Pinger research

Where pingers have been successful in fisheries applications.

Introduction

This assessment considers the development of acoustic methods to reduce bycatch of dolphins in northern Australian gillnet fisheries. Bycatch mitigation of dugongs is also discussed. The Northern Australian fishery experience and the most recent world experience in the scientific literature are contrasted and presented for fishery operators to consider. The application of acoustic devices to mitigation of depredation on gillnet catch, arguably the major international problem involving dolphins interacting with gillnets, is briefly mentioned.

A description of the two acoustic devices built by OceanWatch for the NHT2, Northern Gulf Resource Mangement Group's Pinger project are presented. The two devices were designed for local construction given that an industrial construction method was not available at the time. Each device has specific applications, one for dugong and dolphin species, the other for dolphin species. Both acoustic devices are compatible with Fumunda acoustic pingers for dolphin species with appropriate spacing modification.

Historical aspects of dolphin bycatch and development of acoustic methods to reduce bycatch in Gulf waters

Northern Australian fishery organisations, including the Queensland Fish Management Authority, commenced an examination of dolphin bycatch in gillnets in Arafura Sea and Gulf of Carpentaria waters in the Taiwanese gillnet fish that concluded in 1986. Bycatch often occurred at night when natural acoustic alarms (*e.g.* struggling fish, vessel proximity) were absent. At their best the dolphins should have detected nets (Hembree & Harwood 1987). Dolphin sonar systems have reduced efficiency at times, particularly when they are sleeping, and this is the time when they are most vulnerable to entanglement in gillnets.

Dolphin bycatch in the early 2000's resulted in a threatened closure of the Queensland Gulf gillnet fishery. The first NHT project (DPI&F, OceanWatch, Memorial University, Defence Science and Technology Organisation and in particular Gulf Fishermen's Industry Association) was conducted in Gulf waters to examine the potential for acoustic devices to mitigate dolphin bycatch. The project developed a low frequency pinger suited to dugong and trialled a commercial pinger suited to dolphin. The inshore bottlenose and Indo-Pacific humpback dolphins demonstrated aggressive behaviour to commercial Airmar pingers with a characteristic acoustic signature that resulted in entanglement. The videos generated by DPI&F fishery Observers and Gulf operators were conclusive and the commercial pinger was immediately withdrawn from use by industry. The same commercial pinger evoked the same disastrous responses elsewhere in the southern hemisphere with the same species, but not with other bottlenose species elsewhere. The project-built low frequency pinger did not evoke the same response and the alarms were used thereafter. Adequate device deployment distances were considered to be extremely important.

The primary basis for acoustic aspects of bycatch mitigation in gillnets is that cetaceans, including dolphins, possess acoustic capabilities suited to detection of passive fishing gear. The literature highlights this strength in cetacean acoustic capability but does not highlight the known shortfalls of cetacean acoustic capability.

Inappropriate interpretations of habituation and habitat exclusion effects of acoustic pingers

The capability of acoustic pingers to mitigate bycatch of marine mammals have to date been based on a behaviour pattern of northern hemisphere harbour porpoise to surface at long ranges from nets with pingers and to progressively surface closer to the net with pingers with time, approximately from 200 body lengths to around 100+ body lengths. Marine mammal researchers have expressed concern that habituation to the pingers would occur. While never specifically mentioned in the literature, the unwritten assumption was that long term exposure to the pingers would lead to a total disregard of the sounds resulting in an increase in gillnet entanglement. Rossman (2000) suggested that the use of properly functioning pingers in US fisheries had not shown that they are any less effective after 6 years of widespread use, particularly in the NE Atlantic. After approximately 15 years of continuous pinger use in that fishery area the NMFS Take Reduction Plan for Harbour Porpoise made pinger use obligatory in 2008. It is inconceivable that this would have occurred if habituation induced mortality had actually occurred. The recent conclusion of US Fisheries (NMFS) was that there was no evidence for habituation with the species after examination of 25,000 Observed net sets (Palka *et al* 2009). Continual use of the habituation argument as an example of a problem of pingers using this species therefore should be considered tenuous as an argument against pinger use.

The International Council for Conservation of the Sea (ICES 2008) documented European reports of pinger-induced habituation and exclusion from specific habitats where it was claimed that wide scale pinger deployment may have an undesirable ecological impact. No evidence was found to support the contentions at the population level. It was conceded that harbour porpoise may be excluded to some extent from areas close to nets equipped with pingers, that being the whole point of using pingers (ICES 2008), but it was noted the effect on harbour porpoise disappeared once the pingers were removed (Jørgensen *et al.* 2006). Evidence for habituation to pinger signals leading to increased bycatch was not found.

Dolphin species behave differently and are usually associated with pingers on nets immediately exposure occurs. The longest time scale monitored fishery with dolphin bycatch mitigated by pingers after 14 years of observer monitoring had not demonstrated habituation effects (Caretta *et al.* 2008) provided pingers were deployed correctly. Appropriate pinger deployment and the acoustic detection of nets by mammal sonar systems were also discussed at length by Palka *et al.* (2009).

As for removal of dolphins from habitats, several studies from US and Mediterranean waters between 2008-2009 have determined that pingers with equal or greater acoustic energy to pingers offered to Gulf fishermen, reduced dolphin depredation on Spanish mackerel net catches or red mullet net catches respectively. The pingers tested did not exclude dolphins from the general area of the nets, but depredation from the nets was statistically reduced (Brotons *et al*. 2008, Buscaino *et al*. 2008; Gazo *et al.* 2008.

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US West Coast.

Barlow and Cameron (2003) summarised the effect of 10 kHz Dukane pingers from the Observer data set of the US west coast driftnet fishery. The report included one of the longest continuous monitored fisheries with pinger use and is a world standard for pinger application and assessment. The research determined that the reduction of bycatch of common dolphin and all dolphins were 12 and 4 fold, both significant effects. In 2008 to reinforce the success of the long term pinger application in the fishery, NOAA regulations required fishery operator training with equipment and gear modifications for vessels participating in the California drift gillnet fishery targeting thresher shark and swordfish. Specifically, the regulations included minimum spacing distances for pingers and a requirement to carry sufficient pingers to deploy on the gillnets carried by the vessel.

Carretta *et al*. (2008) provided a further assessment of the 12th year of the Observed fishery. They concluded that in addition to the observations of Barlow & Cameron (2003), the bycatch of beaked whales was also reduced significantly.

US East Coast.

Werner *et al.* (2006) made comment about the development of Take Reduction Teams and pinger use for US North East Atlantic fisheries utilising gillnets. Recent actions of the NOAA Harbour Porpoise Take Reduction Plan (HPTRP) made pingers obligatory for the Gulf of Maine fishery region and there is now a requirement for the fishing industry participants to attend pinger deployment and utilisation courses (http://www.nero.noaa.gov/prot_res/porptrp/ptci.html) conducted under the auspices of NOAA. NOAA has also deployed two styles of pinger detector systems throughout the NOAA regulatory organisations in order to more effectively monitor the obligatory utilisation of pingers (www.nero.noaa.gov/prot_res/porptrp/pinger.html). In July 2009 the HPTRP proposed further geographical inclusions for obligatory pinger use south to the mid Atlantic fishery area.

The NOAA Bottlenose Dolphin Take Reduction Plan for US East Coast waters calls for a number of fishery management measures to reduce bottlenose dolphin mortality. The US east coast net fisheries where pingers are used are currently daylight-only fisheries when dolphins would most likely be at full sonar activity state. Currently the take level does not exceed biological trigger points in 2008 although opening of night fisheries are under consideration. The Bottlenose Dolphin Take Reduction Team recommended a pilot research study to examine whether pingers can be used to deter dolphins from nets without increasing depredation rates. This gear investigation was included in the Fall 2007 Request for Proposals issued by North Carolina Sea Grant and recently awarded to Duke University to conduct associated research during the 2007/8 Spanish mackerel fishery. (http://www.nmfs.noaa.gov/pr/pdfs/interactions/bdtrt2008_mar.pdf).

Read & Waples (2009) determined that Fumunda constant frequency pingers significantly reduced depredation on gillnet catches of Spanish mackerel in US waters. The similarity in gear types and fishery conditions between the US fishery for the true Spanish mackerel (*Scomberomorus maculatus*) in Atlantic waters and Queensland gillnet fisheries for various Spanish mackerel species (*Scomberomorus* spp), are evident in Figure .

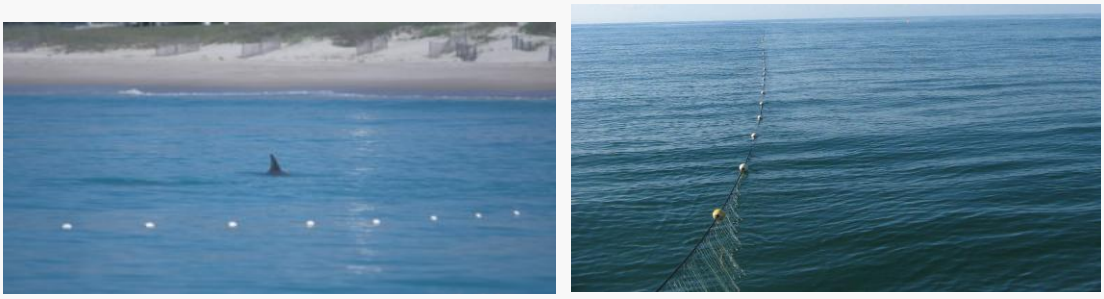

Figure 1. US East coast Spanish mackerel gillnet fishery net sets reinforcing similarity to Queensland fishery conditions. (images courtesy Danielle Waples Duke University)

There was no suggestion from Read & Waples (2009) that the Fumunda 10 kHz pinger forced the dolphins a specified distance away from the pinger associated nets, or caused a deterrence effect with the Atlantic bottlenose dolphin. The pingers functioned as they were designed to and reduced bycatch while also reducing depredation mitigation on the target species. There was no evidence of dolphin aggression towards the Fumunda pingers on the nets.

South Africa.

Dolphin mortalities for KwaZulu Natal Sharks Board nets averaged 58 per year for the period 2004-2008 (http://www.shark.co.za/mort2.htm). Mortalities were reported primarily from approximately 40 klm of gillnets over 340 klm of coastline (Peter & Peddemors 2006a, b) along a continuous stretch of the KwaZulu-Natal coastline with a single isolated area to the north of the state at Richards Bay. By 2004 acoustic pingers of various styles had been incorporated into the Sharks Boards operations to mitigate bycatch. General results suggested that bycatch was reduced but had not been eliminated. Despite the numbers of dolphins taken, the number per net was a relatively rare event and analysis to demonstrate statistical effectiveness of pingers was difficult.

More recent results from within the southern area of the KZNSB area around Durban, Peter & Peddemors (2006a) identified reduced bycatch on inshore bottlenose dolphin with the use of pingers. The authors suggested that pingers enhanced vigilance around nets with pingers. There were concerns about the close entanglement from pingers (20 cm) with probably Airmar pingers based on the timing of availability although that has not as yet been confirmed. Pinger spacing was at a minimum 140 m with pingers often 70 m from the end of the net in extremely poor sound propagation zones adjacent to the surf zone. Better pinger placement could further reduce entanglements.

Europe

Pinger use was credited with a significant reduction in bycatch in Atlantic driftnet fisheries. Striped dolphin bycatch in the tuna driftnet fishery was reduced 87.3% with Aquamark 200 pingers (Imbert *et al.*2001; cited in STECF 2002). French naval authorities monitored the driftnet fishery and in 2001 adopted a 'zero tolerance' approach, with non-compliance being met with large fines (STECF 2002).

Gillnet regulations in EC waters are complex although all net deployments are subject to Regulation 812/2004 and S.I. 274 of 2007 (Council of the European Union (2004). To further improve the efficiency of pinger introduction the European Commission in July 2009 mandated continued research to 2011 in order to enhance pinger effectiveness for all cetacean species and fishery situations. Two EC governments have called for expressions of interest for the development of gillnet pinger locators for fishery regulatory purposes in 2009 where bycatch of both dolphin and porpoise occurs.

Busciano *et al*. (2009) demonstrated how a pinger with sweep tones demonstrated significantly reduced fish losses in gillnets to depredation by Atlantic bottlenose dolphin. Dolphins were observed within 200 m of the nets irrespective if the pingers were active or in control mode, essentially minimising habitat exclusion as has been claimed at least for harbour porpoise. Brotons *et al.* (2008a) observed a comparable behaviour from bottlenose dolphin for some pinger types, including one identical in character to the Fumunda pinger.

Most marine mammal problems in Mediterranean waters involve depredation mitigation of gillnet catches by bottlenose dolphin. Several commercial pinger styles are utilised (Northridge *et al*. 2006). For a specific local example the Cornwall Wildlife Trust in 2009 raised 18,000 pounds to support continuing trials and development of commercial pingers in Cornish coastal waters as a locally recognised group of bottlenose dolphin numbers had dwindled to <20 individuals. http://www.cornwallwildlifetrust.org.uk/conservationprojects/living_seas/dolphin_pinger_trial.htm. The UK RSPCA has conducted workshops on pinger deployment in Cornwall.

Gulf of Carpentaria marine mammal species

Marine mammals with historical and current entanglement history include dugong, and dolphin species including the Australian snubfin, the Indo-Pacific humpback dolphin and Indo-Pacific bottlenose dolphin. The first two species occur in small restricted populations despite individuals being observed out as far as 36 k from the coast. It is imperative for the fishery to reduce bycatch of these species.

Acoustic pingers and dugong

The pinger selected for inshore use to mitigate dugong entanglement has been developed from the original NHT pinger that fishery experience clearly demonstrated was effective with dugong. Gulf and East Coast fishery operators determined that dugong moved around nets at night with operating pingers for the first NHT project conducted by Gulf and east coast net fishers reported as McPherson *et al*. (2004). The fundamental frequency of the pinger has been selected from originally Western Australian and more recently Japanese acoustic experience with dugong in Thailand. Researchers at Kyoto University have extensively studied dugong sounds and determined that playbacks of some sounds attract dugong while others such as the one selected for the pinger kept dugong away at an average 100 m. Further research work is about to be published. The frequency of the pinger is effectively present in the majority of all dugong sounds to maximise detection capability.

Hodgson et al. (2007) expressed misgivings about what they termed 4 kHz, and a 10 kHz pingers set on ropes to modify the behaviour of dugong. Apart from frequency capability issues the method of Hodgson (2004) and Hodgson *et al*. (2007) was to motor up to dugong, anchor a buoy, drift over the dugong and anchor a boat and then compare the reactions of dugong to the pingers lowered into the water. All trials were conducted in clear waters of the Moreton Bay Marine Park during daylight hours. The experimental method involved watching the behaviour of the dugong to close range operating pingers variously lowered into the water. The fact that the dugong almost certainly would have heard the operating pingers just above the water surface up to 20 minutes prior to the experiment commencing was conveniently ignored by the researchers.

The applicability of the JCU research presenting fishery management advice based on pingers-on-floats to replicate a gillnet used in commercial fishery applications, at night and in Gulf waters, is up to fishery operators to decide.

Fishery operators are experienced with dugong, and inshore dolphin, proximity to net fishing operations during the hours of darkness. The mammals may be heard at moderate ranges on still nights by the mammals' surface breathing behaviour with detection of the animals' vocalisations propagating through the alloy hull of net attendance vessels. Dugongs may be readily surprised by even quiet sounds from boats or fish struggling in nets, in effect acoustic alarms. Acoustic pingers simply provide the same function.

Acoustic pingers and dolphin

Peddemors *et al.* (1999a) demonstrated that Indo-Pacific dolphins' behaviour did not significantly change when sweep frequency pingers were used on nets off northern Natal, South Africa. Feeding occurred closer to the stationary nets irrespective of pingers and there were slight changes in swimming speed etc. However, the presence of the pingers did function to reduce a normally low level of bycatch further. Issues such as the deployment spacing at the study site were additional factors that could have further reduced bycatch.

The work of Peddemors *et al*. (1999a) remains the defining research for pingers with Indo-Pacific humpback dolphins with pingers, and notably for the worst-case scenario in the surf zone with an arguably less detectable pinger than a Fumunda. The reduced bycatch of the dolphins with the pingers was encouraging however more work could have generated increased bycatch reduction utilising more recent pingers and with consideration of the special sound propagation characteristics of the surf zone off Richards Bay.

Soto & Marsh (2009) considered that Fumunda pingers would not be suitable for Indo Pacific humpback dolphins in Queensland waters primarily as no ***deterrence*** effect was observed simply based on observation of dolphin behaviour to pingers-on-a-float with sound and people experienced dolphins in clear water conditions in a Marine Park in daylight hours, significantly without any association to a fishing net. Acoustic alarms or acoustic pingers were developed to warn approaching animals to the nets to which they are associated with; with no net involved there would not be any object to be warned about. Reviews of exposure of sound to marine mammals clearly indicate that an absence of a behaviour change to an observer some distance from a mammal does not indicate there is not a perception of that sound and human observers without recourse to data logging equipment of the animals (*e.g.* heart rate, brain response) should not assume that there was no response (Southall *et al.* 2007). The relevance of the observations to Gulf fishery conditions is up to fishery operators to decide as the observations bear little relevance to Gulf fishery conditions. It should be noted that the dolphins did not attack the 10 kHz commercial pinger also provided by Fumunda for Gulf fishery use and as such there is no impediment to incorporation of this pinger into Gulf use.

Description of Oceanwatch low and high frequency pingers for dugong and dolphin.

The OceanWatch acoustic pingers are constructed from high water pressure agricultural PVC fittings. The pingers are activated when the devices are inverted with floatation end uppermost. The devices will function when a few degrees lower than the horizontal.

The low frequency pinger is centred on a sound source at 3.5 kHz. The Source Level of the dominant tone is approximately 133 dB re 1 microPascal at 1m over a 0.3 second duration. The frequency of the signal was selected given its similarity to known dugong vocalisations with the likelihood that the signal was least likely to 'attract dugong close to nets as shown by playbacks of real and synthetic dugong vocalisations. The distance that dugong remained distant to the pinger and certainly not within range to develop any association between the net and pinger was approximately 100 m. The fundamental signal would be poorly heard by inshore dolphins, the higher frequency more so though at lower Source Levels.

The high frequency pinger is more complex. The fundamental frequency of the pinger is based on a signal sweep (with 7 different up-down frequency combinations) between 10 and 30 kHz. Standard acoustic/electrical measurements suggests a Source Level at a maximum of 135 dB re 1 microPascal at 1 m over short durations between 20-30 kHz although the energy exposure level within a relevant hearing range would be less than that of the dugong alarms. The frequency range is where there is little natural background noise to limit dolphin detection range and is well within peak dolphin hearing range, especially for older dolphin with reduced hearing capability. The signal output is primarily a variable frequency output and as such is a lower intensity version of the pingers described by Leeney *et al.* (2007) and Buscaino *et al*. (2009) that encouraged bottlenose dolphin to move away from the immediate vicinity of the pinger sound in European Commission waters.

The low frequency pinger is best suited to dugong although they would be capable of warning inshore dolphins over short ranges. Sweep frequency signals are suited to longer ranges within inshore seagrass/mud substrates although the lower Source Levels restrict the area of detection. Constant and sweep frequency sounds would be detected equally at low signal strength by dolphin hearing systems and can be equated.

The two Oceanwatch pingers are rated for Sound Pressure Level transmitted from the side of each pinger, the usual approach direction of marine mammals for pingers clipped onto the net hanging vertically down. Both pinger types feature a higher Source Level approaching the transducer end of each pinger and especially for frequencies >50 kHz. If a dugong pinger was deployed near the horizontal, the pinger output would provide Source Levels out from the net and provide a higher Source Level swathe of sound along the net.

The recommended pinger deployment distances for OceanWatch and Fumunda pingers are effectively at 100 m spacing offshore (Fumunda and OceanWatch high frequency) and at 60 m spacing inshore (OceanWatch low frequency) where background noise is substantially greater.

Conclusions

The integrated package of acoustic alarms and pingers provided through OceanWatch offer an opportunity for Gulf fishery operators to reduce the ever present risk of entanglement of marine mammals in gillnets while offering a reduction of the likelihood of mammal depredation on gillnet catches that in turn places the animals at risk of entanglement.

The acoustic devices have been constructed, and selected, as they offer the world's best practice for marine mammal warning and interaction reduction. The signal sound level is a balance between detection capability at short range and transmission loss of the signal in high noise environments, particularly inshore waters. The signal frequency is a balance between detection capability and behavioural reaction of mammals not experienced to extreme human noise exposure events.

International experience with pinger deployment is statistically demonstrating clear bycatch reduction while they are becoming mandatory in most US and European fisheries. Opposition to pinger use, and reasons behind them, are rapidly dissipating except from pockets of resistance in Australia. Those arguments should be investigated by fishery operators and introductory literature is provided for operators to consider the effectiveness of pinger deployment for themselves.

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