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A new technique for refloating and release of stranded sperm whales (*Physeter macrocephalus*)

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On 7 March 2007, 12 sperm whales (*Physeter macrocephalus*) stranded on Ocean Beach at Macquarie Harbor on Tasmania's west coast (42°12′59″S, 145°13′41″E). Five animals subsequently perished overnight and throughout the next day, however efforts to refloat the remaining animals during the following 4 d resulted in the seven whales being successfully moved from the shallow water and returned to sea. The unprecedented success of this refloating procedure was achieved through a combination of site characteristics, favorable sea conditions, and the use of powerful jet boats utilizing a modified aquaculture net to pull the whales from their stranded position and subsequently guiding them to deeper water. Here we report on the techniques developed and procedures used in order to assist with refloating efforts of stranded large cetaceans elsewhere in the world.

Sixty percent of all mass stranding events of sperm whales occur in three regions, Tasmania, New Zealand, and the North Sea (Brownell *et al.* 2005). The highly social odontocete sperm and long-finned pilot whales are the most common species for mass strandings (Evans and Hindell 2004, Evans *et al.* 2005). While conjecture over the causes for mass stranding continues (Bradshaw *et al.* 2006), during any stranding event within Tasmania every effort is first given to facilitate the return of healthy individuals to sea. Deceased animals are subsequently necropsied and biological samples are collected, supporting a number of research projects seeking to better understand these events. Obvious logistical difficulties involved with moving sperm whales, which grow to 18 m and weigh over 30 tons (Carwardine 2000), have previously restricted rescue success. These logistical challenges have stimulated the development in the use of nets and boats.

A total of 48 sperm whale strandings have occurred in Tasmania over the past 20 yr, resulting in 209 animals stranded (DPIW, unpublished data). The frequency and regularity of events has resulted in the need to develop new ways to manage strandings. The first use of vessels and nets was successfully trialed during a stranding at Long Point, Flinders Island, Tasmania, in November 2003. A total of 10 sperm whales stranded, with one successfully returned to sea using a modified garfish net. Nets and vessels were again successful at Ocean Beach in June 2004, when five male sperm whales stranded, with one individual successfully returned to sea, using a modified salmon aquaculture net. Subsequent refinements and modifications resulted in the techniques used at Strahan in 2007.

On the afternoon of 7 March 2007, following information from the public, staff from the Resource Management and Conservation Division of the Department of Primary Industry and Water (DPIW) initiated their Incident Control System for the management of mass cetacean strandings. Initial assessment on the morning of 8th March revealed that the whales had moved across a shallow sandbar separating Ocean Beach and were now dispersed within Macquarie Harbor, spread over a distance of 3 km in an area adjacent to a navigation channel (Fig. 1).

The pod was composed of males ranging in size from 11 to 15 m. Each whale was tagged with a numerically numbered Floy-Tag (Floy Tag, 4616 Union Bay Place

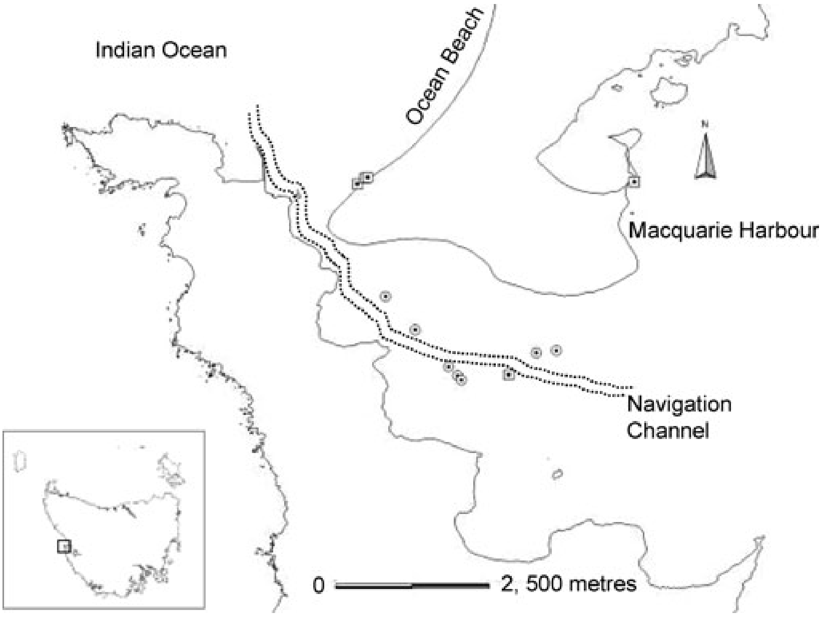

Figure 1. Location of stranded sperm whales in Macquarie Harbor, on 7 March 2007. Circles indicate live whales subsequently rescued, with squares indicating deceased whales. The dotted line represents the navigation channel through Macquarie Harbor.

NE, Seattle, WA, USA) enabling individual recognition and management. For ease of recognition, tag placement was ~200 mm posterior and ventral from the rear edge of the dorsal fin. Live whales were in shallow water next to the deep water of the navigation channel. Animals for release were prioritized on the basis of suitable location, individual health, and body size, with those animals deemed most tractable to refloat given highest priority.

Whale management during the intervening period from the initial stranding until refloating involved placing wet sheets over the animals back during the day to prevent sunburn and skin blistering, and periodic monitoring of respiration rates. The average interval between respiration breaths while whales were resting was 97 ± 33 s ($n = 38$), boating activity around the whales provided stimulation with increased respiration rates observed (19 ± 17 s, $n = 21$). The apparent health, good body condition, strong swimming, and correct body orientation noted in the majority of refloated whales even after 96 h from the initial stranding was noted as a consequence of favorable site characteristics. The support provided to the stranded whales by the constant tide height, with animals resting in ~1 m of still water contributed significantly to their ability to thermoregulate effectively, maintain dorso-ventral orientation, and prevent trauma. Cool temperatures and overcast skies limited skin damage through reduced sun exposure and drying out.

On two occasions where the whales were partially grounded on sandbars and facing deeper water, jet wash alone provided by Hamilton Jet propulsion system (Hamilton Marine, P. O. Box 709, Christchurch, New Zealand) directed toward the tail from ~3 m away resulted in moving the whales off the sandbar. The combination of the physical force from the moving water and the associated increase in tail movement resulting from increased stimulation enabled the release of these stranded whales. The successful refloating and release of the other five whales required the assistance from nets and vessels.

The technique involved the use of a modified net used in the salmonid aquaculture industry. The net is 20 m long and 4.5 m deep, constructed from braided nylon with a 150 mm diagonal mesh size. The net is framed with 20 mm polypropylene rope leading to three bridle lines used for creating the desired net shape, which then lead to a single towing point (20 mm thick). The bottom framing line has an internal lead core, while the top line has 125 mm foam composite buoys placed along the length, allowing the net to hang in the desired orientation in the water column. The net ends are a butterfly construction (2.5 m long), similar to the wings of a trawl net. This ensures even tension distribution during pulling operations, allowing the net to retain the desired shape (Fig. 2).

Towing vessels used were 10-m aluminum skiffs equipped with 350-hp Cummins diesel inboard engines (Cummins Inc., Box 3005, Columbus, IN, USA), delivering power to a Hamilton Jet propulsion system. The vessels are designed to work around ropes and obstructions, and as such have a shallow draught less than 1 m, while the propulsion system ensures that there is a minimum of cutting surfaces and protruding metal edges.

To successfully and safely surround the whale with the net and provide adequate support during towing it was important that the whale was evenly positioned within

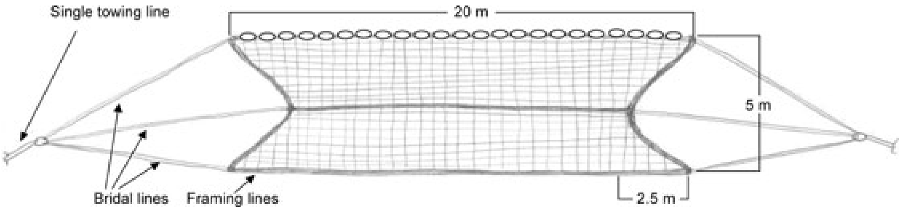

Figure 2. Design specifications of net used in sperm whale rescue.

the net while equal towing pressure was applied from both vessels. The optimum location of the whale within the net requires the head positioned just inside from butterfly wing ends so that the weight of the head and body is supported within the main body of the net. The use of nets and ropes with large cetaceans creates a risk of entanglement, and as such contingency and mitigation plans need to be previously discussed and implemented should this scenario arise. Obvious care needs to be taken to ensure that ropes do not bind on any part of the animal or appendages become caught within the net mesh.

During the net deployment the vessels were positioned in the shallows facing the deep-water channel. The net was paid out and slowly maneuvered into position (Fig. 3). When optimum positioning of the whale within the net was achieved, sufficient towing line was let out to ensure the vessels were at least 10 m from the head and tail, and heading at an angle of ~45° away from the desired true heading. This ensured that the net remained taught in a panel shape and did not compress the whales body as could happen with a bag-shaped net. Towing periods required to release whales ranged from 5 to 23 min. Periods lasting longer

Figure 3. Towing vessels with deployed rescue net approaching stranded sperm whale. Notice the channel marker in the left background indicating the distance required to move the whale.

than 5 min were interspersed with rest periods at 5-min intervals. During these times the net remained in position, but towing tension was released for 1–2 min allowing the whales to surface and breath. Number and quality of breaths were recorded, with towing recommencing after at least four to six breaths. Once the whales reached deep water, towing pressure was relieved and the whales simply swam away from the net, or towing direction was slowly reversed pulling the net from the whales.

Using this technique one whale was released during the second day of the stranding, a further two on the third day, and the final two released on the fourth day, 96 h after the initial stranding event. During one towing event the whale rolled into the net and subsequently became entangled with a single wrap of the net around the anterior portion of the body. Disentanglement contingency plans were implemented and the tail section of the net immediately cut free, relieving the binding pressure on the net. Gentle tension on the remaining towing point and whale movement resulted in freeing the roll of net. A second attempt resulted in successfully refloating the whale.

In order to direct disorientated whales into the navigation channel, and out to open sea, vessels were placed immediately behind and to the side of the animal, at a distance of between 20 and 60 m. Periodic banging on the vessel hull was generally sufficient to direct whale movement, however on three occasions the whales appeared determined to restrand and the use of Acoustic Deterrent Devices (Seal Control Units, CA, USA) was implemented.

Animal health at whale strandings is obviously a key consideration, particularly during those strandings where returning individuals to sea is a viable option facilitated by human intervention. The success of this recent stranding with the use of boats, nets, acoustic deterrents, and associated engine noise needs to be justified within the context of this intervention argument. There are some hypotheses suggesting that anthropogenic noise and sonar (Ketten *et al.* 1993, Balcomb and Claridge 2001), heightened sensory stimulation (Mawson 1978), and even distraction (Wood 1979) are causal mechanisms for strandings. As such we conducted a number of acoustic tests on the auditory output from the vessels and the associated techniques used during this stranding and related these to the auditory range of sperm whales to ensure further long-term anthropogenic impacts did not occur through our actions.

We conducted acoustic tests to approximate the sound levels that would be received by the whales from engine noise alone, engine noise and propulsion system, and from the acoustic deterrents. Tests were conducted on sand substrate in less than 5-m water depth, thereby replicating the stranding environment. Sound recordings were made with a High Tech Inc., (Gulfport, MS, USA) SSQ-41B hydrophone (sensitivity—171 dBV re 1 μPa ± 1.4 dB from 5 Hz to 30 kHz) and analyzed using Matlab software. Received levels (RLs) are given in Table 1.

The acoustic repertoire of sperm whales is limited to a series of medium-to-high intensity clicks (Møhl *et al.* 2000), with recorded source levels (SL) previously thought to be in the range of 180 dB re 1 μPa (Watkins 1980). However, recent acoustic research of bachelor male pods similar to those stranded at Strahan have found SL at 223 dB re 1 μPa (Møhl *et al.* 2000), with some click outputs peaking at SL of 236 dB re 1 μPa (Møhl *et al.* 2003).

Table 1. Broadband (5 Hz–24 kHz) received levels (RLs) of acoustic sources during testing. Measurements of vessel noise are root mean square measurements of sound from the most intense portions of the waveform. Measurements of the impulsive acoustic deterrents are peak-to-peak (p–p) measurements.

Acoustic source	Primary energy (kHz)	RL (dB re 1 μPa)
Acoustic deterrent	<1	188–193+*(p–p)
Vessel 1 engine noise only	0.3–1	149–153
Vessel 1 engine and propulsion	0.3–1.4	142–143
Vessel 2 engine noise only	2.2–5.3	148–149
Vessel 2 engine and propulsion	0.3–1.2, 2.2–5.4	146–149

*Note that 11 of 16 measurements overloaded the preamplifier of the hydrophone at levels of 188–193 dB (p–p), and therefore represent a lower bound to the levels likely received by the whales.

This research provides some quantitative results suggesting that sperm whales are regularly exposed to intense sounds and that the received sound levels from the techniques employed in this refloating and release would not lead to any deleterious auditory trauma as a result of our intervention. This is further supported in recent literature describing the observation of six male sperm whales during a series of underwater detonations (231 dB re 1 μPa peRMS, peak equivalent root mean square) (Madsen and Møhl 2000). The proximity of the whales to the detonation site suggests that the whales received the resulting pressure wave at 173 dB re 1 μPa peRMS, with no discernible change observed in either surface behavior or acoustic click production. Furthermore, research on the temporary shift in the hearing thresholds in odontocetes (beluga whale, *Delphinapterus leucas)* following exposure to underwater impulses from a seismic watergun (226 dB *re* 1 μPa, peak-to-peak), found that hearing thresholds returned to within 2 dB of the pre-exposure value approximately 4 min after exposure (Finneran *et al.* 2002).

In light of this, the results from this rescue are encouraging, and given the auditory environment that sperm whales inhabit there is no evidence to suggest that long-term anthropogenic impacts occurred through our actions. At present, following the release of stranded cetaceans we conduct extensive coastal aerial surveys covering a radius ~150 km from the point of release, to detect possible restranding of returned cetaceans. Survey flights were flown each day during this stranding and no whales were observed. In future strandings we aim to initiate a satellite tracking program to investigate the survivorship of these whales once returned to sea. As further data are required to determine medium- to long-term survival post-release, such tracking studies of stranded cetaceans will greatly increase the ability to implement informed management options during cetacean strandings (Mate 1989).

The future application of this technique is now a viable option in the management of large cetacean strandings. Where whales are stranded against the shore, land-based net deployment, and extended towing lines relayed to larger vessels lying offshore, would be challenging, but a real possibility. The development of this procedure in association with a program to determine post-release whale survivorship will aid in the management of whale strandings and provide some insight of the immediate prospects of refloated and released whales.

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