**Workshop 6: The use of acoustic information by depredating whales and implications for deterrence**
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Better insight into understanding how whales use underwater sound is critical to our understanding of how whales depredate fishing gear, and to find ways to deter them from this behaviour. Whales may acquire information about their environment 'actively' by putting sound into the water, such as echolocation clicks, or they may do so 'passively', by listening and making deductions from what they hear. These two different methods of using sound combine to enable whales to undertake their normal daily activities. Depredating whales are able to passively listen for sounds that fishing vessels make, to determine whether or not it is worthwhile to approach the gear. As the whales move closer to the fishing vessel, they are able to use their own active mechanisms (echolocation, vision) to acquire further information. It is not possible to precisely state the distances at which whales cue in on fishing activity because the propagation of sound underwater is complex, and it depend on a number of factors such as the frequency range and intensity of the boat noise, the underwater bathymetry, the sound speed profile and the state of the sea.

In this workshop, acoustic information (sound) was divided into long, medium (1 km) and short (a few meters) ranges, and discussed accordingly. A number of research goals and deterrence methods were also identified.

Note: To better understand the role of sound underwater, it is important to remember that whales are adapted to use sound much the way humans use vision to acquire information about their environment. That combined with the fact that sound travels much further underwater than it does in air points to the need for a greater understanding of underwater acoustics.

**What are the sounds that whales may use to detect fishing activity?**
Engine and propeller noise, particularly changes in speed and gear, as vessels jog to stay in position, likely provide key information to whales that the vessel is actively engaged in bringing fish on board.

Hydraulic noise may provide information to whales, although in Prince William Sound, boats fishing side by side took turns hauling gear, but killer whales were able to quickly determine which vessels were actively fishing and which were simply turning their hydraulics on and off. This may reflect the difference between a boat that is actively jogging in position compared to one that is drifting.

The tapping of the line with a gaff (longliners)

Echosounders in the 28-200 kHz range are detectable by whales.

**What are the long range cues that whales use to enable them to depredate?**
It appears that killer whales can hear vessel noise from 50 to 70 km away, whereas sperm whales may respond to vessels within 20 km or possibly farther. Boats tend to have their own underwater noise 'signature', that can enable whales to distinguish between boats. Whales may use this information to decide whether to move towards the vessel or not. Using hydrophones to record vessel noise while it is engaged in different activities may help to provide valuable feedback as to the cues that whales may use.

**What are the medium range (<1 km) cues that whales use?**
Within a kilometre, whales can use echolocation to acquire information, as well as to continue to listen passively to sounds. Whales may visually cue in to the lights, particularly sodium lights, that are used in some areas (particularly Alaska). It is possible that whales may also be able to detect the radio frequencies by boats, although more research is needed.

Echolocation functions for whales much in the same way sonar does for boats: the size of the airspace determines the target strength, and can provide information on the type, size and condition of the fish that are being caught. Tangles in the line may also generate bubbles that whales may be able to detect using echolocation. It may confuse whales into thinking that a large fish is on the line, but more research is needed to better understand this phenomenon.

Sounds that whales may be able to hear passively include gear being dropped on deck, the strumming of the line (which may make different sounds depending on whether there are hooked fish or not, as well as the species of fish caught [some fish spin, others lie flat]), tangles in the line, hydraulics being turned on and off, as well as listening to the communication signals or echolocation signals of other whales.

Both killer whales and sperm whales are able to recognize different vessels, and they may also be aware of the 'fishing routine' that certain boats follow. This could be particularly true for vessels that set their lines for relatively short periods of time (due to the presence of sea lice or lack of freezer facilities on board, so that they must return to port frequently). The whales therefore stay in the area in anticipation of gear being hauled aboard because they expect to be rewarded.

**What are the short range (within a few meters) cues that whales use?**
Whales likely echolocate and use visual cues to detect the species and size of fish on the line. They seem able to detect when a fish is hooked in the stomach, and leave the fish alone. In some areas, such as South Georgia, whales do not depredate fish that are damaged by sea lice. As well, fish that are caught produce sounds as they struggle, which are likely detectable by whales.

**Methods to deter whales using acoustics- Suggestions for further research**
The group felt that some of these proposed suggestions may take years to be effective.

<u>Before vessels begin fishing:</u>
1. Visual and acoustical monitoring for the presence of whales and avoid fishing in areas/ time periods, where whales may be in area.

2. Retrofitting vessels so that they are quieter underwater. This suggestion has high costs associated with it but can be effective in reducing the distance that whales may be able to detect a vessel.

<u>Once vessels are out in the fishing grounds:</u>
1. Change vessel handling behaviour, to avoid dramatic changes in speed or gear, since these sounds transmit very easily underwater. It may be useful to measure boat noise during various stages of hauling.
2. Co-ordinate communication with other fishing vessels to the maximum extent possible. A resounding conclusion throughout all of the workshops was that it is important that there be a commitment across the fleet not to feed the whales.

3. Minimize time in the areas that are characteristic of where fishing is taking place. Do not loiter in the area unless actively engaged in fishing.
4. Be unpredictable in travel and setting patterns.
5. Use hydrophones, both remotely and on individual boats if possible, to acquire information before committing to setting the gear.
6. Set false cues, such as long lines without hooks, so that the whales begin to lose their association of longlines with food.

Possible useful actions over medium range distances (1 km) while fishing:
1. Use fake visual (and possible auditory) cues, such as dummy gear
2. Mask the presence of gear using underwater noise
3. Experiment with the echosounder on and off to see what effect if any it has.
4. Use quiet auxillary systems
5. Minimize sodium and / or deck lights
6. Retain offal and discard when whales are not in the area. Again, this is consistent with developing policies to not feed whales.

Short range solutions to be studied (within a few meters):
1. Shorten the lengths of the gangions
2. Use hydrophones while hauling to determine when whales may be in area. This may be more reliable than relying on visual sightings of whales for determining when to return gear into the water to avoid feeding the whales.
3. Develop passive acoustic reflectors that reflect sound back to the whales.
4. Develop sources of active acoustic devices* that produce
    a) sounds that mask fishing activity
    b) predator sounds, such as killer whales
    c) bubbles, or bubble sounds
    d) pinging noises

    Such work would likely need to be performed by fishermen themselves, with researchers in an observation capacity. Otherwise, obtaining permits for such work could take years.

5. Measure the frequency range and characteristics of echolocation signals used to home in on fish using underwater video and acoustic recorders on the line.

*These should be compatible with marine mammal protection regulations or guidelines within the relevant government jurisdiction.