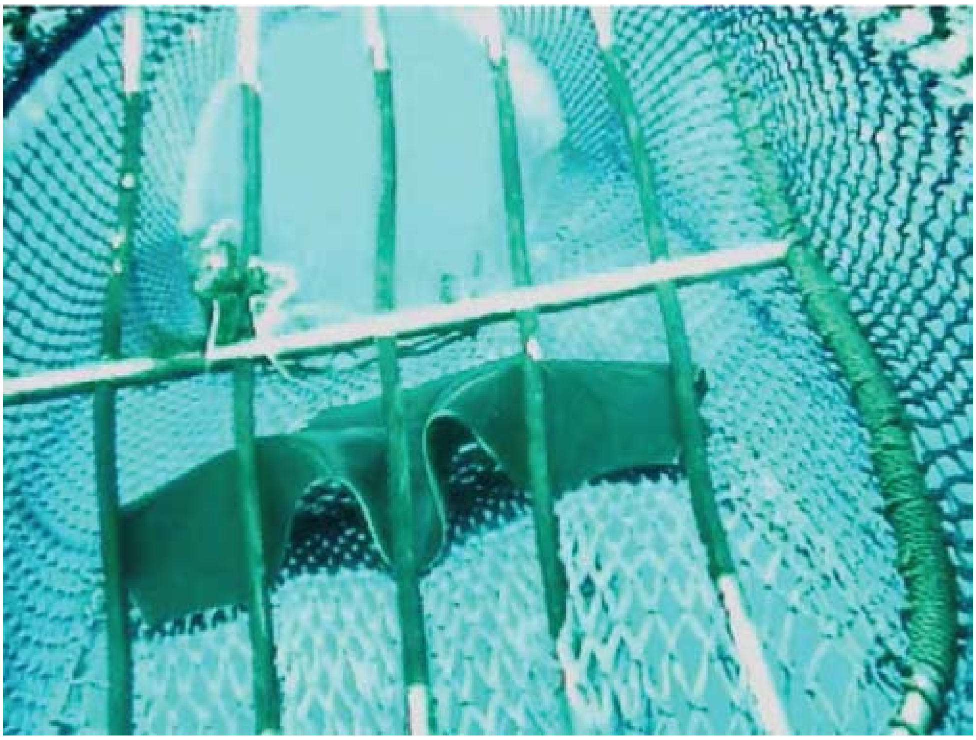

Figure 16. Semi-flexible event manufactured in Fremantle by Australia Bay Seafoods.

The camera footage was edited to include footage of scalefish interacting with the grid as well as footage of turtles, sharks, rays, dolphins, and sea snakes. The footage showed dolphins backing down to a position about 3 m from the grid and then swimming upstream out of the net. No dolphins were ever seen swimming head first towards the grid. The footage showed large sharks including leopard sharks and one sandbar shark, and large rays passing out through the escape opening. In addition several large sponges went out of the net through the escape opening. During the trials on this trip, there was one dolphin fatality. When the net was retrieved, the dolphin was briefly seen to fall out of the escape opening. It is unknown if this dolphin entered the net mouth and passed through the escape opening or was attempting to enter the net via the escape opening.

With the camera upstream of the grid, facing upstream, dolphins were seen backing down towards the grid and then swimming towards the net opening. When the camera was positioned downstream of the grid facing towards the grid, there was only one dolphin sighting. On this occasion, a dolphin was seen upstream of grid, facing upstream.

The scalefish were seen to take up position just downstream of the grid (on the cod-end side) and had sufficient swimming speed for them to keep pace with the grid. Stronger swimmers like cobia, trevally, and small sharks after passing through the grid were able to swim from the codend, upstream through the grid. This behavior is consistent with the water speed at the grid being about 1 knot less than the speed of the net through the water (Northridge pers. comm. 16th December 2004). On the video footage, no scalefish were seen exiting through the escape opening. On one occasion, as the retrieved net cleared the water, scalefish were seen congregated at the grid, and these fish fell out through the escape opening as the net was lifted from the water.

Skippers reported other instances of loss of scalefish when the net was retrieved. On the grid trial trip conducted between the 6th June and the 16th of June 2005, alterations were made to reduce the loss of scalefish. This included setting the kevlar flap further back and increasing the length of the cover on the escape opening.

The video footage from 112 tapes was edited and compiled into CDs and DVDs (Table 2). A summary of the content of the 1.5 hour video stream titled "Stephenson (2005) Pilbara Trawl Fishery Bycatch Mitigation" is shown in Table 3.

Table 2. The length, titles and format of the CDs and DVDs produced in this project.

Video Length (minutes)	Title	Format	Disc Type
80	Stephenson (2005). PTF Bycatch Mitigation, Trials with Acoustic Pingers	PAL	DVD
8	Stephenson (2005) Exclusion grids in the Pilbara Trawl Fishery. 8 min version	PAL mpeg2	DVD/ CD
2	Stephenson (2005) Exclusion grids in the Pilbara Trawl Fishery. 2 min version	PAL mpeg2	DVD/ CD
80	Stephenson (2005) Pilbara Trawl Fishery Bycatch Mitigation. 80 min version	PAL	DVD
10	Stephenson (2005) Pilbara Trawl Fishery Bycatch Mitigation. 10 min version	PAL	DVD

Table 3. Content of the video stream of each shot for the trips between June 6th and June 16th 2005 (Stephenson (2005) Pilbara Trawl Fishery Bycatch Mitigation. 80 min version).

Date	Trip	Shot	Images Captured	Camera position in relation to grid	Camera facing
6/05/2005	45	4	Dolphins backing down to grid. shark swimming	Upstream	Vessel
7/05/2005	45	13	Small shark swimming, ends up behind camera	Upstream	Vessel
8/05/2005	45	19	2 sea snakes and small ray fall behind camera, dolphin backing down to grid	Downstream	Vessel
8/05/2005	45	20	Small shark	Upstream	Cod end
8/05/2005	45	21	Dolphin backs down behind camera towards grid, can be seen catching fish. Dolphins also seen outside net	Upstream	Vessel
9/05/2005	45	27	3 sea snakes, ray and small shark fall behind camera, dolphins in the mouth of net.	Upstream	Vessel
9/05/2005	45	29	Sea snake falls behind camera	Upstream	Vessel
13/05/2005	46	7	Sea snakes falls behind grid, 2 dolphins visible in mouth of net.	Upstream	Vessel
14/05/2005	46	14	Turtle, ray and small shark fall behind camera	Upstream	Vessel
14/05/2005	46	15	Small shark, sea snake and small ray fall behind camera. Dolphin backs into net, always in front of camera.	Upstream	Vessel
16/05/2005	46	33	Dolphin backs down towards grid, always in front of the camera.	Upstream	Vessel
16/05/2005	46	34	Dolphins in mouth of net.	Upstream	Vessel
16/05/2005	46	35	Ray, leopard shark and sea snake fall behind camera. Dolphin always in front of camera.	Upstream	Vessel
16/05/2005	46	36	Fiddler ray and sea snake fall behind camera, 2 dolphins back down towards grid, always in front camera.	Upstream	Vessel
16/05/2005	46	37	Dolphins in mouth of net.	Upstream	Vessel

5.4 Log book and Observer Data

5.4.1 Differences in dolphin catches by vessel and time period

Data from logbooks and the observer program between January 1, 2004 to June 30, 2005 was analysed. The data was pooled by 5 vessels, 3 six-monthly periods, and 4 management areas. The six-monthly semesters in 2004 and the first semester in 2005 were Semester 1 (first half of 2004), Semester 2 (second half of 2004), and Semester 3 (first half of 2005).

The number of shots with dolphin catches was different between semesters (df = 2, $\alpha = 0.1$, $\aleph^2 = 5.58$, p = 0.061), with the catch being 3.8, 5.8, and 10.8 per 1000 shots for the three periods, Semester 1, Semester 2, and Semester 3 respectively.

The number of shots with dolphin catches was different between vessels (df = 4,$\alpha = 0.1$, $\aleph^2 = 16.2$, p = 0.001). One vessel reported no catches over the 3 semesters. Of the remaining 4 vessels, the reported catch rate generally increased over time from, January 2004 to December 2005 for all vessels. The reporting is considered to be more accurate in Semester 3 and for this period the reported catch rates varied between vessels from 6.1 to 19.6 dolphins per 1000 shots with the mean catch rate for all 5 vessels being 10.8 per 1000 shots.

5.4.2 Differences in dolphin catches between trawl shot duration

The catch rate in the first six months of 2005, when reporting is considered more reliable, varied between 2.6 and 6.6 dolphins per 1000 hours with an average of 4.0 per 1000 hours for the 5 vessels.

5.4.3 Relationship between dolphin catches and trawl times

There was no difference between the duration of trawl shots between management areas (p = 0.0012). The ANOVA (Table 4) showed there was a significant difference in the duration of trawl shot between vessels, (p = 0.993) and between shot duration with and without dolphin catches (p = 0.102), but the interaction was not significant (Table 4, Figure 17).

Table 4. Results of ANOVA for shot trawl time for main factors vessel and dolphin capture for trawl shots on three vessels in 2004–2005.

	SS	df	MS	F	p
Intercept	658.11	1	658.11	1000.8	0.0000
Vessel	8.829	2	4.415	6.71	0.0012
Dolphin	1.753	1	1.753	2.67	0.1024
Vessel*Dolphin	0.0092	2	0.0046	0.007	0.9930
Error	952.17	1448	0.6576		

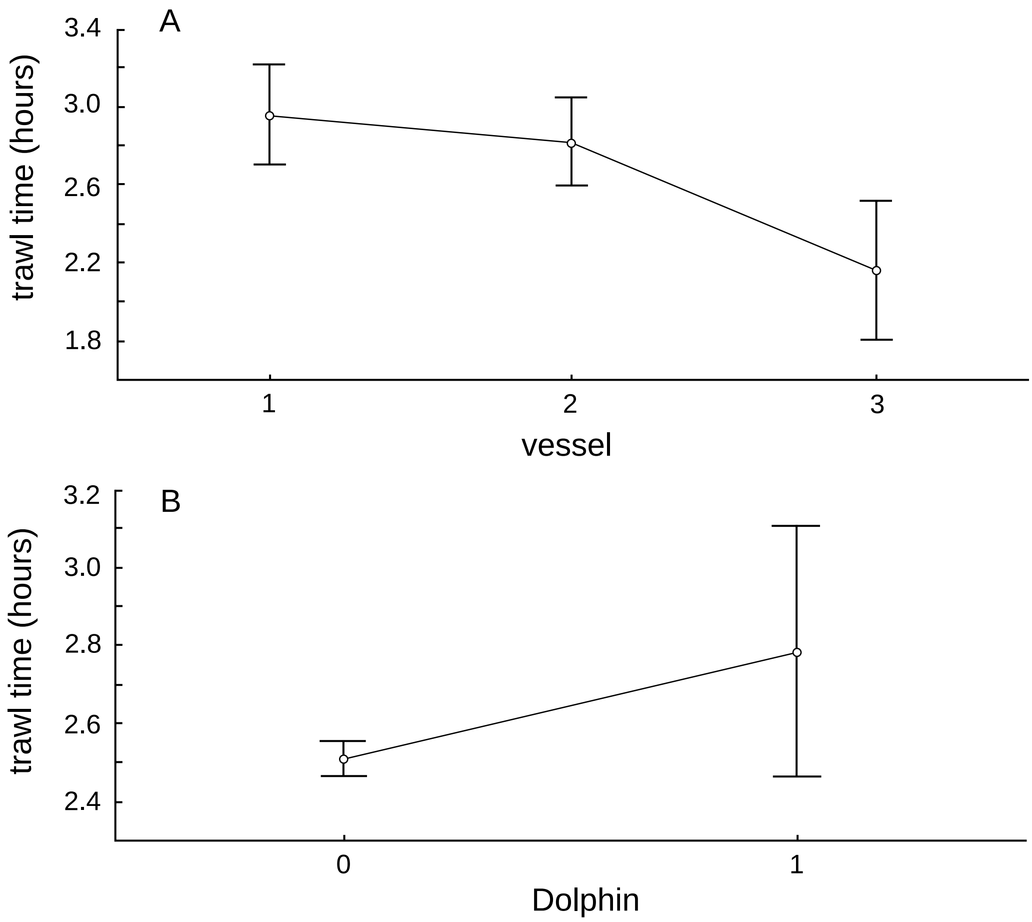

Figure 17. A: average trawl duration between vessel 1, 2 and 3 (with 95% confidence intervals). B: average trawl duration for shots with (1) and without (0) dolphin catches (and 95% confidence intervals).

5.4.4 Observer recorded dolphin catches

The number of shots with and without dolphin catch when observers were on board was compared to the number of shots with and without dolphins recorded in skipper's logbooks when no observer was on board. Considering only the three vessels which had observer coverage (one vessel in Semester 1, two vessels in Semester 2, and three vessels in Semester 3), there was a significant difference between the reported catch with and without observers on board vessels (df = 2, $\alpha = 0.1$, $\aleph^2 = 5.84$, p = 0.05). The catch rate reported by observers over the three semester time period was more than twice that reported on skippers logbooks when observers were absent (13.3 and 5.6 dolphins/1000 shots respectively). Over time, the discrepancy between the observer reported catch rate and the skipper's logbook catch rate decreased (Table 5). In Semester 3, the reported rate was not significantly different between observer data and skippers logbook data ($\aleph^2 = 5.84$, p = 0.016). The number of shots recorded in each semester and management area is shown in Table 6 with the total number of trawl shots in 2004 being 5584 and in 2005 the total number of shots all year being 5473.

Table 5. Dolphin catch rate (number/1000 shots) during non-observer and observer trips by boat, semester, and management area.

	Semester 1 Jan-June 2004	Semester 2 July-Dec 2004	Semester 3 Jan-June 2005	2004 and 2005
No observer	6.9	3.2	8.9	5.6
Observer	18.5	12.6	13.3	13.3

There was no significant difference in the number of shots between areas with and without dolphin catches (df = 3, $\alpha = 0.1$, $\aleph^2 = 3.6$, p = 0.31) (Table 6). A higher catch in Area 1 was due to the greater number of shots in this area (Figure 18).

Table 6. Number of shots recorded during non-observer and observer trips by semester and management area. The number of shots in 2004 was 5584 and in the whole of 2005 was 5473.

		Management area				
		1	2	4	5	all
Semester 1	Observer	2	11	6	28	47
	Logbook	1101	457	509	528	2595
Semester 2	Observer	76	42	36	24	178
	Logbook	1118	557	532	557	2764
Semester 3	Observer	288	73	42	62	465
	Logbook	1007	380	323	545	2255
2004 and 2005	Observer	366	126	84	114	690
	Logbook	3226	1394	1364	1630	7416

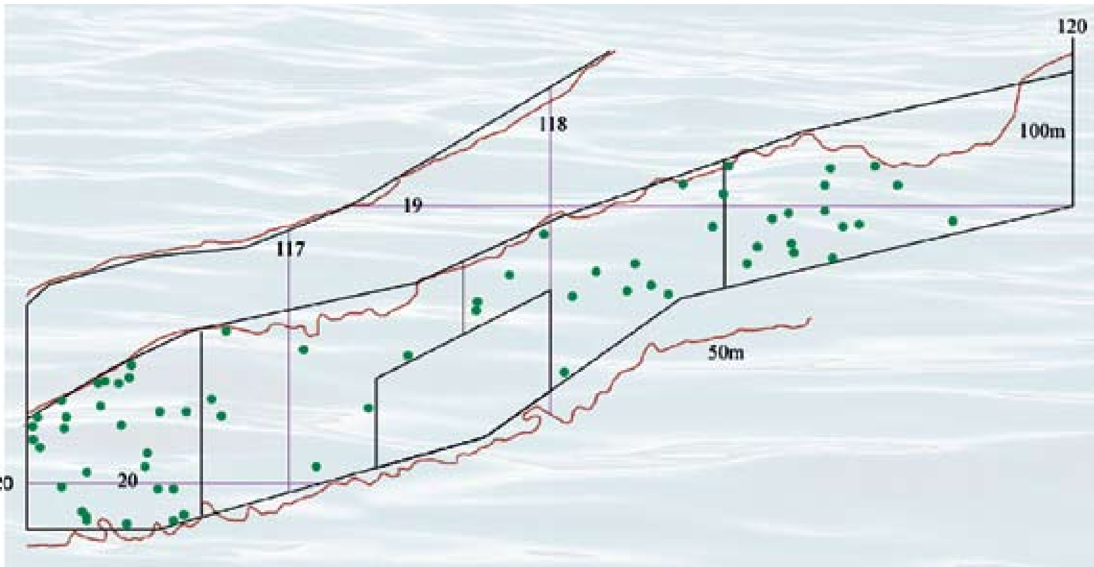

Figure 18. Spatial distribution of dolphin catches reported in skipper's logbooks between January 1 2004 and June 30 2005.

The dolphins were generally caught between daylight hours, with 92% of the dolphins caught between 7am and 8pm (Figure 19). This temporal pattern of dolphin catch was not related to the time of winch up as fishing and winch up occurred over the whole 24 hour period.

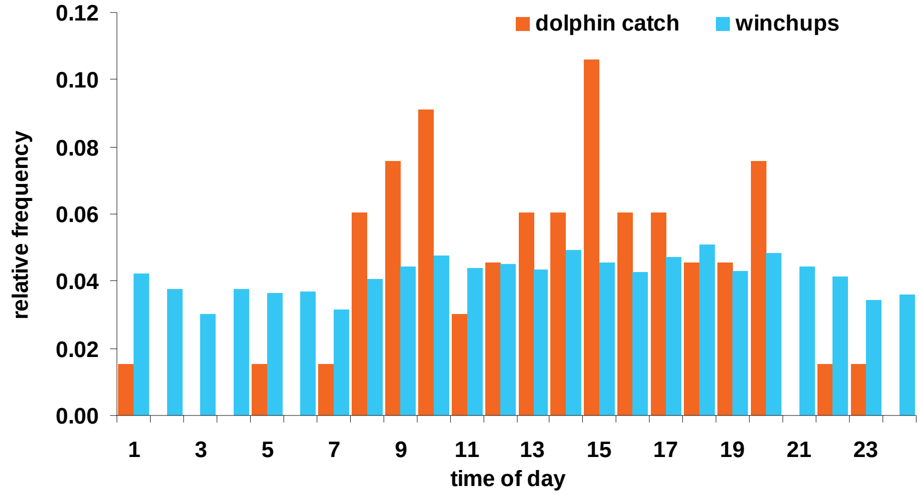

Figure 19. The relative frequency of dolphins caught in each time period between January 1, 2004 and June 30, 2005 (n = 69) by time of day (orange) and the proportion of winch-ups by time-of-day (blue) (n = 8462).

With the depth of dolphin capture divided into 10 m depth categories, there was no significant difference between the number of shots with and without dolphin catch for the six depth areas (Table 7) (df = 4, $\alpha = 0.1$, $\aleph^2 = 5.04$, p = 0.41). The higher catch in some depths is related to the effort expended.

Table 7. Number of shots in each depth zone with and without dolphin catches between January 1 2004 and June 30 2005.

depth	50	60	70	80	90	100	total
dolphins	5	13	18	16	12	2	66
no dolphins	686	2461	1879	1588	1287	495	8396
total	691	2474	1897	1604	1299	497	8462
relative % catch per shot	0.72	0.53	0.95	1.00	0.92	0.40	0.78

5.4.5 Selection grids

On the first trip of the grid trials in January 2005, one dead dolphin was observed to roll out of the escape opening when the net cleared the water on winch up. On the second vessel to trial the grid, no dolphin fatalities were reported between January and July 2005. On a third vessel, two dolphin fatalities occurred during the first trip of grid trials but video footage of the net/grid combination, showed the net to be not fishing properly. There was no significant difference between the number of shots with and without dolphin catches (df = 1, $\alpha = 0.1$, $\aleph^2 = 0.02$, p = 0.89).

Table 8. The number of shots with the grid deployed and not deployed, together with the dolphin catch.

	no grid	grid	total
Dolphins	29	3	32
No dolphins	2587	292	2879
Total	2616	295	2911

5.4.6 Bycatch of sharks and rays: January 1 2005 to June 30 2005

When the selection grid, with bar spacing of 15.5 cm, was deployed, rays selectively escaped (Figure 20 A). No rays of width greater than 90 cm passed through the grid into the cod-end. The proportion of rays captured is shown in Figure 20 B. The fitted logistic function indicated that 90% of the rays with width over 80.1 cm are excluded by the grid, and 95% of the rays over 90.2 cm are excluded by the grid. The number of "large rays" caught, with the grid not deployed was 273 in 558 shots (472 per 1000 shots) compared to 2 in 69 shots (29 per 1000 shots) with the grid deployed. There was no reduction in the catch of "small rays" when the grid was deployed.

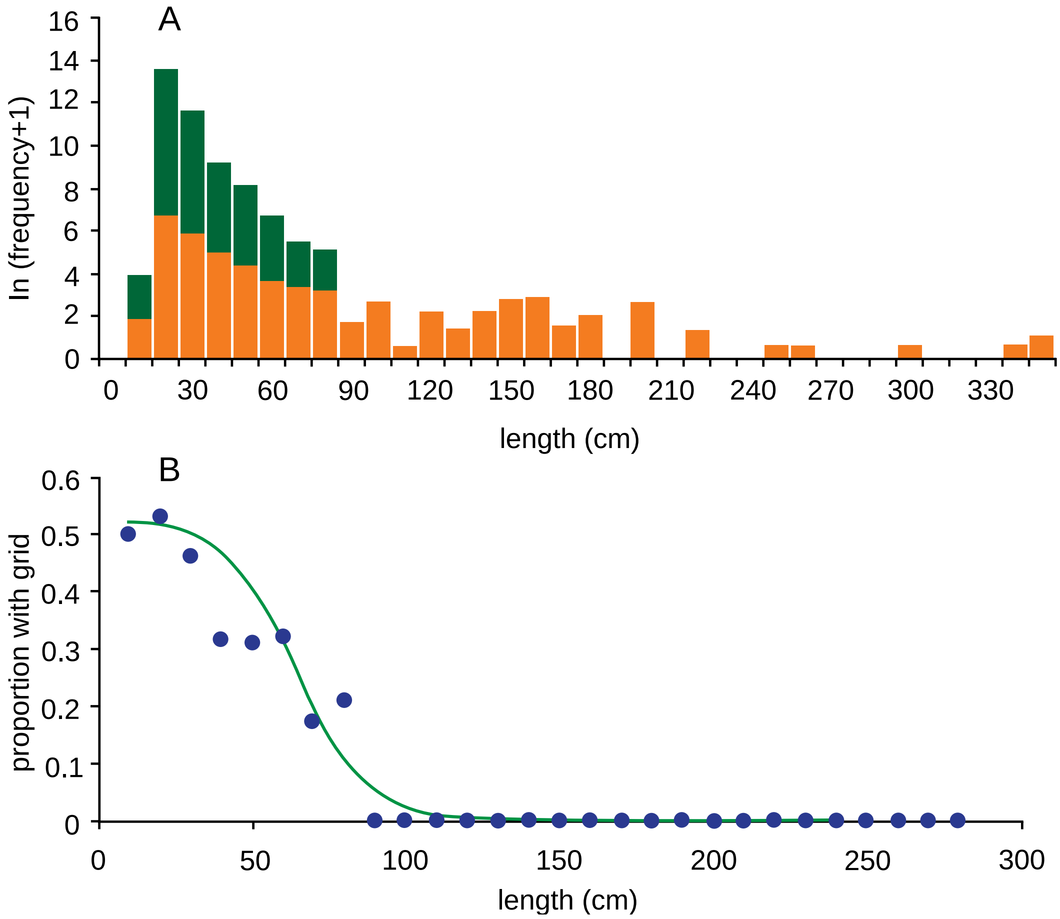

Figure 20. A: natural logarithm of the frequency of capture of rays for each width class, with and without the selection grid deployed. B: proportion of rays captured in each width class, with the selection grid deployed, together with a fitted logistic function.

The grid selectively removed sharks from the catch (Figure 21 A). No sharks of length greater than 150 cm passed through the grid into the cod-end. The proportion of sharks captured when the grid was deployed is shown in Figure 21 B. The fitted logistic function indicated that 90% of the sharks with a length over 152 mm are excluded by the grid, and 95% of the sharks over 165 mm are excluded by the grid. The number animals caught in the category large sharks, with the grid not deployed was 139 in 558 shots (472 per 1000 shots) compared to 5 in 69 shots (72 per 1000 shots) with the grid deployed. There was no reduction in the catch of small sharks when the grid was deployed.

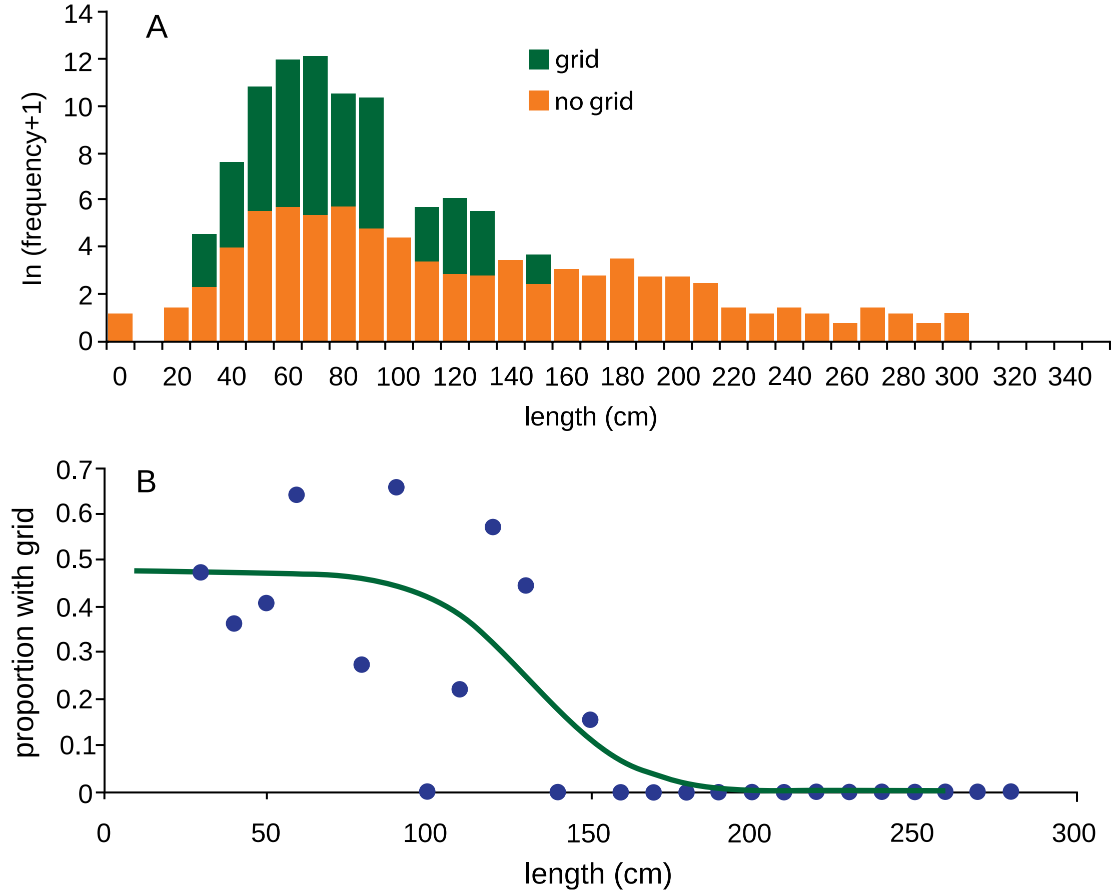

Figure 21. **A:** natural logarithm of the frequency of capture of sharks for each width class, with and without the selection grid deployed. **B:** proportion of sharks captured in each width class, with the selection grid deployed, together with a fitted logistic function.

Of special interest is the catch of sandbar sharks, which are over-exploited in the Pilbara. With the grid deployed, the sandbar shark catch was reduced to zero in most age classes (Figure 22). The number sandbar sharks caught with the grid not deployed was 55 in 558 shots (99 per 1000 shots) compared to 1 in 69 shots (14 per 1000 shots) with the grid deployed.

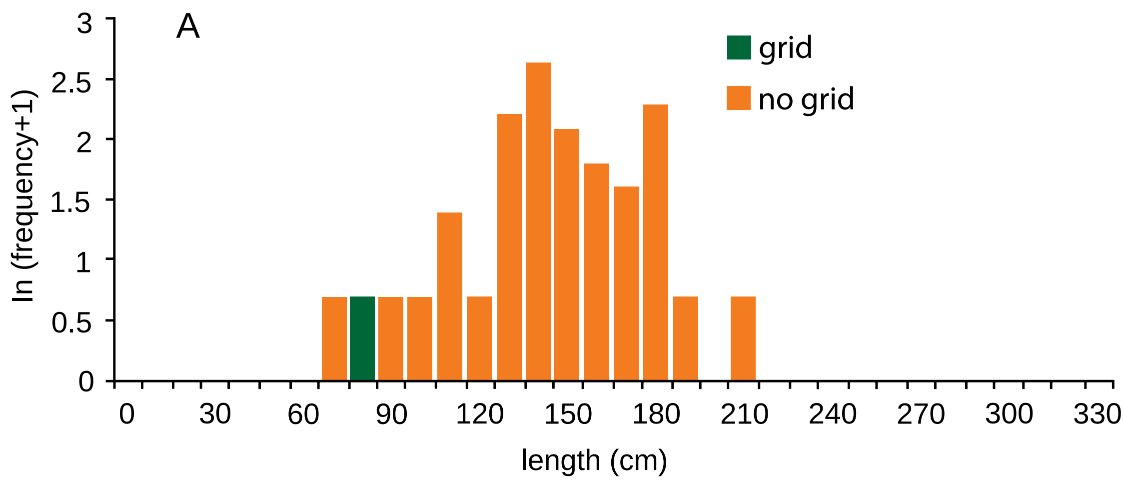

Figure 22. Catch of sandbar sharks with and without the selection grid deployed.

5.4.7 *Scalefish catches with selection grids and management areas*

Factorial ANOVA was used on the CPUE (kg per trawl hour) of small fish (blue spot emperor, flag fish, threadfin bream and frypan snapper), large fish (red emperor, Rankin cod, saddletailed snapper, spangled emperor, red snapper, and goldband snapper) and total catch (all species). The analysis found no interactions between management areas and grids (p = 0.13, 0.24 and 0.63, for small fish, large fish and total catch respectively), so the analyses were repeated using main effects ANOVA. For all three analyses (small fish, large fish and total catch) the CPUE differed significantly (Table 9, 10 & 11 and Figure 23) between management areas (p-values of 0.00, 0.00 and 0.00, respectively). The catch rates did not differ between shots with grids deployed and when grids were not deployed (p-values of 0.49, 0.69 and 0.14, for the three fish size categories).

Table 9. Results of ANOVA of CPUE (kg/hour) of small fish (blue spot emperor, flag fish, threadfin bream and frypan snapper).

Small Fish

	SS	df	MS	F	p
Intercept	1719128	1	1719128	623.41	0.0000
Management area	258843	3	86281	31.29	0.0000
grid	1314	1	1314	0.476	0.4901
Error	6929849	2513	2758		

Table 10. Results of ANOVA of CPUE (kg/hour) large fish (red emperor, Rankin cod, saddletailed snapper, spangled emperor, red snapper and goldband snapper).

Large Fish

	SS	df	MS	F	p
Intercept	3607645	1	3607645	193.14	0.0000
management area	472093	3	157364	8.424	0.00001
grid	3023	1	3023	0.1618	0.6875
Error	46940097	2513	18679		

Table 11. Results of ANOVA of CPUE (kg/hour) of all scalefish.

Total Catch

	SS	df	MS	F	p
Intercept	55995340	1	55995340	214.3809	0.000000
Management area	4992975	3	1664325	6.3719	0.000267
grid	566709	1	566709	2.1697	0.140881
Error	656384522	2513	261196		

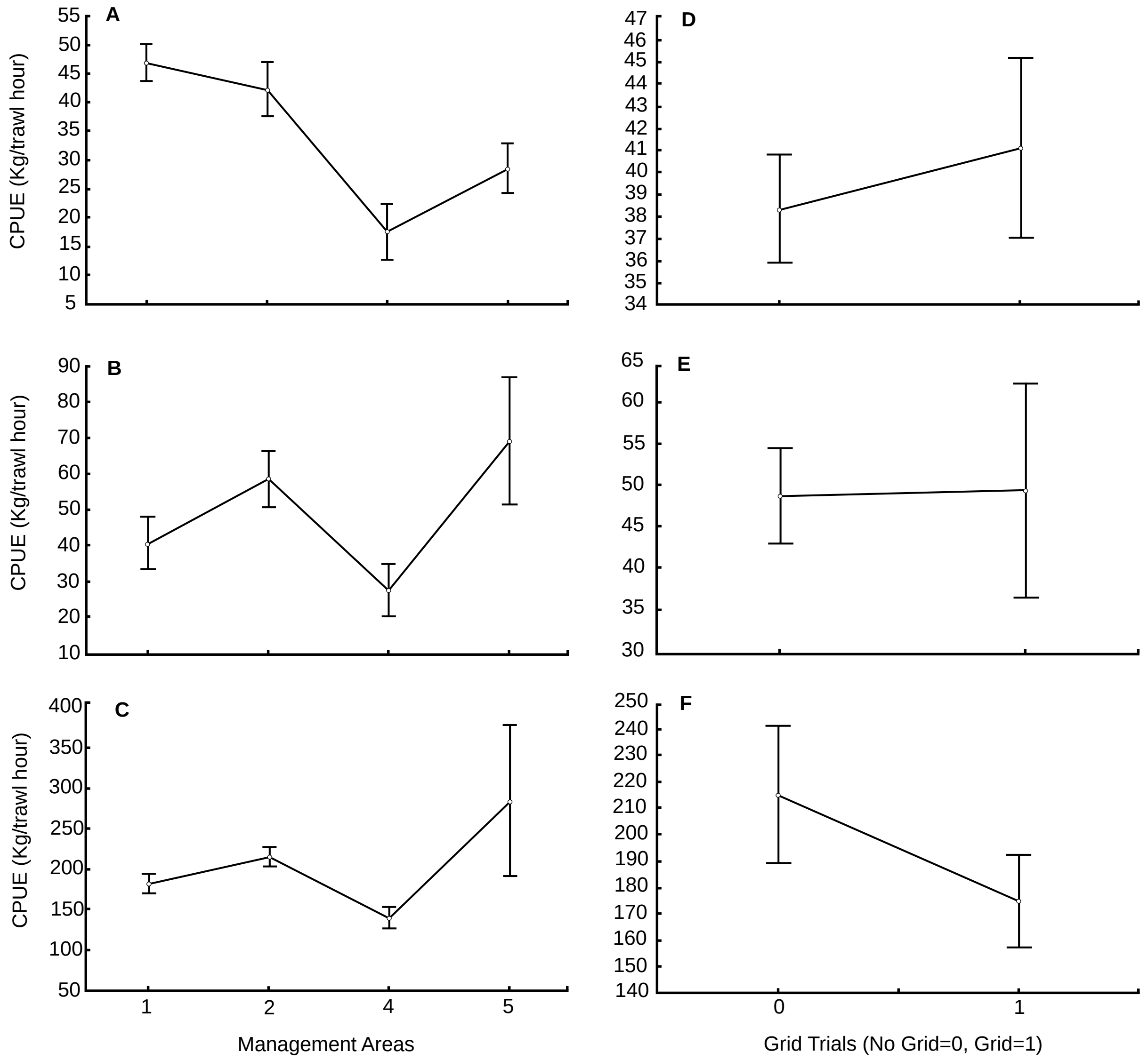

Figure 23. Weighted Mean CPUE by management area for small fish (Panel A), large fish (Panel B) and all scalefish (Panel C); weighted mean CPUE by grid deployment for small fish (Panel D), large fish (Panel E) and all scalefish (Panel F).

6.0 Discussion

The results of the selection grid trials indicated that there are limited options in reducing the dolphin catch. The lack of a spatial pattern in the catch (no significant difference in dolphin catch by management area or water depth) indicate that area closures will probably be ineffective in reducing dolphin catches.

There is a strong 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.

There is a significant difference in dolphin catches between vessels, with two vessels, in this study, consistently having a catch rate twice that of two other vessels. There is considerable potential for reducing the dolphin catch by standardizing fishing gear and method of winch up. The two vessels with the higher catch rate used a grey net material compared to the standard green net used by the rest of the fleet. In addition there are differences in operation of the hydraulics that can alter the speed of the net through the water during winch up. During future observer programs, these vessel differences should be documented so that fishing methods with the lowest dolphin catch rates can be adopted as standards in the fishery.

In the present study there was no indication that “Savewave” acoustic pingers reduced the number of dolphins inside the trawl net. This is consistent with the results of trials in the UK sea bass fishery where Dukane NetMark and AQUAmark 200 pingers both failed to reduce the catch rate of common dolphins (Northridge 2003, 2004). Despite the negative results, the use of acoustic pingers has not been abandoned in trawl fisheries with France currently trialing pingers in the Irish Sea trawl fishery with results expected in mid 2006 (Northridge 2004).

The flexible selection grid, manufactured in Scotland, and trialed in this study, was unsuccessful as it resulted in greatly reduced catches of scalefish. A flexible grid from the same manufacturer, when trialed in the UK sea bass fishery was perceived by the vessel crew to reduce fish catches as it altered the operation of the net. The crew in UK stiffened the grid it but was later abandoned because it was found that a rigid grid constructed from metal tubing was much more successful in reducing dolphin catches (Northridge 2004).

The semi-rigid grid, manufactured in Fremantle, and used in this study appears to be successful in reducing bottlenose dolphin catches in the Pilbara Trawl Fishery. The behavior of the dolphins, that is, backing towards the grid, appears to indicate that this selection grid is readily detected by the dolphins. The pressure wave assumed to be 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 grid trials 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 dolphin behavior, where they consistently back 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, pers. comm. June 2005). Reducing the bar spacing, to less than the present 155 mm may reduce the likelihood of this occurring but would affect the catches of large scalefish.

From January 1, 2004 to June 30, 2005, there was an increase in the reported dolphin catch rate by all vessels in this study. The dolphin catch reported on skipper's logbooks in 2004 was 36. There was scant observer coverage in 2004 (1% and 4% of the days at sea had observer coverage in the first and second halves of the year) but the catch rate reported by observers was more than twice this. In the first half of 2005, there was 9% observer coverage of the trawl fleet and there was no significant difference between the observer and skippers logbook dolphin catch rates, with the annual catch in 2005 expected to be approximately 60. In 2004 and 2005 there was little change in fishing practices and the greater reported dolphin catch in 2005 was likely to be due to improved reporting.

On the one vessel that used the grid consistently between February and July 2005, the reported dolphin catch with the grid deployed was zero, compared to seven captures with no grid deployed. This reduction in catch rates is encouraging but it is not known if some dolphins exited through the escape opening nor is their likely fate on exit known. In the UK sea bass fishery, no dolphins have been observed to escape through the escape opening (Northridge 2003). This observation in the UK, together with the behavior of the dolphins in the Pilbara, gives indications that selection grids could be effective in reducing dolphin catches. Further investigation of the operation of the grid should include video camera footage to ensure that dolphins are not dying and then being expelled through the grid escape opening.

On the vessel which used the grid extensively in the first half of 2005, the turtle catch was one with the grid deployed compared with six when the grid was not deployed.

There appeared to be little reduction in scalefish catches when the grid is deployed. However there were a few instances where the fish were just upstream of the grid when the net was lifted from the water and these scalefish fell through the grid and out of the escape opening. In another incident, the grid appeared to be blocked with triggerfish and edible scalefish were lost as the net was lifted from the water.

A second Pilbara vessel conducted grid trials in September 2005. There were continuous problems with loss of catch and the video footage showed the net to be narrowed upstream of the grid and loose and waving around downstream of the grid. The crew reported greatly reduced scalefish catch and two dolphins were caught with the grid deployed. One dolphin caught was an adult female with net abrasions on the body and especially on the snout. The second capture was a juvenile with abrasions around the tail suggesting that the tail fluke was caught in the grid. This indicates that there is likely to be a period of variable scalefish catches and possibly dolphin catches when grids are first used on a vessel.

Although the selection grids were aimed primarily at reducing dolphin and turtle catches, the reduction in the catch of large sharks and rays is an important secondary benefit. With grids deployed, the catch of rays and sharks was greatly reduced and the catch of sandbar sharks was reduced to almost zero.

During 2005 there were three dolphin captures when the grid was deployed. There is a need to extend the grid trials with a sufficient number of shots so that the power of the experiment is sufficient to draw conclusions about the effectiveness of selection grids in reducing the dolphin catch.

7.0 Benefits and adoption

This project indicated that the sem-flexable grid was practical to use and appeared to deter dolphins venturing too far into the trawl net. After some adjustments to the grid, the skippers and crew agreed there were benefits of no having to deal with large sharks, rays, and large sponges on the deck and there appeared to be no catch reduction. There was also the benefit of a reduction of damage to the catch from large objects in the codend. Skippers and crew on two vessels were keen adopt the selection grid of their own accord because of these benefits.

8.0 Further Development

Following this research, skippers were instructed in the use of the underwater cameras and housings and this enabled them to improve the operation of the grid by adjusting its angle and position in the net, and to improve the design of the escape opening.

9.0 Planned outcomes

Video footage of the behaviour of dolphins in the trawl net, and the performance of the selection grid was sent to skippers. This, together with further footage collected by skippers after the completion of this project, enabled them to improve operation of their fishing gear with grids deployed. The video footage was also sent to Yvon Morizur the Director of the Sciences and Technologies Department of IFEMER in France and to Simon Northridge of St Andrews University, both of whom are working on dolphin catch mitigation in the sea bass fishery. This video footage from this FRDC project has been used at meetings with fishers and managers to assist in their efforts to reduce dolphin bycatch.

10.0 Conclusion

"Savewave" Acoustic pingers appear to be ineffective in keeping dolphins out of the trawl net in the Pilbara Trawl Fishery.

The flexible grid constructed from polypropylene pipe appears to be impractical, as the net and grid combination did not fish properly, with scalefish catch close to zero.

The semi-flexible grid appeared to be effective in reducing the dolphin catch as on the vessel that used the grid for five months in 2005, the dolphin catch reported by the skipper was zero when the grid was deployed, but this was not confirmed by observers. On another vessel which trialed the grid for one trip, with observers on board, three dolphins were caught. The video footage showed that the net was not operating properly and this dolphin catch does not negate the proposition that the exclusion grid may reduce dolphin catches.

There is a need for an extension to this project in the form of a designed experiment with the appropriate power to determine if selection grids are effective in reducing dolphin catches.

The design of an experiment to test if grids reduce the dolphin catch is shown in Appendix 1. In October 2005, funding from Department of Fisheries was approved to perform this experiment. This experiment is expected to start in early January 2006 and last for approximately 7 months.

In addition, it is suggested that the observer program should continue to quantify the bycatch, especially protected species. Sharks and rays should be measured to evaluate the impact of selection grids on these animals and biological information should be collected for any dolphins captured.

11.0 Intellectual Property

No intellectual property was generated in this project.

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13.0 Appendices

Appendix 1: Design of experiment to test the proposition that grids reduce dolphin catches

Ho: the hypothesis that the proportion of shots with dolphin deaths is the same with and without grids.

Ha: the alternative hypothesis that the proportion of shots with dolphin deaths is reduced with the grid deployed.

The probability that Ha is accepted when it is false is called a type II error. The power of the design is 1 minus the probability of a type II error.

The power of the experimental design will increase with the number of trawl shots observed and also with the degree to which the selection grid reduces the dolphin catch. On the basis that the probability of a dolphin capture on a trawl shot is 0.01 (that recorded on logbooks in 2005) and the desired power of the test is 0.8, then the observed catch reduction required for the rejection of Ho is shown in Table 12.

Table 12. For the number of observed shots, N, the expected number of dolphin captures is μ (assuming a probability of capture of 0.01). With a power of 0.8, x is the maximum dolphin catch for rejection of the hypothesis that the grid does not reduce the dolphin catch.

N	μ	x
300	3	1
400	4	2
500	5	2
600	6	3
700	7	4
800	8	5
900	9	5

The trials to test the hypothesis would involve observations for 160 days to produce bycatch data for 800 trawl shots, 400 with the grid deployed and 400 with the grid not deployed. It is anticipated that 6 trawl shots a day would need to be conducted in daylight hours and video footage obtained for most of these shots in order to determine the circumstances when dolphins died.