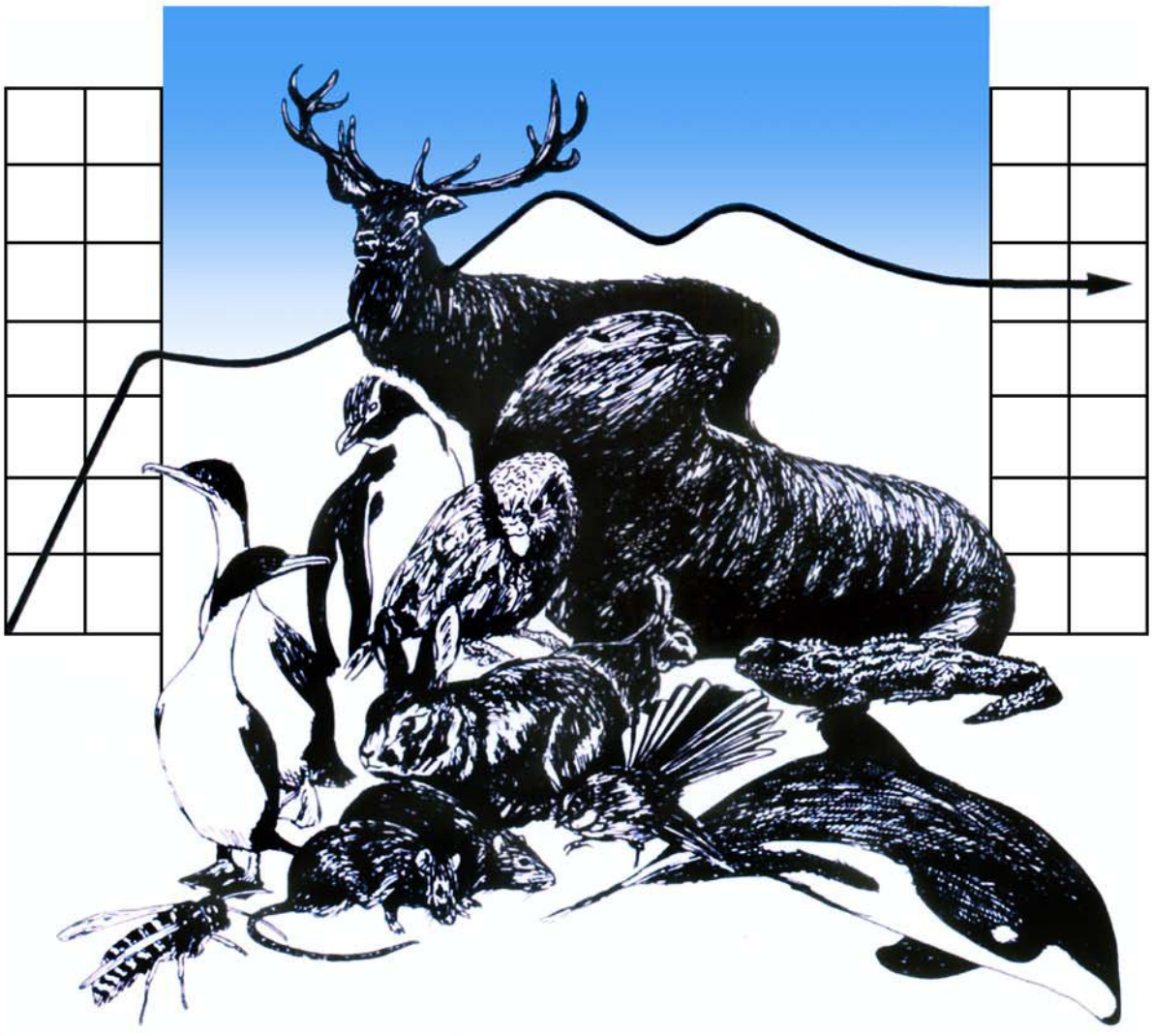
UNIVERSITY of OTAGO

Te Whare Wānanga o Otāgo

NEW ZEALAND

DEPARTMENT OF ZOOLOGY



WILDLIFE MANAGEMENT

Impact of Deep Sea Oil Development on New Zealand marine wildlife

Aniela Reid & Lisa van Halderen

A report submitted in partial fulfilment of the
Post-graduate Diploma in Wildlife Management

University of Otago

2013

University of Otago
Department of Zoology
P.O. Box 56, Dunedin
New Zealand

WLM Report Number: 268

Impact of Deep Sea Oil Development on New Zealand marine wildlife

Authors:

Aniela Reid: anielareid@hotmail.com
Lisa van Halderen: vanli343@student.otago.ac.nz

Deep Sea Oil Development

Background

Due to the exploitation of oil reserves in easily accessible areas, oil companies are moving to areas previously considered inaccessible and too risky. Currently, the Taranaki Basin is the only producing basin in New Zealand. The total reserves in the area are estimated at ~560 million barrels (mmbbls) of oil and 6400 billion cubic feet (Bcf) of gas. In 2010, ~21 mmbbls of oil and 157 Bcf of gas originated from the Taranaki Basin. This area as well as the rest of New Zealand is mostly unexplored. There are, at present, 30 offshore exploration permits granted by New Zealand Petroleum and Mineral in Taranaki and west coast North Island, East Coast North Island, Raukumara Basin and the Great South Basin off the south east of the South Island. In addition, there are five pending permit applications.

The drilling process in deep sea oil development is far deeper and riskier than areas previously exploited for oil. It involves greater earthquake risks, extreme ocean swells and higher pressures. If an oil leak were to occur, it would be far harder to stop it at these depths and the consequences on New Zealand's environment and wildlife would be disastrous. There are currently no protection measures employed in order to protect the New Zealand marine environment from a deep sea oil spill.

Oil spills

During each phase of deep sea oil development, the ability to predict the occurrence, size and number of oil spills is impossible. The nature and impact of an oil spill depends on a wide range of factors which include the type and amount of oil, water current and weather systems, the method of the clean-up response, the physical area affected and the type of organisms present. Most oils float on the surface of the water affecting wildlife with its toxicity and/or by coating their bodies. The effects of oil can be short or long term and can impact a wide variety of organisms from planktonic species to larger vertebrates. Most animals however do not avoid oil spills. Some fish are attracted to oils as it looks like food; seals, cetaceans and birds may go through these oil spills to get to the fish. Oil adhering to feathers or fur can cause such problems as hypothermia by reducing or destroying the insulation, reduce mobility (more vulnerable to predation and drowning), reduced normal behaviour and sickness.

Depending on the volume of the spill and ocean currents, the oil from an oil spill can move hundreds of kilometres from the release site. Certain hydrocarbons such as Benzene or Ethylene dissolve in water where they can be highly toxic to aquatic organisms. These types of oil, once dissolved, are invisible to the human eye and therefore impossible to get rid of in the clean up process. Oil can also combine with suspended material and then settle to the ocean floor or even wash up on shorelines. This accumulation of oil degrades far slower than oil that has not combined with sediment and is therefore far more resistant to physical processes such as weathering.

Clean up of oil spills

The first step in the clean up process after an oil spill is to attempt to collect the oil in a ring of rubbery material to prevent its spread. An inflated boom is commonly used and is reeled into the water and pulled behind a large vessel. Absorbent booms can be used to absorb and skim oil off the surface of the water.

Controlled burning of the oil is another method employed in the clean up process. This involves the burning off of the oil on the surface of the water.

The clean up process of an oil spill can also involve the use of chemicals to break down the oil. The chemical Corexit 9500 was used in both the Gulf of Mexico spill and the early days of the Rena disaster. Authorities stopped using it here in New Zealand after it appeared to be ineffective. Dispersants such as Corexit 9500 reduce the oil to a toxic sludge and the effects of these dispersants on wildlife species in New Zealand is unknown. They merely add to the toxic load that impact the wildlife after the event of an oil spill. Given the response to the Rena oil spill and the use of an ineffective chemical, it brings to question how authorities will react in the case of future oil spills.

Due to the high pressures, remoteness and sometimes extreme weather encountered in areas where deep sea oil development is underway, the clean up process is far harder to employ. For example, oil spills in near freezing water take far longer to degrade and there is no method to contain the oil if the spill is trapped underneath an ice sheet. Additionally, ice can cut the floating booms, releasing the oil that was contained.

Phases of New Zealand's marine oil industry

Prospecting: To get bathymetric data, information on the depth of the seafloor, surveying ships use a multi-beam echo-sounder. In order to get information on geological structures beneath the seafloor, a seismic source and a streamer of multiple hydrophones are used which may be up to 15km long. Up to 100% of the prospecting licence area may be surveyed sequentially over a period of several weeks to several months. There may be severe acoustic impacts of seismic surveys on marine mammals and other species, as well entanglement in the seismic streamer.

Exploration: Usually a drill ship or platform is used to assess the oil reserves of rock strata. It may take several weeks to months to reach the target depth depending on the type of rock. Lights on the drilling platform can attract seabirds and marine mammals may interact with the equipment. Benthic ecosystems on the seafloor will be impacted directly by the drilling. Lubricant is used in the drilling process which may be oil-based, synthetic, or water-based. These can increase the toxicity of drill cuttings which were previously dumped on the seafloor; cuttings from new wells are likely to be collected and dumped onshore, however this is not entirely certain. Additionally, underwater noise will be produced in this phase.

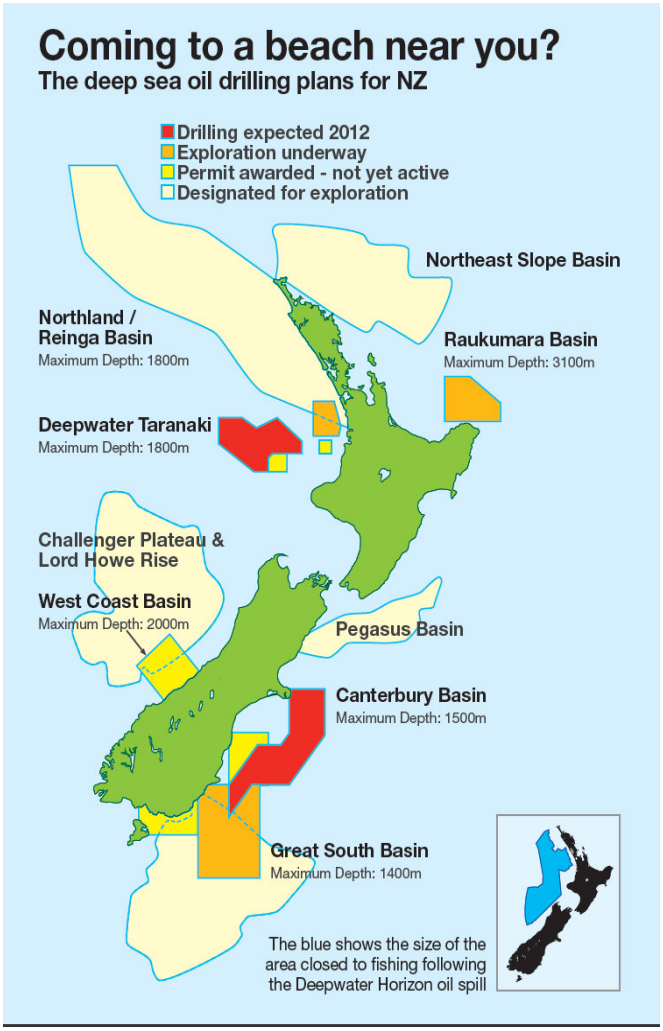
It is a common misconception that the most impact and risk imposed by deep sea oil development is the production phase (see the next phase). However, the exploration phase can also result in a blowout due to the high pressure at these extreme depths. Generally the geology and pressure of the area is unknown at this stage and unexpected changes in pressure can occur. The Deepwater Horizon spill in the Gulf of Mexico was an exploratory well that had a blowout due to the release of high-pressure, flammable methane gas. It is therefore a hazardous phase in deep sea oil development and can lead to an oil spill.

Production: This may involve a surface production platform and a pipeline to the shore or a seabed facility of similar nature. The surface platform may affect wildlife in a similar way to the effects of the exploration platform. The seabed will be affected by the well itself and the legs of the surface platform if in depths that allow the structure to be based on the seafloor – most deep sea platforms are floating (ones that reach the sea floor aren't viable beyond about 500m depth). If a submerged pipeline is constructed, it may have serious effects on the seabed. The area of the platform may decrease the size of the habitat used for foraging by some fish species or provide an artificial reef-like surface and increase reef habitat for other species.

Additional to the platform and pipeline effects, there will be an increase in ship traffic as vessels are used to transport oil and supplies to and from the offshore rig. These ships will cause an increase in human-generated noise underwater, interfering with the communication systems, habitats and behaviour of marine animals.

Abandonment/Decommissioning: The effects if this phase is dependent on whether the production platform and equipment is dismantled and removed, sunk to the seafloor, or left intact. All these alternatives require preparatory work in the way of cleaning the structures of oil and toxic substances. The abandoned equipment will have lasting impacts on the benthic environment as the platform slowly rusts over a long time period.

Deep Sea Oil Development Plans for New Zealand



Currents around New Zealand

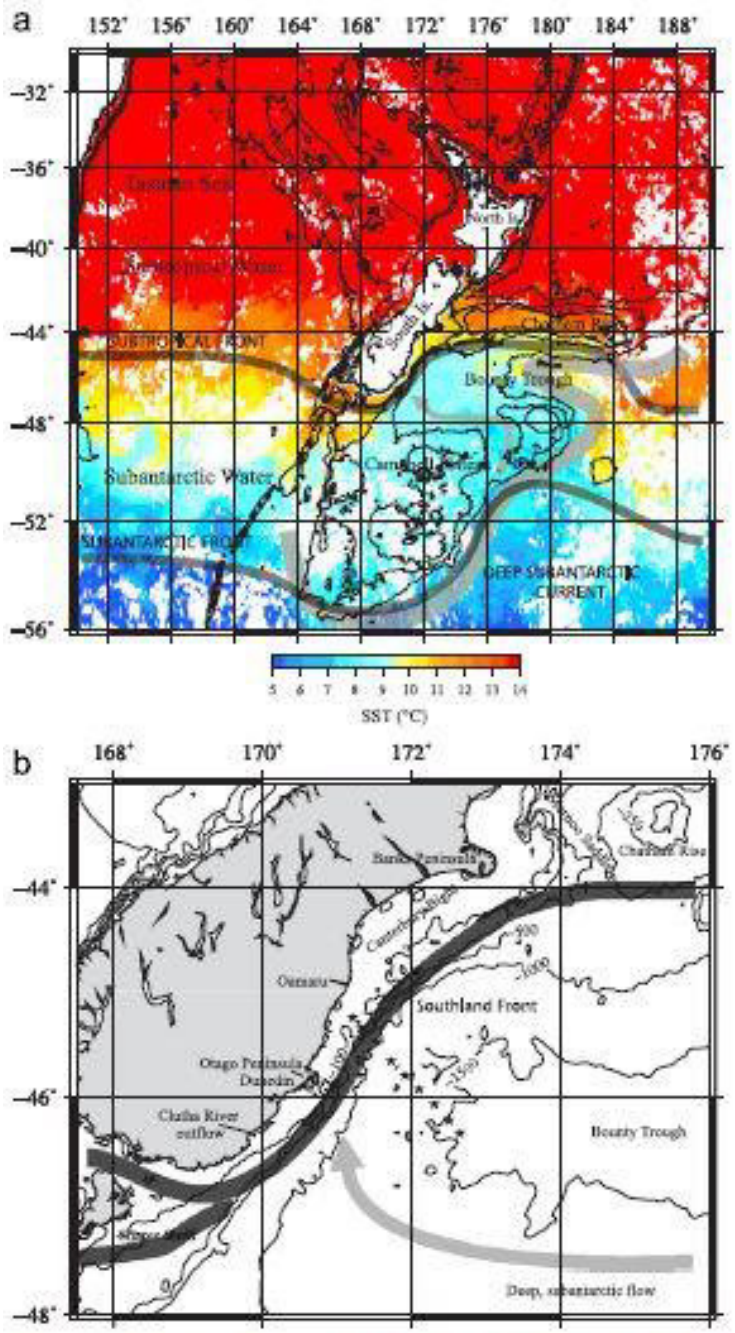


Fig. 1. (a) The approximate positions of the Subtropical and Subantarctic Fronts (dark grey), and deep subantarctic currents (light grey) around South and North Islands, New Zealand. Sea surface temperatures (°C) are for June 2004. (b) Location of the Southland Front off South Island. Black contours show the bathymetry (m). Black stars mark the CTD casts from NIWA cruise 3006 in April 1993.

Hopkins J, Shaw A.G.P, Challenor P. 2010. The Southland Front, New Zealand: Variability and ENSO correlations. Continental Shelf Research, 30: 1535–1548.

Cetaceans in New Zealand waters

By Aniela Reid

Image: Hector's dolphin

(from http://www.abbotthouse.co.nz/christchurch-dolphin.html)

The known cetacean species within New Zealand

Whales, dolphins and porpoises are marine mammals which belong to a group of animals called cetaceans (Order Cetacea). New Zealand's marine zone includes approximately 47 cetacean species, which is over half of the world's approximate 80 species of cetaceans (Weeber 2011). This is understandable as New Zealand has an exclusive economic zone (area of sea and seabed) of four million square kilometres, has highly productive waters and is part of the migratory route of some whales (Baker et al 2010). Cetaceans are major consumers within most trophic levels in the food web, and given their biomass and abundance, they have a major role in the structure and functioning of marine ecosystems (Bowen 1997). Cetaceans are generally long lived with low reproductive rates and low natural mortality rates. They are however vulnerable to a range of human related threats which include; bycatch, entanglement in fishing nets, hunting, competition with fishing industries for food, boat-related impacts, tourism, pollution, and mining.

Cetaceans are divided into two main groups; the Baleen whales (suborder Mysticetes) and Toothed whale (suborder Odontocetes). Baleen whales have two blowholes, baleen plates for filtering food such as small schooling fish, krill and plankton, rather than having teeth, and do not use sophisticated echolocation. Baleen whales produce loud low-frequency sounds originating most likely from their larynx and are used mainly for communication Baleen whales tend to be larger than toothed whales and are highly migratory. There are 13 species of baleen whales in the world, of which 10 species have been observed in New Zealand waters (Baker et al 2010). These species include:

- Humpback whale (*Megaptera novaengliae*) – Least Concern (ICUN 2012)
- Fin whale (*Balaenoptera physalus*) – Endangered (ICUN 2012)
- Blue whale (*Balaenoptera musculus*) - Endangered (ICUN 2012)
- Antarctic and Dwarf Minke whale (*Balaenoptera bonaerensis* and *B. acutorostrata* subspecies) – Data deficient and Least Concern respectively (ICUN 2012)
- Sei whales (*Balaenoptera borealis*) - Endangered (ICUN 2012)
- Pygmy right whale (*Caperea marginata*) – Data Deficient (ICUN 2012)
- Southern right whale (*Eubalaena australis*) – Least Concern (ICUN 2012)
- Brydes Whale (*Balaenoptera edeni*) (compromises of two or possibly three species) – Data deficient (ICUN 2012)

Three species; the Southern right, Bryde's and dwarf minke are the only baleen whales known to breed in New Zealand waters. Despite not breeding in New Zealand waters, the other baleen whales which are migratory, predictably and cyclically visit and depend on New Zealand's waters as part of their normal life cycle (Baker et al 2010).

Toothed whales have a single nostril (blowhole), teeth, and use sound waves in a method called echolocation to catch prey such as fish or squid, for navigation and for social interaction. There are approximately 72 species of toothed whales in the world, of which 30 species have been observed in New Zealand waters; including 10 dolphins and 1 porpoise. Species sighted include:

- Hector's dolphin (*Cephalorhynchus hectori)* – Endangered (ICUN 2012)
- Mauis dolphin (*Cephalorhynchus hectori maui*) – Critically endangered (DOC)
- Short-beaked common dolphin (*Delphinus delphis)* – Least concern (ICUN 2012)
- Dusky Dolphin (*Lagenorhynchus obscurus*) – Data deficient (ICUN 2012)
- Common bottlenose dolphin (*Tursiops truncatus*) – Least Concern (ICUN 2012)
- False Killer whale (*Pseudorca crassidens*) – Data deficient (ICUN 2012)
- Killer whale/Orca (*Orcinus orca*) – Data deficient (ICUN 2012)
- Pilot whale (*Globicephala spp*) – 2 species. Data deficient (ICUN 2012)
- Beaked whales (approximately 11 species) – Data deficient (ICUN 2012)
- Sperm whale (*Physeter macrocephalus*) – Vulnerable (ICUN 2012)

Anthropogenic noise effects on cetaceans

During the prospecting phase; seismic (acoustic) surveys are conducted using multi-beam echo-sounders and airguns that emit pulsed, high-energy sound waves directed towards the seafloor. These sound waves penetrate and reflect off the seabed, which are then detected by hydrophones (Steiner 2012). These low-frequency sounds (10 Hz- 1000 Hz) also propagate horizontally for hundreds of kilometres and can be detected up to 3000km from the source. They source level in a usual array is extremely loud, around 233-260dB re1µPa which is even louder than a 747 jet engine on take-off (Steiner 2012). There is a tendency for the source level to increase as deeper waters are surveyed (Aguilar 2012). A prospecting licence area may be surveyed sequentially over a period of several weeks to several months, thus ensonifying a large area of ocean habitat and its accompanying species. The impacts of seismic surveys will differ between species depending on their sensitivity and type of sound. It will also depend on whether animals are exposed to high level noises at close rangers or low level exposures at distances further from the acoustic source.

Cetaceans are dependent on sound for most or nearly all aspects of their life including navigation, reproduction, communication, feeding and predator avoidance (Popper 2003). Cetaceans utalize a wide range of acoustic frequencies, from the blue whale which emits 15 Hz sounds to harbour porpoises which emit 120-150kHz (Weilgart 2007) Human-introduced frequencies often overlap with those signals emitted by cetaceans which is concerning. Cetaceans exposed to elevated noise levels can mask cetacean calls or result in permanent or temporary threshold shifts, which is the change in the ability of the animal to hear a

particular frequency, where it may become less sensitive at one or more frequencies due to exposure to sound (Nowacheck et al 2007). Noise masking and threshold shifts can prevent cetaceans from finding their prey, avoiding danger, navigating, finding mates, pod members or young (Nieukirk et al. 2004, Nowacheck et al 2007).

Elevated noise may cause behavioural disturbances, where cetaceans deviate from their normal behaviour. This may include the abandonment of important activities such as feeding or nursing in response to sound (Nowacheck et al 2007). Cetaceans may also move away from feeding and mating grounds, move or alter their migration routes, alter their calls, make navigation errors and accidently blunder into fishing nets or ships (Todd et al 1996, Miller et al 2000, Weller et al 2002, Weilgart 2007). Cetaceans have also been reported to panic from loud underwater sounds either immediately fleeing, rapidly diving deeper or rising to the surface quickly which can result in decompression sickness (similar to the “bends”) and beaching (Weilgart 2007).

There is extensive evidence linking underwater sonar with fatal whale strandings and injuries (Weilgart 2007). The International Whaling Commission’s Scientific Committee and a U.S. Navy-commissioned report have supported the evidence for military sonar (of which the loudness and frequency is similar to that used in acoustic drilling surveys) causing mass cetacean strandings, especially for beaked whales (Engel et al 2004, Levine et al. 2004, Weilgart 2007). Seismic air guns may also be responsible for whale strandings (Engel et al. 2004). Necropsies conducted on stranded beaked whale carcasses after sonar events revealed severe diffuse congestion, haemorrhaging and bleeding around acoustic jaw fat, ears, brain and kidneys, gas bubble-associated lesions and embolisms and evidence for decompression sickness (Fernandez et al 2005). Cetaceans also show heightened stress responses and a weakened immune system following intense noise exposure (Romano et al. 2004, Weilgart 2007). Persistent and/or acoustic noise should be considered to cause population level impacts and has been thought to contribute to several whale species decline or lack of recovery (Weller et al 2002).

The effects of pollution from drilling wastes, cuttings and suspended sediment on cetaceans

Exploration drilling is conducted to further delineate and assess the oil reservoir. Most surface production platforms in the deep sea are floating, others in less deep water extend to the seafloor directly impacting the sea bed. The area of the platform may decrease the size of the habitat used for foraging by some marine species. Additionally it may provide an artificial reef-like habitat for species which may attract further fish and cetacean species

(Page and Dugan 1999). Atmospheric emissions of harmful substances such as nitrogen dioxide and sulphur dioxide are released from platforms and ships. In calm weather these emissions, which are heavier than air may linger in calm weather where they may be potentially inhaled by cetaceans (Slooten pers comm).

Wastes from drilling can cause toxicological impacts. These impacts originate from either the drilling of chemically enriched muds, and the discharge of these muds, waste cuttings or contaminated water. Drilling rigs typically discharge 80-160m3 of waste muds over 1-2 hours into the water. This increases turbidity from sediment suspension, heavy metal pollution including mercury, lead and arsenic. Additionally, domestic waste from the ship/rig including sewage, wash water, deck drainage is also discharged. This waste will eventually disperse and dilute to non-harmful levels, however it potentially causes localized toxic and harmful effects near the discharge site. The toxic effects of heavy metals, hydrocarbons and other chemicals released from oil development and other sources have been widely reported amongst many cetacean species. The impacts of chemical pollution on cetaceans can include the poisoning of animals within the marine food chain. This accumulates along the chain, biomagnifying and concentrating in the top predators, including cetaceans. Consequently, this results in direct physical poisoning of cetaceans or degradation of important habitats. Toxic effects reported in marine mammals with high levels of pollutants include; abnormal endocrine, nervous and digestive systems, immunosuppression, liver and kidney disease, reproductive, growth and development issues, tumours and cancer (Fujise et al 1988, von Burg & Greenwood 1991, Leonzio et al 1992, Parsons 1999, Kakuschke & Prange 2007). Research has shown that meat of pilot, minke, and beaked whale, as well as common and bottlenose dolphin being sold in the market for human consumption had very high levels of mercury and cadmium (Endo et al 2004).

Over the past 20 years, Beluga Whales, Delphinapterus leucas, have declined as a result of habitat degradation, pollution and bycatch. Key threats include the Port of Anchorage expansion, oil and gas exploration and production, and discharge from sewage treatment plants. A study by Beland et al (1993) showed that beluga whales have high levels of compounds from organic and metallic chemicals of industrial and agricultural origin. They also have high incidences of tumors, malignant neoplasms, lesions and cancer.

A blubber biopsy study carried by Sascha et al (2007) on endangered northern bottlenose whales (Hyperoodon ampullatus) in the Marine Protected Area on the Scotian Shelf, Canada before and after the development and extraction of oil and gas from the surrounding shelf areas. These rigs began production operations in 1998. These dolphins were analysed for cytochrome P4501A1 (CYP1A1) protein expression, which is a biomarker for exposure to contaminants and for actual levels of persistent contaminants. Prior to development (1996-97) CYP1A1 showed low expression in whales but higher levels during 2003, co-occurring with the onset of development and extraction of oil and gas. PCB congeners, organochlorine compounds, 4,4'-DDE and 13 trans-nonachlor were all higher in

2002-03 relative to 1996-97. This study clearly highlights the pollutive impact mediated by oil and gas development on surround cetaceans.

Effect of an increase in ship traffic on cetaceans

The surface production platform, pipeline and waste discharge may affect wildlife comparably to that during the exploration phase. There will however be an increase in ship traffic as vessels are used to transport oil and supplies to and from the offshore rig. These ships will cause an increase in human-generated noise underwater, of which the general impacts on cetaceans have been outlined. Ships also heighten the risk of ship strike which can cause immediate death or serious injuries which can lead to eventual death. These injuries include; massive blunt impact trauma, fractured bones including jaws, skulls or vertebrate, propeller wounds, internal bleeding and bruising or brain damage (Laist et al 2001). Many of these ships are internationally owned, resulting in the potential for invasive species to be introduced to New Zealand (such as ballast water) wasters, harming or changing our marine ecosystems.

Effects of the abandonment/decommissioning phase on cetaceans

The effects if this phase is dependent on whether the production platform and equipment is dismantled and removed, sunk to the seafloor, or left intact. The equipment is cleaned of oil and other substances, however some of these cleaning products may have unknown effects in the environment. The abandoned equipment will have lasting impacts on the benthic environment as the platform slowly rusts over a long time period releasing potential pollutants into the environment.

Effects of oil on cetaceans

The greatest environmental risk during oil development is that of well control or a 'blowout'. Deep water reservoirs are under a massive amount of pressure (30,000 pounds per square inch) which must be counterbalanced in order to maintain control. If control is lost a blowout will occur releasing a large amount of oil into the water The loss of control can occur at any stage during the drilling process and be caused by a number of factors such as poor well design, equipment or cement failure, unexpected pressure anomalies, inexperience and poor management by the drill crew. The ability to predict the occurrence,

nature, size and number of oil spills is impossible but it should be assumed that several small oil spills are likely to occur at any oil well. There is extensive scientific literature on the effects of hydrocarbons on the marine environment and its direct or indirect impact on cetaceans. Direct impacts include ingesting or inhaling the oil or its vapours, leading to sickness or death. Indirect effects include loss of habitat, immediate contamination of food sources or death of food sources. This results in reduced survival, fitness and reproduction.

Toxicological effects of oil include; burning or blinding eyes, irritating or damaging sensitive membranes in the nose, mouth and eyes. Oil and hydrocarbons can cause poisoning, pneumonia in the lungs, damage red blood cells, supress the immune system, cause stress, organ damage and reproductive problems (Geraci & Aubin 1988, NOAA). Oil can also block the blowholes of cetaceans resulting in death. Research on cetaceans has shown that they can detect oil slicks. Some cetaceans show avoidance while others will swim though it by choice, accidently or whilst unting for food (Geraci & Aubin 1988).

The effects of oil spills on marine animals were highlighted in the Deepwater Horizon spill in 2010 in the Gulf of Mexico. This oil spill, from 5000 feet water depth was transported and spread in deepwater plumes, with only 15% reaching the surface. Approximately 4.9 million barrels of oil (205.8 million gallons) was released into the environment from this spill. A report from the Centre of Biological Diversity in 2011 found that the number of cetaceans stranded of killed was underestimated by the government and was likely to be 50 times greater than expected (Williams et al 2011). This report suggested that 25,900 marine mammals including bottlenose dolphins, spinner dolphins, melon-headed whales and sperm whales were harmed or killed. Due to the number of strandings and deaths; the National Oceanic and Atmospheric Administration (NOAA) declared an Unusual Mortality Event. Research on bottlenose dolphins after the oil spill ascertained that the dolphins were underweight, anemic, had abonormal hormone levels, low blood sugar and symptoms of liver and lung disease (NOAA). Many bottlenose dolphins including newborn, fetal and stillborn dolphins stranded after the oil spill and still continue to this day.

Depending on the volume of the spill and ocean currents, the oil from an oil spill can move hundreds of kilometres from the release site. Due to the dispersal ability of oil in the ocean, along with the longevity and the behaviours of many local and migratory cetacean species the toxicological and environmental effects of oil can be widespread and exist for years. The clean-up of oil spills can also be quite dangerous to cetaceans. Controlled burning of oil can harm cetaceans as they come to the surface to breathe. Chemical dispersants used for cleaning are also potentially toxic in themselves.

In depth focus on some of the species that are at stake:

Baleen Whales

Humpback whale

(Megaptera novaengliae) – Least Concern (ICUN 2012)

The humpback whale, is a migratory species and has a cosmopolitan distribution throughout the oceans of the North Atlantic, North Pacific and Southern Hemisphere. Southern Hemisphere humpbacks feed in the Antarctic during summer and migrate north to breeding grounds in subtropical or tropical waters in the winter (Gibbs and Childerhouse 2000). Humpbacks have diverse feeding techniques in order to hunt krill and small schooling fish such as mackerel and herring.

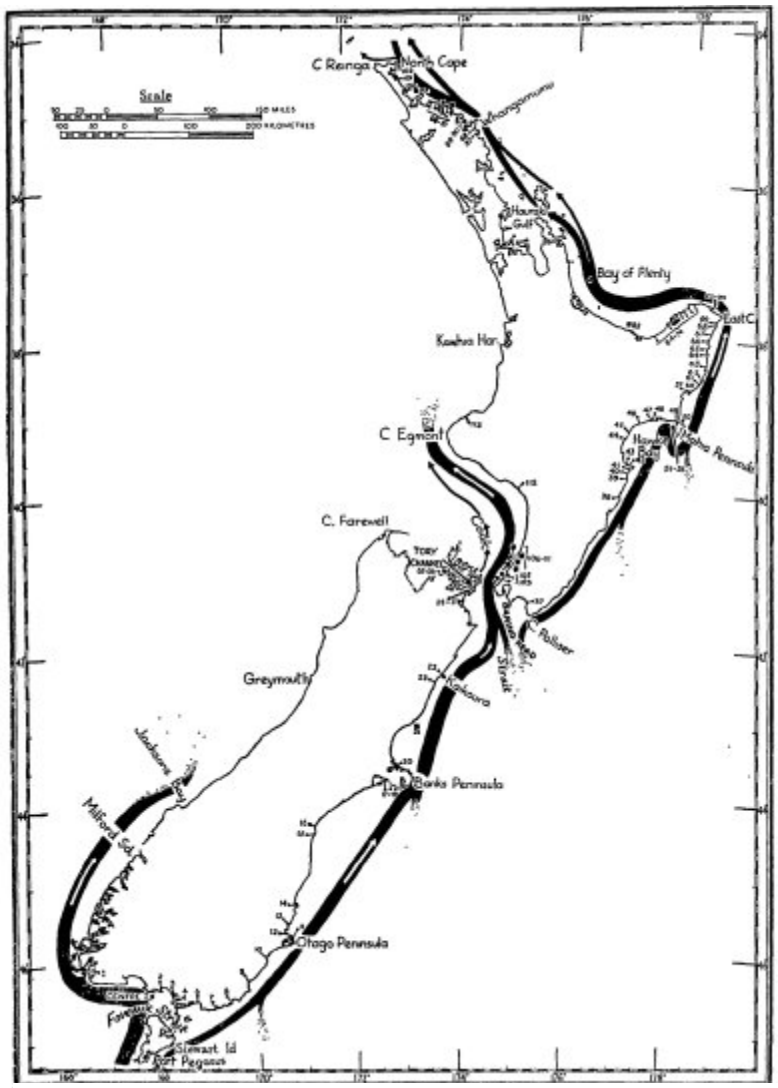


Figure 1: Humpback migration paths along New Zealand coast (Dawbin 1956)

Humpbacks are a relatively common coastal species and use New Zealand waters on their migration. Dawbin (1956) suggests that humpbacks in New Zealand migrating north during late May to early August, pass along the east coast of the South Island and then split into two groups. One group passes along through Cook Strait and up the West coast of the north Island, and the other continues up the east of the North Island. Some humpbacks also pass the western side of Stewart

Island and the south-west corner of the South Island before moving offshore (Dawbin 1956, Gibbs and Childerhouse 2000).

Southern migrating humpbacks during mid-September to early December, tend to travel along the west coasts of the North and South Islands, forming a large group near the south-west corner of the South Island before moving further south. Some humpback follow the east coastlines before moving offshore (Dawbin 1956, Gibbs and Childerhouse 2000).

Humpbacks are likely to change their song occurance in response to airguns and ships, perhaps as far as 200km. Risch et al (2012) demonstrated that humpbacks reduced their song occurrence, concurrent with transmissions of an Ocean Acoustic Waveguide Remote Sensing experiment that was 200 km away. Humpbacks also change their singing activity and tend to swim away in the presence of loud boats (Sousa-Lima and Clark 2008). There have been no studies investigating humpback behaviour or impact close to an acoustic source, however acoustic trauma in humpbacks have been reported in individuals that have been near underwater explosions.

Because humpback sing complex songs on their breeding grounds and on their migration and feeding grounds, noise pollution will have a very negative effect on this species. Changes in humpback singing activities and normal behaviour are likely to result from airguns and ship trafficking, especially along the east coast of the South Island. However the magnitude of this effect and whether humpbacks avoid this disturbance completely is unknown.

Wiley et al. (1995), when assessing the strandings of 38 humpbacks during 1985-1992 in the U.S. mid-Atlantic concluded that most stranded animals were sexually immature and had only recently separated from their mothers. Areas such as the U.S. mid-Atlantic which are important for humpback migration. Here, juveniles are more vulnerable to anthropogenic factors. New Zealand is also an important area along the migration route, of which many calves and juveniles use.

It is likely that various chemical pollutants can affect the immune system of humpbacks (Castro et al 2010). Castro et al (2010) suggested that some of the observed skin anomalies present on humpback whales in Ecuador may be a result of chemical water contamination, ship collisions, and fishing gear interactions. Humpbacks in New Zealand waters therefore may be at risk from discharges from drilling.

Humpbacks, like any other whale are vulnerable to oil spills. In August 2009, a Turkish ship began to sink causing oil to be spilled into the water just off the southern tip of Madagascar. After this oil spill, humpback whales began to wash ashore, many of which had their blowholes blocked with diesel and oil (Jotman 2009). There is still no evidence to suggest the humpback whales avoid contaminated waters in the event of an oil spill (Dahlheim and

von Ziegesar 1993). If an oil spill were to occur in New Zealand waters during the humpbacks migration, it could be disastrous for the species.

Image: Humpback whale (*Megaptera novaengliae*)
(Photo by Phil Cothran from http://photography.nationalgeographic.com/photography/photo-of-the-day/humpback-whale-calf-underwater/)

Blue whale and Fin whale

(Balaenoptera musculus) and (Balaenoptera physalus) respectively– both Endangered (ICUN 2012)

The blue whale is the largest animal ever to live and feed mainly on krill. They produce the loudest low-frequency sound of all animals, which can travel hundreds of kilometres. Blue whales were once plentiful in the 19th century, however hunting in the 20th century saw their numbers decline. The distribution and abundace of blue whales in the Southern Hemisphere and northern Indian Ocean is poorly understood. There are an estimated 2000 blue whales left. These Antarctic blue whales migrate to temperate equatorial waters in the winter for mating and calving and then return to their summer feeding grounds in the Antarctic. Blue whales migrate past New Zealand coasts, but are rarely seen close to shore. Blue whale sightings have been reported in; The Cook Strait, Taranaki waters between Puniho and Cape Egmont and down the east coast of both the North and South Islands.

Melcón et al (2012) passively monitored blue whale vocalizations in response to anthropogenic noise in the Southern California Bight. When sonar was present; blue whales were less likely to produce calls. The reduction in calls was more pronounced when the sonar source was closer to the animal and at higher frequencies. In the presence of ships whose low frequencies overlap with that of the whales, foraging blue whales increase the amplitude of their calls to keep a high signal to noise ratio (McKenna 2001). The studies by McKenna (2001) and Melcón et al (2012) demonstrated that anthropogenic noise, even that outside the frequency production range of the blue whales appears to elicit changes in vocal behaviour which may have long-term implications for individuals or the population at large.

Fin whales also have rare sightings in New Zealand. They have been reported in Kaikoura and down the east coast of the South Island. The fin whale produces the lowest frequency song in nature which can propagate thousands of kilometres away. The southern hemisphere population is estimated to be about 20,000 and follows a similar global migration pattern to that of the blue whale.

Fin whales also appear to modify their acoustic behaviour in response to shipping traffic and airgun events (Castellote et al 2010). In high anthropogenic noise conditions for both shipping traffic and airgun events, the fin whale 20-Hz pulse duration shortened, bandwidth decreased, and center and peak frequencies decreased (Castellote et al 2010). Fin whales also moved away from the airgun source and out the detection area of the study for a long period of time, beyond which of the duration of the airgun activity (Castellote et al 2010).

Very little is known about the endangered blue and fin whale. Migratory whales have altered their migration routes in order to avoid noise and show changes in foraging behaviour. Oil exploration along the East Coast of New Zealand may therefore cause these

whales to potentially change their migration patterns along our coasts. Active airguns from exploration may also cause them to stop calling. This is likely to have major implications for their communication and perhaps foraging behaviour. Blue and Fin whales are likely to move away from areas where there are airguns (Castellote et al 2010).Blue whales were also amongst those whales which beached after the Deepwater Horizon oil spill. Beaching could result in New Zealand if an oil spill were to occur when these whales are present during their migrations.

Blue and Fin whale sightings are rare due to the fact that they are endangered and that they do not swim close to shore. It is unknown how important New Zealand waters are for these whales during their migration. In this case it us unknown how the population will respond if deep sea oil exploration were to occur. Due to the fact that they are endangered, show behavioural changes and avoidance to anthropogenic noise, they are likely to be impacted by oil spills. Consequently, it is wise to take a precautionary approach.

Image: Fin whale (*Balaenoptera physalus*)
(from http://true-wildlife.blogspot.co.nz/2011/02/fin-whale.html)

Southern right whale

(Eubalaena australis) – Least Concern (ICUN 2012)

Southern right whales are skim or ram filter feeders, which prey on copepods and euphasuids (krill) (Best 1994). Southern right whales are a highly mobile migratory species, migrating between winter calving grounds and summer offshore feeding grounds, generally at higher latitudes (Best 1994). In summer, right whales can be found in habitats which aggregate zooplankton prey such as coastal deep basins and the polar front/subtropical convergence (Elwen & Best 2004). In winter, they tend to inhabit bays sheltered from wind and swell (Elwen & Best 2004) of which cow/calf pairs rest, travel and likely nurse close inshore sometimes over a period of several days and weeks. There are 13 winter calving grounds of southern right whales, one of which is the Auckland/Campbell Islands (Patenaude 2000).

The southern right whale (SRW) is the baleen whale most closely associated with New Zealand because, in the past, they used to come inshore to sheltered harbours on the mainland to mate and calve (Carroll et al 2011). However extensive hunting in the 19th century depleted their numbers and shrank their range. Today the right whale population appears to be recovering and now are rarely but increasingly being sighted around the mainland. These areas include: East Coast, Hawkes Bay, Wanganui/Wellington, Mahurangi Harbour/Auckland, Otago, Kaikoura/Canterbury, Northland and Nelson (Patenaude 2003). The extent of this increase is difficult to establish due to a variety of sighting biases and inconsistent sighting effort over time (Patenaude 2003). The location of reported sightings over past two decades and past historical distribution indicates that there are several coastal areas which are important to SRW which include (Patenaude 2003):

East Coast/Hawkes Bay and Bay of Plenty Conservancy in winter and spring for cows with calves Southland; in particular the coastline from Stewart Island and Otago appears to be the preferential habitat, at least for non-cow/calf pairs. Banks Peninsula, Marlborough Sounds and Wellington are, to a lesser extent, important SWR habitats.

The East Coast/ Hawkes Bay and Bay of Plenty coastlines are a critical habitat for the continual recovery of the SRW population around mainland New Zealand (Patenaude 2003). Marine mammal protection guidelines should be enforced, human-related activities which threaten and disturb SRW cows and calves should be minimized (Patenaude 2003). Individual SRW which have been sighted around the mainland and in the Auckland/Campbell islands have ship strike injuries and scars (Rayment 2012 pers comm). Existing and proposed human-related activities such as boating, whale-watching, oil or gas exploration should be evaluated and closely monitored in order to mitigate and prevent serious negative impact on the SRW recover y (Patenaude 2003).

The Auckland and Campbell islands are the primary breeding and calving grounds for southern right whales in New Zealand waters (Patenaude 2000). From early May to at least the end of September is the residency period, where numbers are highest (Patenaude 2000). The photographic identification catalogue contains 410 animals (including 76 cows), but mark-recapture analysis suggests the population size to be between 740-1140 (Patenaude 2000). At the Auckland Is, southern right whales concentrate in waters surrounding Port Ross, Enderby Island and Laurie Harbour (Patenaude 2000).

Image: Southern right whale
(from http://www.kimchowaroundtheworld.com/public/013_KimChowCircum/037_NovemberDaily.html)

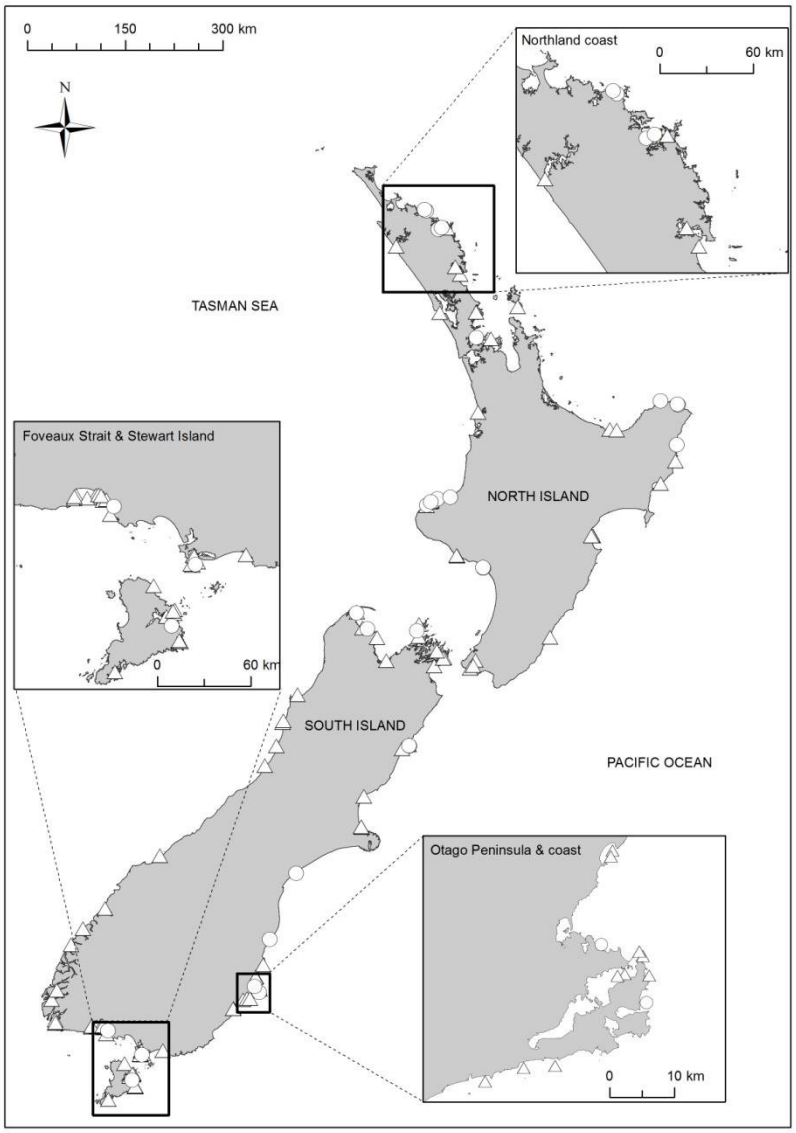
Genetic analysis indicates that there is little gene flow between the Auckland Island populations and southwestern Australia population and other wintering grounds, highlighting the uniqueness of this New Zealand population (Patenaude 2000). The uniqueness and restricted breeding size range however makes the southern right whale very vulnerable. Vocalizations are important communication between conspecifics, especially between mother and calf (Clark 1983). Ship strikes and incidental entanglements in fishing gear has been identified by the International Whaling Commission as the most significant causes of human-induced mortality in right whales (IWC 2001).

There has been no investigation into the effects of anthropogenic noise, ship strike or entanglement in fishing gear in southern right whales but have been investigated in the Northern Atlantic Right Whales. The recovering North Atlantic right whale population began declining once again around 1992 (Fujiwara &Caswell 2001). The decline is most likely a result from the cumulative impacts of pollution, ecosystem effects of fishing, climate change and other human related impacts (Fujiwara &Caswell 2001; NOAA 2008).

Northern right whales in the western North Atlantic number about 300 animals and from 1970-1999, 45 right whale deaths were reliably documented of which 16 were due to ship collisions and 3 due to entanglement in fishing gear (Knowlton & Kraus 2001). There have been 18 probable fishing entanglement mortalities since 1986 and more than 75% of live whales have fishing entanglement scars (Waring et al 2010). Vessel strike is also a major problem in the North Atlantic of which there have been over 24 NARW deaths from ship strike since 1970 (NOAA 2008; Waring et al 2010). Reducing vessel speed and adjusting shipping routes have been implemented in order to reduce this problem (NOAA 2008). Vocalisations are also important in the NARW population, however their

effective area for communication has reduced by over 90% over the last 100 years probably as a result from surrounding anthropogenic noise (Parks et al 2007). There is evidence that exposure to low-frequency ship noise may be associated with chronic stress in the NARW which has implications for all baleen whales in heavy ship traffic areas (Rolland et al 2012).

Present day threats to southern right whales include fishing, coastal development, human harassment and the potential unknown effects of low genetic diversity (Patenaude 2002). Genetic modelling of historical whaling suggests that the current low mtDNA diversity of the New Zealand southern right whale is likely the outcome of a severe and prolonged bottleneck (Patenaude 2002). Deep sea oil development around New Zealand will expose SRW to noise pollution, potential oil spills, chemical pollution, boat collisions and entanglement with or ingestion of marine debris which is likely to either limit or prevent the recovery of the already declined population of SRW around mainland New Zealand and in the Auckland/Campbell islands.



Confirmed SRW sightings 2003-2011 (Rayment per comm 2012).

Toothed Whales

Hector's dolphin, Maui's dolphin and Bottlenose dolphin

(Cephalorhynchus hectori) – Endangered (ICUN 2012);
(Cephalorhynchus hectori maui) – Critically endangered (DOC) and
(Tursiops truncatus) – Least Concern (ICUN 2012) respectively

Hectors and Maui's dolphin are endemic to New Zealand. They are two different subspecies; Hectors dolphin occurs principally in South Island waters and the Maui's dolphin occurs in the north-west coast of the North Island. Maui's dolphins are recognised as a separate subspecies from the Hector's dolphin based on genetic and morphological differences. Hector's dolphins are referred as a taonga by Maori. The Department of Conservation threat status concludes that Hector's dolphin is "nationally endangered" and that Maui's dolphin is "nationally critical" (Slooten et al. 2006). The Maui's dolphin population is very small of only an estimated 111 individuals and has a restricted distribution between Taranaki and Northland (Slooten et al. 2006).

Hectors dolphin consists of three genetically distinct and geographically isolated populations which are found on the east coast of the South Island, the west coast of the South Island and the south coast of the South Island. The population estimate for Hectors dolphin is 7,270 individuals (95% CI: 5303- 9966). Hectors dolphins are an inshore coastal species with a limited home range, are short-lived (20 years), have a low reproductive rate (1 calf every 2-4 years) and late onset of sexual maturity (7-9y years). Population growth models suggest that the population growth rate is approximately 1.8% per year meaning Hector's are threatened by very low levels of mortality. Even under ideal circumstances a population of 100 individuals would only grow by 1-2 animals a year at the most.

Threats to Hectors and Maui dolphin include: bycatch in trawling and gillnetting, drowning by ghost nets, habitat degradation, pollution, boat collision, tourism and invasive research. Bycatch was estimated to be 110-150 between 2000-2006 in just commercial gillnets which is vastly unsustainable (Davies et al 2008). The Threat Management Plan identifies bycatch in gillnet and trawl fisheries as the number one threat for New Zealand dolphins (Slooten 2012).

Marine Mammal Sanctuaries have been established to protect Hector's/Maui dolphins on (Weeber 2011):

- West Coast of the North Island (between Maunganui Bluff in Northland to Oakura Beach, Taranaki). The sanctuary's offshore boundary extends from mean high water springs to the 12 nm territorial sea limit.
- Clifford and Cloudy Bay extends from Cape Campbell to a point 12 nm offshore in a direct line to Tory Channel.
- Banks Peninsula – from Rakaia River around Banks Peninsula to the Mouth of the Waipara River and 12 nm offshore.
- Catlins Coast - from Three Brother's Point offshore 5 nm to a point 6.9 nm offshore to Bushy Point Beacon.
- Te Waewae Bay – inside a line from Pahia point to Sand Hill Point.

A long term study on the Banks Peninsula Marine Mammal Sanctuary shows a 5.4% increase in survival rates and has slowed the previous rapid population decline (Slooten 2012). This sanctuary provides evidence that area-based management can work if the designated protected area is the right size, in the correct place, manages and/or removes key threats and when no new threats are added (e.g maring mining) (Slooten 2012). In other areas, New Zealand dolphin populations are still predicted to decline under current management (Slooten 2012). This is the result of dolphins still being caught as bycatch in areas with no, little or inadequate protection measures (north and west coasts in South Island) (Slooten 2012). Extending protection to further cover the NZ dolphin habitat (100m depth contour) would reduce fishing related mortality and increase population recovery (Slooten 2012).

Open-population capture–recapture models based on microsatellite genotyping of living and dead dolphins sampled between January 2001 and November 2007 suggest that the Maui's population was likely to be declining across the study period (could not be confirmed with 95% confidence) (Baker et al. 2012). Dead carcasses from both fishing-related mortality and non-anthropogenic mortality were found highlighting the potential for stochastic events and inbreeding effects in the small population place a high priority on eliminating any human activity related mortality (Baker et al. 2012). Both Hectors and Mauis dolphin show high site fidelity which makes them vulnerable to threats such as fishing, tourism and mining within their habitats (MOF and DOC 2007).

Bottlenose dolphins are widely distributed throughout the world in cold temperate and tropical seas. In New Zealand they and are found in three main areas: the eastern North Island (Doubtless Bay to Tauranga); the north of the South Island (Cloudy Bay to Westport); and Fiordland, which holds the biggest group of bottlenose dolphins in Doubtful Sound (Hutching 2009). They are a coastal species and feed mostly on inshore bottom-dwelling fish and invertebrate species close to the shore (DOC na). They also feed on water fish species and oceanic squid offshore. Due to the coastal and inquisitive nature they are vulnerable to human-activities and impacts, especially marine mammal tourism and boat strike (DOC na). Bottlenose dolphins tend to travel in groups of about 30 individuals close to shore (DOC na).

The population in Doubtful Sound previously had been shown to be in decline however in recent years from 2009-2012 this population now appears to have increased in abundance (Henderson 2012).

Image: Bottlenose dolphins
(Photo by Stuart Westmorland/Corbis from
http://www.guardian.co.uk/environment/2008/jun/07/bottlenose.dolphin)

Deep sea oil development – how it may threaten bottlenose, Hector's and Maui's dolphin

Increase in boating traffic: Several shore and boat based studies on bottlenose, common and Hectors dolphin have indicated that dolphins show behavioural changes in response to approaching vessels and to the intensity of vessel traffic. (Samuels et al., 2003). In the presence of boats, hectors dolphins form more compact groups. Such behaviour Is also observed when they are surprised or threatened (DOC & MOF 2007). Observations suggest interactions with boats even if approached might be stressful (DOC & MOF 2007). Hectors and bottlenose dolphins show both attraction to vessels (usually at initial stage of encounter) or aversion (in later stages in ecounters) or equivocal behaviour (Bejder et al., 1999). In bottlenose dolphins in the northeast island, resting behaviour decreased and milling behaviour increased when boats were present (Constantine et al. 2003). In Milford Sound, males bottlenoses avoid tourist boats as soon as they were present, while females employ a diving vertical avoidance strategy only when interactions become intrusive (Lusseau 2003)

Dolphins that spend a great deal of time and energy either avoiding or interacting with boats may result with reduced biological fitness or displacement of individuals from an area. Consequently this causes disrupted energy budgets, reduced breeding, feeding and/or resting activities (DOC & MOF 2007).

Noise: It is possible that noise disturbance from boats, sonar or mining may interfere with the dolphins communication systems and social interactive behaviours, ability for them to locate their prey or result in exclusion from ecologically important areas (DOC & MOF 2007). There is not enough known for whether noise, from increased boat trafficking and deep sea oil development will be a serious problem for Hectors, common or bottlenose dolphin (DOC & MOF 2007). Due to the current population status of Maui's dolphin additional threats pose a great risk to the continual survival of the species.

The use of sonar during deep sea oil development has the real potential to negatively impact upon these echolocating dolphins. Bottlenose, Hector's and Maui's dolphin use sound for communication, navigation, and hunting. Mooney et al. (2008) found that intense sonar pings induce a temporary threshold shift in the hearing of bottlenose dolphins. Mooney et al (2009) using controlled experimental studies, showed that mid-frequency sonar can induce temporary hearing loss in a bottlenose dolphin. Thus Mooney et al (2009) demonstrated that sonar can induce physiological and behavioural effects in bottlenose dolphins. These exposures must be of prolonged, high sound exposures levels to generate these effects on the bottlenose dolphins (Mooney et al. 2008; 2009). The sonar used in the deep sea oil prospecting and exploration phases' match these criteria and hence is likely to generate these effects in bottlenose dolphins. Temporary deafness can leave these dolphins disorientated, increasing the risk for dolphins to accidently swim into gill or trawl nets, shallow areas or be washed ashore.

Recently, in 2012, there has been a mass stranding and die-off event of dolphins, which included bottlenose dolphins off Peru's northern coast (Fraser 2012). The death toll, which could be as high as 2,800 are still yet to be determined (Fraser 2012). Some of the animals examined showed middle-ear haemorrhaging, fracture of the ear's periotic bone, lung lesions and bubbles in the blood which suggests that high levels of acoustic impact caused these injuries but not immediate death (Fraser 2012). Many of the animals which beached were alive before they died (Fraser 2012). "The animal would become disoriented, would have intense pain, and would have to make a great effort to breathe," said veterinarian Carlos Yaipén (Fraser 2012). Brandon Southall , former director of NOAA's ocean acoustics program, said the injuries shown on the dolphins stranded in Peru would be "atypical, but not impossible" for an acoustic-related stranding (Fraser 2012).Several oil leases under exploration are located off the coast of Peru where the strandings occurred, however, it is not clear whether sonar testing had occurred (Fraser 2012). Other experts suggest that pollution may have played a role while others say there is not enough evidence to determine a true cause of injury and death (Fraser 2012).

Most odontocetes hearing sensitivity decreases below 2 kHz (Department of the Navy 2007). Hence it is unlikely for sonars emitting a particular frequency that a cetacean hears poorly or not at all, to have a significant behavioural of physiological impact upon the cetacean (Ketten 2001). Nedwell et al., (2004) and the within the Final Supplemental Environmental Impact Statement For Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar Report (Department of the Navy 2007) suggest that low frequency transmissions from low frequency sonar are unlikely to have major impacts upon animals which have poor low frequency hearing such as beaked whales, bottlenose dolphins and orcas (summarized in: Nedwell et al., 2004). Bottlenose dolphins are generally assumed to have a functional hearing range of 100 Hz to 150 kHz (Brill 2001).

An underwater experiment by Turl (1993) however suggests that the bottlenose dolphins in the Atlantic may detect low-frequency sounds, to as low as 50Hz by some mechanism other than conventional hearing, potentially detecting particle velocity or some combination of pressure and velocity. Hector's dolphins echolocate and vocalise at 115–135 kHz in pitch (Dawson & Thorpe 1990) however their hearing sensitivity has not been researched. The echolocating calls and hearing sensitivity of Maui's dolphins have not been fully researched but they are likely to be similar to the high-pitched, narrow-band, pure tones of low power produced by Hectors dolphin (Jonker & Ferreira 2004). Hydrophones placed within their habitat picked up the echolocating calls from Maui's dolphins of which the frequency signals ranged between 110 and 140 kHz (Jonker & Ferreira 2004). The low-frequency sounds used in prospecting and exploration in deep sea oil development range from 10 Hz- 1000 Hz, of which appears to be well within the range of bottlenose dolphins and hence are likely to have an impact. It is unknown if sonar will have an impact upon Hector's and Maui's dolphin.

Pollution from debris, wastes and oil: The coastal habitat of Hectors dolphin exposes them to a variety of pollutants and contaminants such as organochlorines and heavy metals(DOC & MOF 2007). Hector's dolphin tissue has been found to contain high levels of organochlorines (DDT,PCBs and dioxins) (DOC & MOF 2007). With the proposed areas for deep sea oil exploration, the threat of wastes from drilling and oil spills are present throughout much Hector's, Maui's, common and bottlenose dolphin habitat (DOC & MOF 2007). The risk from hydrocarbon compounds and oil have not been quantified for Hector's and Maui's dolphin (DOC & MOF 2007).

After the Deepwater Horizon oil spill and two environmental perturbations in 2010 there was an unusual number of near term and neonatal bottlenose dolphin (*Tursiops truncatus*) mortalities during the calving season in the northern Gulf of Mexico in 2011 (Carmichael et al. 2012). This data provides strong observational evidence regarding the timing of the Deepwater Horizon oil spill, other environmental stressors and mortality of bottlenose dolphins (Carmichael et al. 2012). Tissue samples and necropsies on stranded dolphins revealed that these dolphins were underweight, anemic, had abonormal hormone levels, low blood sugar and symptoms of liver and lung disease (NOAA). Many bottlenose dolphins including newborn, fetal and stillborn dolphins stranded after the oil spill and still continue to this day.

Figure 2: Hector's and Maui's Dolphin distribution map. DOC & MOF (2007).

Figure 3: Distribution of Bottlenose Dolphins in New Zealand (Hutching 2009)

Beaked whales

(approximately 11 species) – Data deficient (ICUN 2012)

Beaked whales (family Ziphiidae) are among the least known of all cetaceans due to their preference for deep waters, their elusive and shy habits and in some instances possible low abundances (Wilson 1992). Most of the 21 species currently described are from a small number of stranded and dead specimens, with some species never having been seen alive (Dalebout et al. 2004).New Zealand waters hold the highest diversity of beaked whale species (Dalebout et al. 2004) of which there are approximately 11 species (Hutching 2009).

Some of the beaked whales in New Zealand include (Hutching 2009).

- Shepherd's - *Tasmacetus shepherdi*
- Gray - *Mesoplodon grayi*
- Arnoux's / Southern four-tooth - *Berardius arnouxi*
- Cuvier - *Ziphius cavirostris*
- Strap-toothed - *Mesoplodon layardii*
- Southern bottlenose - *Hyperoodon planifrons*
- Andrew's beaked -*Mesoplodon bowdoini*
- Blainville's /Dense-beaked - *Mesoplodon densirostris*
- Gingko-toothed - *Mesoplodon gingkodens*
- Hector's - *Mesoplodon hectori*
- Peruvian - *Mesoplodon peruvianus*

Beaked whales live in the open ocean and feed on squid for which they dive over 300 meters (Hutching 2009). Beaked whales vary from 3-13m in length, have a small head with a bulging forehead and beak. The males of some species have teeth-like tusks which emerge from their bottom jaw (Hutching 2009). As live beaked whales are rarely spotted and hence cannot be studied, research in New Zealand concentrates on stranded whales (Hutching 2009). The most common strandings of beaked whale species in New Zealand are the Gray's beaked whale, which is assumed to be the most common beaked whale within New Zealand; Cuvier's, Arnoux's and the strap-toothed beaked whale (Hutching 2009).

Gray's beaked whales have a circumglobal distribution in the cool-temperate waters of the Southern Hemisphere (Culik 2010). These whales usually occur singly, but groups of around 2-6 have been observed (Dalebout et al. 2004). Chatham Island appears to be a hot spot for Gray's whale strandings, where there have been at least four recorded mass stranding events, of which one in 1874 involved the stranding of approximately 25 animals (Dalebout et al. 2004).. These events suggest that there may be some social organisation in Gray's

whales (Martin 1990). Due the uncommonness of strandings and lack of sightings, the Gray's whale is not considered to be abundant (Bannister et al. 1996).

Cuvier's beaked whales range from equatorial tropical to cold-temperate waters and tend to be found over and near the continental slope (Allen et al. 2012). Studies from across the world suggest that small resident populations exist in various locations with individuals showing site-fidelity within the populations (Allen et al. 2012). There is a great deal of morphological variation in Curviers beaked whales around the world including regional pigmentation pattern and osteological cranial characters differences (Heyning 1989). Worldwide, stomach content analysis has shown that cephalopods compromise the bulk of the Curvier's diet. Tagging studies off the Canary islands suggest that Cuvier's beaked whales dive to an average depth of 1070m which last 58 minutes long, during which time they make approximately 30 attempts to capture prey, using echolocation, for each dive (Tyack et al. 2006; (Allen et al. 2012). Shipping noise may disrupt the normal behaviour of Cuvier's whales (Aguilar de Soto et al. 2006).

All over the world, mass strandings of beaked whales have been reported in scientific literature since 1874 (D'Amico et al. 2009). Many of these strandings in the last few decades have coincided with naval active sonar exercises using mid-frequency sonar (usually defined as operating at frequencies between 3 to 14kHz) (D'Amico et al. 2009). Beaked whales are one of the most susceptible group of species to certain anthropogenic noises (Tyack et al. 2006; D'Amico et al. 2009).Grays, Cuvier's and Blainville's beaked whales are all commonly involved in mass stranding events, especially in association with sonar (Tyack et al. 2006; D'Amico et al. 2009). Exposure to sonar has been determined to be the probable cause in beaked whale stranding events in: Greece 1996 (Frantzis1998), Bahamas 2000 (National Oceanographic and Atmospheric Administration and US Department of the Navy 2001), Madeira 2000 (Freitas 2004), and Canary Islands 2002 (Ferna´ndez et al. 2005). Over 40 mass stranding events (two or more individuals) of Cuvier's beaked whales since 1960 have been reported worldwide, of which about 70% has been associated with naval manoeuvres, use of active military sonar or seismic surveys (International Whaling Commission 2005, Weilgart 2007).

When exposed to sonar, tagged Blainville beaked whales stopped echolocating during their deep foraging dives and ascended slowly and moved away from the exposed area (Tyack et al. 2006),. Whales only return to the exposed area 2-3 days after the sonar exercises ceased, suggesting that sonar leads to foraging disruption and avoidance behaviour (Tyack et al. 2006). Changes in dive behaviour, such as frightened rapid ascents in response to noise exposure may result in injuries such air bubbles in the blood and tissues and decompression sickness (Tyack et al. 2011; (Allen et al. 2012). In the mass stranding event in the Bahamas in 2000, stranded whales had haemorrhaging around the brain, in the inner ears, and in the acoustic fats/melon (fats required for echolocating) (National Oceanographic and Atmospheric Administration and US Department of the Navy 2001; Weilgart 2007). In

response, the US Navy and the National Oceanic and Atmospheric Administration in their interim report concluded that “an acoustic or impulse injury . . . caused the animals to strand . . . and subsequently die as a result of cardiovascular collapse . . .’’ and that ‘‘. . . tactical mid-range frequency sonars aboard U.S.Navy ships that were in use during the sonar exercise in question were the most plausible source of this acoustic or impulse trauma”) (National Oceanographic and Atmospheric Administration and US Department of the Navy 2001). The exact mechanisms by which beaked whales are killed or injured by anthropogenic noise still remains a mystery (Cox et al. 2006). However, it is evident from these studies and other studies that exposure to military sonar increases the probability of individual and mass lethal stranding, especially in beaked whales from either traumatic injuries caused by exposure to particular loud sonar frequencies or mediated by a behavioural response, such as a change in diving pattern (Tyack et al. 2011; Allen et al. 2012).

As beaked whales are highly sensitive to anthropogenic noise, increased boating traffic, underwater noise from drilling and seismic surveys from deep sea oil development in New Zealand are highly likely to result in avoidance behaviour or cause mass strandings events which could be very detrimental to these species of which nothing is known about their population statuses.

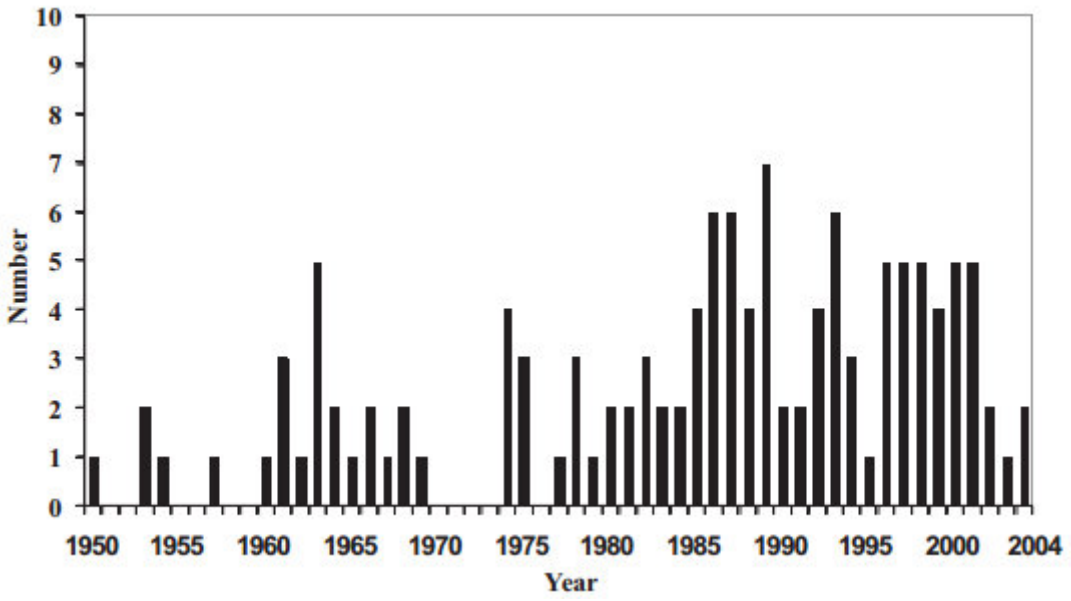


Figure 4: Number of global recorded beaked whale mass stranding events by year from 1950 to 2004 from D’Amico et al. (2009)

Sperm whale

(Physeter macrocephalus) – Vulnerable (ICUN 2012)

In New Zealand, sperm whales are found at Kaikoura, around Stewart Island, off the East and North Cape and around the west of New Zealand (Hutching 2012). Sperm whales dive deep into deep ocean trenches (reaching depths of 3 kilometres) where they find their prey by echolocation (Hutching 2012). In some populations, sperm whales spend about 80% of their time underwater where they are clicking almost continuously (Douglas & Dawson 2005).

Kiakoura has a deep-water canyon, which plunges 1,000 metres and, just 4.5 kilometres close to the shore and is a foraging ground for about 80 bachelor sperm whales (Hutching 2012). About half of these whales remain at Kaikoura for more than one season while others move on. Sperm whales here feed mainly on giant squid, groper, ling and other fish species (Hutching 2012).

Image: Sperm whale
(from http://www.thesun.co.uk/sol/homepage/showbiz/tv/2727665/Heston-Blumenthal-serves-up-whale-vomit-for-Christmas-show.html)

Males and females live mostly separately (Hutching 2012). Groups of around 50 closely related whales form which consist of several females and immature whales of both sexes (Hutching 2012). These whales can live together for up to ten years and lead a cooperative lifestyle (Hutching 2012). Young males leave these groups between 7-10 years where they will form bachelor groups (Hutching 2012). As they mature into adults, they will become increasingly more solitary (Hutching 2012).

Sperm whales have shown mixed reactions to seismic survey noise. In polar waters, exposure to distant seismic pulses, sperm whales did not elicit observable avoidance behaviours nor did they change their normal clicking patterns (Madsen et al. 2002). Stone (1998; 2000) reported that there was no change in sperm whale sighting rates with seismic surveys. In contrast, in the Gulf of Mexico, there appeared to be a negative correlation between seismic surveys and the presence of sperm whales (Mate et al. 1994). In the Indian ocean, possibly in response to seismic survey pulses, sperm whales ceased clicking (Bowles et al. 1994)

Sperm whales also appear to be impacted by the presence of boats. Richer et al. (2003) reported that several aspects of sperm whale behaviour in Kaikoura were significantly affected by the presence of whale watching boats which included: decreased blow interval, increased surface time, increase in the frequency and amount of heading changes, decrease in time to first click and more frequent aerial behaviours. Reactions to the boats varied with season and among individuals, with some whales being more tolerant than others (Richter et al. 2003). The increase in boating traffic in areas with sperm whales is hence likely to result in changed behaviour.

More on New Zealand whales

Pilot whales and false killer whales are species which are known to strand frequently and have been recorded to do so before the industrial revolution (Weilgart 2007). Strandings may occur if animals are ill, diseased, injured, if animals get stuck in shallow waters due to the tides or from trying to escape from a predator (Weilgart 2007). Mass strandings can occur when other members of the herd follow stranded individuals for any of the above reasons (Weilgart 2007).

It is not always clear why mass stranding occurs, but scientists say it appears to become more common for pilot whales in the South Island in New Zealand when they pass our waters during their summer migration to and from Antarctic waters (Karimjee 2012).

Reduced calling rates or a complete pause of vocalizations has been documented for fin whales in response to boat noise (Watkins 1986), for sperm whales in response to military sonar (Watkins et al. 1985), for pilot and sperm whales in response to low-frequency ATOC-like sounds and seismic surveys (Bowles et al. 1994).

Conclusion

Any oil spill will have a dramatic impact in terms of actually exposing the whales to toxic substances, as well as their food sources. However, the continual discharge of waste mud and debris from the drilling rigs will potentially cause localized toxic and harmful effects.

The stress, changes in behaviour and physiological effects that will come from increased boating traffic, drilling and seismic surveys are things of concern especially for New Zealand cetaceans. Whales which have previously shown increased stress, avoidance, behavioural and/or physiological

responses to noise pollution include: Hector's, Maui's, bottlenose, humpback. Blue, fin, beaked whales, pilot and sperm whales.

Whales which show high site fidelity or have important breeding sites in particular localised areas such as Hectors, Maui, Bottlenose and Southern Right Whale will be more vulnerable to deep sea oil development as they will continue to remain in the area despite the additional stress and consequences. Many whales throughout New Zealand waters already have either have a low population size or already face a number of threats such as fishing bycatch, entanglement in fishing gear, boat strike or the negative impacts of tourism. Deep sea oil development will be an additional major threat for many whale populations. For those critically endangered species such as the Maui dolphin, the additional threats which come with deep sea oil development may send this population into extinction.

References

A centre for Biological Diversity Report. 2011. From Centre for Biological Diversity. A Deadly Toll: The Gulf Oil Spill and the unfolding wildlife disaster. Accessed on 30/08/12 from http://www.biologicaldiversity.org/programs/public_lands/energy/dirty_energy_development/oil_and_gas/gulf_oil_spill/a_deadly_toll.html

Aguilar de Soto, N, Johnson M, Madsen PT, Tyack P L, Bocconcelli A & Borsani F. 2006. Does intense ship noise disrupt foraging in deep diving Cuvier's beaked whales (Ziphius cavirostris)? Marine Mammal Science, 22 (3), 690-699.

Allen BM, Brownell RL, Mead JG. 2012. Species review of Cuvier's beaked whale, Ziphius cavirostris. Accessed on 20/10/12 from http://iwcoffice.org/cache/downloads/ejns600wgnsc8c0c088cckckw/SC-63-SM17.pdf

Baker CS, Chilvers BL, Constantine R, DuFresne S, Mattlin RH, van Helden A, Hitchmough R. 2010. Conservation status of New Zealand marine mammals (suborders Cetacea and Pinnipedia), 2009, New Zealand Journal of Marine and Freshwater Research, 44:2, 101-115

Baker CS, Hamner RM, Cooke J, Heimeier D, Vant M, Steel D, Constantine R. 2012. Low abundance and probable decline of the critically endangered Maui's dolphin estimated by genotype capture–recapture. Animal Conservation. Print ISSN 1367-9430

Bannister JL, Kemper CM, Warneke RM. 1996. The Action Plan for Australian Cetaceans. [Online]. Canberra: Australian Nature Conservation Agency. Available from:http://www.environment.gov.au/coasts/publications/cetaceans-action-plan/pubs/whaleplan.pdf.

Bejder LSM, Dawson S, and Harraway JA. 1999. Responses by Hector's dolphins to boats and swimmers in Porpoise Bay, New Zealand. Marine Mammal Science 15(3): 738-750.

Bello J. 2007. Drilling in Bristol Bay Could Be Nail in the Coffin for World's Most Endangered Whale Population. Accessed on 17/10/12 from http://worldwildlife.org/press_releases/drilling-in-bristol-bay-could-be-nail-in-the-coffin-for-world-s-most-endangered-whale-population

Best P. 1994 Seasonality of reproduction and the length of gestation in southern right whales Eubalaena australis. Journal of Zoology 232: 175-189

Bowen WD. 1997. Role of marine mammals in aquatic ecosystems. Marine Ecology Progress Series 158; 267-274.

Bowles AE, Smultea M, Wu¨rsig B, DeMaster DP, and Palka D. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. J. Acoust. Soc. Am. 96: 2469–2484. doi:10.1121/1.410120. PMID:7963037.

Bowles AE, Smultea M, Würsig B, DeMaster SP and Palka D. 1994. Relative abundance and behavior of marine mammals exposed to transmissions from the Heard Island Feasibility Test. Journal of the Acoustical Society of America 96, 2469–2484.

Brill R, Moore PWB, Dankiewicz L. 2001. Assessment of dolphin (Tursiops truncatus) auditory sensitivity and hearing loss using jawphones. J. Acoust. Soc. Am. Volume 109, Issue 4, pp. 1717-1722

Carmichael RH, Graham WM, Aven A, Worthy G, Howden S (2012) Were Multiple Stressors a 'Perfect Storm' for Northern Gulf of Mexico Bottlenose Dolphins (Tursiops truncatus) in 2011? PLoS ONE 7(7): e41155. doi:10.1371/journal.pone.0041155

Carroll E, Patenaude N, Alexander A, Steel DJ, Harcourt R, Childerhouse S, Smith S, Bannister JL,Constantine R, Baker CS. 2011. Population structure and individual movement of southern right whales around New Zealand and Australia. Marine Ecology Progress Series. 432:257-268

Castellote M, Clark CW, Lammers MO. 2010. Acoustic compensation to shipping and airgun noise by Mediterranean fin whales (Balaenoptera physalus). J. Acoust. Soc. Am. 127; 1726-1726

Castro C, Kaufman G, Maldini D. 2010. A preliminary review of skin conditions and other body anomalies observed on humpback whales (Megaptera novaeangliae) from Ecuador.

Clark CW. 1983. Communication and Behavior of the Southern Right Whale (Eubalaena australis). In Communication and Behavior of Whales (R. Payne, ed.). AAAS Selected Symposium 76. Westview Press; Boulder, Colorado, pp. 163-198.

Constantine R, Brunton DH and Baker CS. 2003. Effects of tourism on behavioural ecology of bottlenose dolphins of northeastern New Zealand. Department of Conservation, Wellington.

Cox, T.M., Ragen, T.J., Read, A.J., Vos, E., Baird, R.W., Balcomb, K., Barlow, J., Caldwell, J., Cranford, T., Crum, L., D'Amico, A., D'Spain, G., Ferna´ndez, A., Finneran, J., Gentry, R., Gerth, W., Gulland, F., Hildebrand, J., Houser, D., Hullar, T., Jepson, P.D., Ketten, D., MacLeod, C.D., Miller, P., Moore, S., Mountain, D., Palka, D., Ponganis, P., Rommel, S., Rowles, T., Taylor, B., Tyack, P., Wartzok, D., Gisiner, R., Mead, J., and Benner, L. 2006. Understanding the impacts of anthropogenic sound on beaked whales. J. Cetacean Res. Manag. 7: 177–187.

Culik B. 2010. Odontocetes. The toothed whales: "Mesoplodon grayi". UNEP/CMS Secretariat, Bonn, Germany. http://www.cms.int/reports/small_cetaceans/index.htm

D'Amico A, Gisiner RC, Ketten DR, Hammock JA, Johnson C, Tyack PL, and Mead J. 2009. Beaked whale strandings and naval exercises. Aquat Mamm 34: 452–472

Dahlheim, M. E. and 0 von Ziegesar. 1993. Effects of the Enon Vukfez oil spill on the abundance and distribution of humpback whales (Megqreru novaeangliue), in Prince William Sound. Enon Vukiez Oil Spill State/Federal Natural Resource Damage Assessment Final Report (Marine Mammal Study Number l), U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Seattle, Washington.

Dalebout ML, Baker CS, Mead JG, Cockcroft VG, Yamada TK. 2004. A Comprehensive and Validated Molecular Taxonomy of BeakedWhales, Family Ziphiidae. Journal of Heredity 95(6):459–473

Davies NM, Bian R, Starr P, Lallemand P, Gilbert D, McKenzie J. 2008. Risk analysis for Hector's Dolphin and Maui's dolphin. Report for Ministry of Fisheries.

Dawbin, W H. 1956. The migrations of humpback whales which pass the New Zealand coast. Transactions of the Royal Society of New Zealand 84 : 147-196.

Dawson SM, Thorpe CW. 1990: A quantitative analysis of the sounds of Hector's dolphin. Ethology 86: 131–145.

Department of the Navy. 2007. Executive Summary Final Supplemental Environmental Impact Statement for Surveillance Towed Array Sensor System Low Frequency Active (SURTASS LFA) Sonar. Accessed on 19/10/12 from http://www.surtass-lfa-eis.com/docs/SURTASS_LFA_FSEIS.pdf

DOC & MOF 2007. Hector's Dolphin Threat Management Discussion Document . Ministry of Fisheries and the Department of Conservation, Wellington.

DOC (n.d) Facts about bottlenose dolphin Accessed on 19/10/12 from http://www.doc.govt.nz/conservation/native-animals/marine-mammals/dolphins/bottlenose-dolphin/facts/

Douglas LA and Dawson SM. 2005. Click rates and silences of sperm whales at Kaikoura, New Zealand. J. Acoust. Soc. Am. 118; 523–529.

Elwen, S.H., & Best, P.B. (2004). Environmental factors influencing the distribution of southern right whales (Eubalaena australis) on the south coast of South Africa I: Broad scale patterns. Marine Mammal Science 20(3): 567-582

Endo T, Haraguchi K, Cipriano F, Simmonds MP, Hotta Y and Sakata M. 2004. Contamination by mercury and cadmium in the cetacean products from the Japanese market. Chemosphere 54:1653-1662

Engel MH, Marcondes MCC, Martins CCA, Luna FO, Lima RP, and Campos A. 2004. Are seismic surveys responsible for cetacean strandings? An unusual mortality of adult humpback whales in Abrolhos Bank, northeastern coast of Brazil. Paper SC/56/E28 presented to IWC Scientific Committee, Sorrento, Italy (unpublished). [Available from the Office of the Journal of CetaceanResearch and Management.]

FC Jonker and. Ferreira SM. 2004. Can echolocation devices be used to define harbour use by Maui's dolphins? Department of Conservation, Wellington.

Ferna´ndez, A, Edwards JF, Rodrı´guez F, Espinosa de los Monteros A., Herra´ez P, Castro P, Jaber JR, Martı´n V, and Arbelo M. 2005. ''Gas and fat embolic syndrome'' involving a mass stranding of beaked whales (family Ziphiidae) exposed to anthropogenic sonar signals. Vet. Pathol. 42: 446–457. doi:10. 1354/vp.42-4-446. PMID:16006604.

Fernandez A, Edwards JF, Rodriguez F, Espinosa de los Monteros A, Herraez P, Castro, P, Jaber JR, Martin V, and Arbelo, M. 2005. "Gas and fat embolic syndrome" involving a mass stranding of beaked whales (Family Ziphiidae) exposed to anthropogenic sonar signals. Vet Pathol 42:446–457.

Frantzis, A. 1998. Does acoustic testing strand whales? Nature (London), 392: 29. doi:10.1038/32068. PMID:9510243

Fraser B. 2012. Thousands of dolphins may have died in Peru's massive die-off; cause could remain mystery. Accessed on 19/10/12 from http://www.environmentalhealthnews.org/ehs/news/2012/perus-dolphin-die-off

Freitas L. 2004. The stranding of three Cuvier's beaked whales Ziphius cavirostris in Madeira archipelago. In Proceedings of the Workshop on Active Sonar and Cetaceans, Las Palmas, Gran Canaria, 8 March 2003. Edited by P.G.H. Evans and L.A. Miller. European Cetacean Society Newsletter No. 42, Special Issue. pp. 28–32.

Fujise, Y, Honda K, Tatsukawa R, and Mishima S. 1988. Tissue distribution of heavy metals in Dall's porpoise in the northwestern Pacific. Marine Pollution Bulletin 19: 226-30.

Fujiwara M, and Caswell H. 2001. Demography of the endangered North Atlantic right whale. Nature, 414(6863): 537–541. doi:10.1038/35107054. PMID:11734852.

Geraci JR and Aubin D. 1988. Synthesis of Effects of oil on marine mammals. Battelle Ocean Sciences, California.

Gibbs N and Childerhouse S. 2000. Humpback whales around New Zealand. Department of Conservation, Wellington.

Henderson S. 2012. Abundance and survival of bottlenose Dolphins in Doubtful Sound and Dusky Sound – 2009 – 2012. Department of Conservation, Wellington.

Heyning JE, 1989. Cuvier's beaked whale Ziphius cavirostris G. Cuvier, 1823. pp. 289-308 in: Ridgway, S. H. and Harrison, R. J. (eds) Handbook of Marine Mammals, volume 4: River dolphins and the larger toothed whales, Academic Press, London.

Hutching G. 2009. 'Dolphins', Te Ara - the Encyclopedia of New Zealand, updated 24-Sep-11 URL: http://www.TeAra.govt.nz/en/dolphins/4/1

International Whaling Commission. 2005. Report of the scientific committee. Annex K. Report of the Standing Working Group on environmental concerns. J. Cetacean Res. Manag. 7(Suppl.): 267–305.

IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. <www.iucnredlist.org>. Downloaded on 28 August 2012.

IWC 2001: Report of the workshop on the comprehensive assessment of right whales: a worldwide comparison. Journal of Cetacean Research and Management Special Issue 2: 1–60

Jotman 2009. Turkish ship spills oil off Madagascar, humpback whales dying. Accessed on 31/08/12 from http://jotman.blogspot.co.nz/2009/09/turkish-ship-spills-oil-off-madagascar.html

Kakuschke A and Prange A. 2007. The Influence of Metal Pollution on the Immune System A Potential Stressor for Marine Mammals in the North Sea. International Journal of Comparative Psychology, 20: 179-193

Karimjee M. 2012. New Zealand: 36 pilot whales die after stranding. Accessed on 22/10/12 from http://www.globalpost.com/dispatch/news/regions/asia-pacific/120124/new-zealand-36-pilot-whales-die-after-stranding-video

Ketten D. 2001. Congressional Testimony House Resources Committee, Subcommittee on Fisheries Conservation, Wildlife and Oceans Hearing: Marine Mammal Protection Act/Low Frequency Sonar. October 11, 2001.

Knowlton A and Kraus S. 2001. Mortality and serious injury of northern right whales (Eubalaena glacialis) in the western North Atlantic Ocean. J. CETACEAN RES. MANAGE. (SPECIAL ISSUE) 2, 193–208

Laist DW, Knowlton A, Mead J, Collet A, Podesta M. 2001. Collisions Between Ships And Whales. Marine Mammal Science 17(1):35–75.

Leonzio C, Focardi S and Fossi C. 1992. Heavy metals and selenium in stranded dolphins of the northern Tyrrhenian (NW Mediterranean). Science of the Total Environment 119: 77-84.

Levine, H., Bildsten, L, Brenner, M., Callan, C., Flatté, S., Goodman, J., Gregg, M., Katz, J., Munk, W., Weinberger, P. 2004. Active Sonar Waveform. JSR-03-200. Report from MITRE Corporation, JASON program, for the Office of Naval Research.

Lusseau D. 2003. Male and female bottlenose dolphins Tursiops spp. have different strategies to avoid interactions with tour boats in Doubtful Sound, New Zealand. Marine ecology progress series 257; p267-274

Madsen PT, Payne R, Kristiansen NU, Wahlberg M, Kerr I, Møhl B. 2002. Sperm whale sound production studied with ultrasound-time-depthrecording tags, J. Exp. Biol. 205, 1899–1906.

Madsen PT, Møhl B, Nielsen BK and Wahlberg M. 2002. Male sperm whale behaviour during exposures to distant seismic survey pulses. Aquatic Mammals 28.3, 231–240

Mate BR, Stafford KM, Ljungblad DK. 1994. A change in sperm whale (Physeter macrocephalus) distribution correlated to seismic surveys in the Gulf of Mexico. Journal of the Acoustical Society of America 96 pt. 2, 3268–3269

McKenna MF. 2001. Blue whale response to underwater noise from commercial ships. In: PhD Thesis in Oceanography at the University of California San Diego. 218 p.

Melcón ML, Cummins AJ, Kerosky SM, Roche LK, Wiggins SM, et al. 2012. Blue Whales Respond to Anthropogenic Noise. PLoS ONE 7(2): e32681. doi:10.1371/journal.pone.0032681

Miller, P.J.O., N. Biasson, A. Samuels, and P.L. Tyack. 2000. Whale songs lengthen in response to sonar. Nature 405: 903.

Mooney TA, Nachtigall PE, Vlachos S. 2008. Intense sonar pings induce temporary threshold shift in a bottlenose dolphin (Tursiops truncatus). The Journal of the Acoustical Society of America 123(5):3618. DOI:10.1121/1.2934830

Mooney TA, Nachtigall PE, Vlachos S. 2009. Sonar-induced temporary hearing loss in dolphins. Biology letters (impact factor: 3.52). 05/2009; 5(4):565-7. DOI:10.1098/rsbl.2009.0099

National Oceanic and Atmospheric Administration (NOAA). Accessed on 30/08/12 from http://www.nmfs.noaa.gov/

National Oceanographic and Atmospheric Administration and US Department of the Navy. 2001. Joint interim report: Bahamas marine mammal stranding event of 15–16 March 2000. US Department of Commerce, Washington, D.C.

Nedwell JRB, Edwards B, Turnpenny AWH, and Gordon J. 2004. Fish and Marine Mammal Audiograms: A Summary of Available Information. September 3, 2004

Nieukirk, S. L., Stafford, K. M., Mellinger, D. K., Dziak, R. P., and Fox, C. G. 2004. Low-frequency whale and seismic airgun sounds recorded in the mid-Atlantic Ocean. Journal of the Acoustical Society of America 115(4): 1832-1843.

NOAA. 2008. Endangered Fish and Wildlife; Final rule to implement speed restrictions to reduce the threat of ship collisions with North Atlantic right whales (10 October 2008). Federal Register Vol. 73. No. 198. pp. 60173–60191

Nowachek DP, Thorne LH, Johnston DW, Tyack PL. 2007. Responses of cetaceans to anthropogenic noise. Mammal Review 37; 81–115.

Page HM and Dugan J. 1999. Effect of Offshore Oil Platform structures on the distribution patterns of commercially important benthic crustaceans, with emphasis on the rock crab. Final Technical Summary. U.S Department of the Interior Minerals Management Service. Pacific OCS Region.

Parks SE, Clark C, Tyack P. 2007 Short- and long-term changes in right whale calling behavior: the potential effects of noise on acoustic communication. J. Acoust. Soc. Am. 122, 3725–3731.

Parsons, E.C.M. 1999. Trace metal concentrations in the tissues of cetaceans from Hong Kong's territorial waters. Environmental Conservation 26: 30-40.

Patenaude N. 2000. Southern right whales wintering in the Auckland Islands. Department of Conservation, Wellington.

Patenaude N. 2002. Demographic and Genetic Status of Southern Right Whales at the Auckland Islands, New Zealand. Thesis (PhD--Biological Sciences)--University of Auckland

Patenaude NJ. 2003. Sightings of southern right whales around 'mainland' New Zealand, Department of Conservation, Wellington.

Pirzl R, Patenaude N, Burnell S, Bannister J. 2009. Movements of southern right whales (Eubalaena australis) between Australian and subantarctic New Zealand populations. MARINE MAMMAL SCIENCE, 25(2): 455–461

Popper. A. N. 2003. The effects of anthropogenic sounds on fishes. Fisheries 28 (10): 24-31.

Rayment W. 2012. Personal Communication

Richter CF, Dawson SM, Slooten E.. 2003: Sperm whale watching off Kaikoura, New Zealand: effects of current activities on surfacing and vocalisation patterns. Science for Conservation 219. Department of Conservation, Wellington. 78 p.

Risch D, Corkeron PJ, Ellison WT, van Parijs SM. 2012. Changes in Humpback Whale Song Occurrence in Response to an Acoustic Source 200 km Away. PLoS One; 7(1): e29741.

Rolland RM, Parks S, Hunt KE, Castellote M, Corkeron PJ, Mowacek DP, Wasser SK, Kraus SD. Evidence that ship noise increases stress in right whales. Proceedings of The Royal Society B: Biological Sciences 279:. 17372363-2368

Romano, T.A., M.J. Keogh, C. Kelly, P. Feng, L. Berk, C.E. Schlundt, D.A. Carder, and J.J. Finneran. 2004. Anthropogenic sound and marine mammal health: measures of the nervous and immune systems before and after intense sound exposure. Canadian Journal of Fisheries and Aquatic Sciences 61: 1124-1134.

Samuels, A., L. Bejder, R. Constantine and S. Heinrich. 2003. A review of swimming with wild cetaceans with a special focus on the Southern Hemisphere. In: Gales, N., Hindell, M., Kirkwood, R., (Eds.), Marine Mammals and Humans: Towards a Sustainable Balance. CSIRO Publishing, Collingwood, Australia. pp 265-291. Schrope, M. 2002. Whale death

Sascha K. Hooker et al., 2007. Changes in persistent contaminant concentration and CYP1A1 protein expression in biopsy samples from northern bottlenose whales, Hyperoodon ampullatus, following the onset of nearby oil and gas development, Environmental Pollution doi:10.1016/j.envpol.2007.05.027

Slooten E, Dawson SM, Rayment WJ, Childerhouse SJ. 2006) A new abundance estimate for Maui's dolphin: What does it mean for managing this critically endangered species? Biol Conserv 128: 576-581

Slooten E. 2012. How effective is area-based management in reducing bycatch of the New Zealand dolphin?

Slooten L. 2012. Personal Communication

Sousa-Lima RS, Clark CW. 2008. Modeling the effect of boat traffic on the fluctuation of humpback whale singing activity in the Abrolhos National Marine Park, Brazil. Can Acoustics. 2008;36(1):174–181.

Steiner R. 2012. Affidavit of Richard Steiner.

Stone CJ. 1998. Cetacean observations during seismic surveys in 1997. JNCC Rep. 278. Joint Nature Conserv. Commit., Aberdeen, Scotland. 55 p.+Appendices.

Stone CJ. 2000. Cetacean observations during seismic surveys in 1998. JNCC Rep. 301. Joint Nature Conserv. Commit., Aberdeen, Scotland. 62 p.+Appendices

Todd, S., P. Stevick, J. Lein, F. Marques, and D. Ketten. 1996. Behavioural effects of exposure to underwater explosions in humpback whales (Megaptera novaeangliae). Canadian Journal of Zoology. 74: 1661- 1672.

Turl C. 1993. Low-frequency sound detection by a bottlenose dolphin. J. Acoust. Soc. Am. 94 (5).

Tyack PL, Johnson M, Aguilar de Soto N, Sturlese A, Madsen PT. 2006. Extreme diving behaviour of beaked whale species known to strand in conjunction with use of military sonars. J Exp Biol 209: 4238–4253.

Von Burg, R. and Greenwood, M.R. 1991. Mercury. In: Trace Metals and their Compounds in the Environment (Ed. by E. Merian). VCH Publishers, Weinheim, Germany.

Waring, G.T.; Josephson E, Maze-Foley K, Rosel, PE, Editors. 2010.."NORTH ATLANTIC RIGHT WHALE (Eubalaena glacialis): Western Atlantic Stock".U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments. NOAA Tech Memo (National Marine Fisheries Service) NMFS NE 219: 8–18.

Watkins WA, Moore KE and Tyack P. 1985. Sperm whaleacoustic behaviors in the southeast Caribbean. Cetology, 49: 1–15.

Watkins WA. 1986. Whale reactions to human activities in Cape Cod waters. Mar. Mamm. Sci. 2: 251–262. doi:10.1111/j.1748-7692.1986.tb00134.x.

Weeber B. 2011. Ocean Treasures – what's at stake. Report to Greenpeace.

Weilgart L. 2007. The impacts of anthropogenic ocean noise on cetaceans and implications for management. Can. J. Zool. 85: 1091–1116

Weller, D.W., Y.V. Ivashchenko, G.A. Tsidulko, A.M. Burdin, and R.L. Brownell, Jr. 2002. Influence of seismic surveys on western Grey Whales off Sakhalin Island, Russia in 2001. International Whaling Commission SC/54/BRG14. 15 pp. (unpublished). [Available from the Office of the Journal of Cetacean Research and Management.]

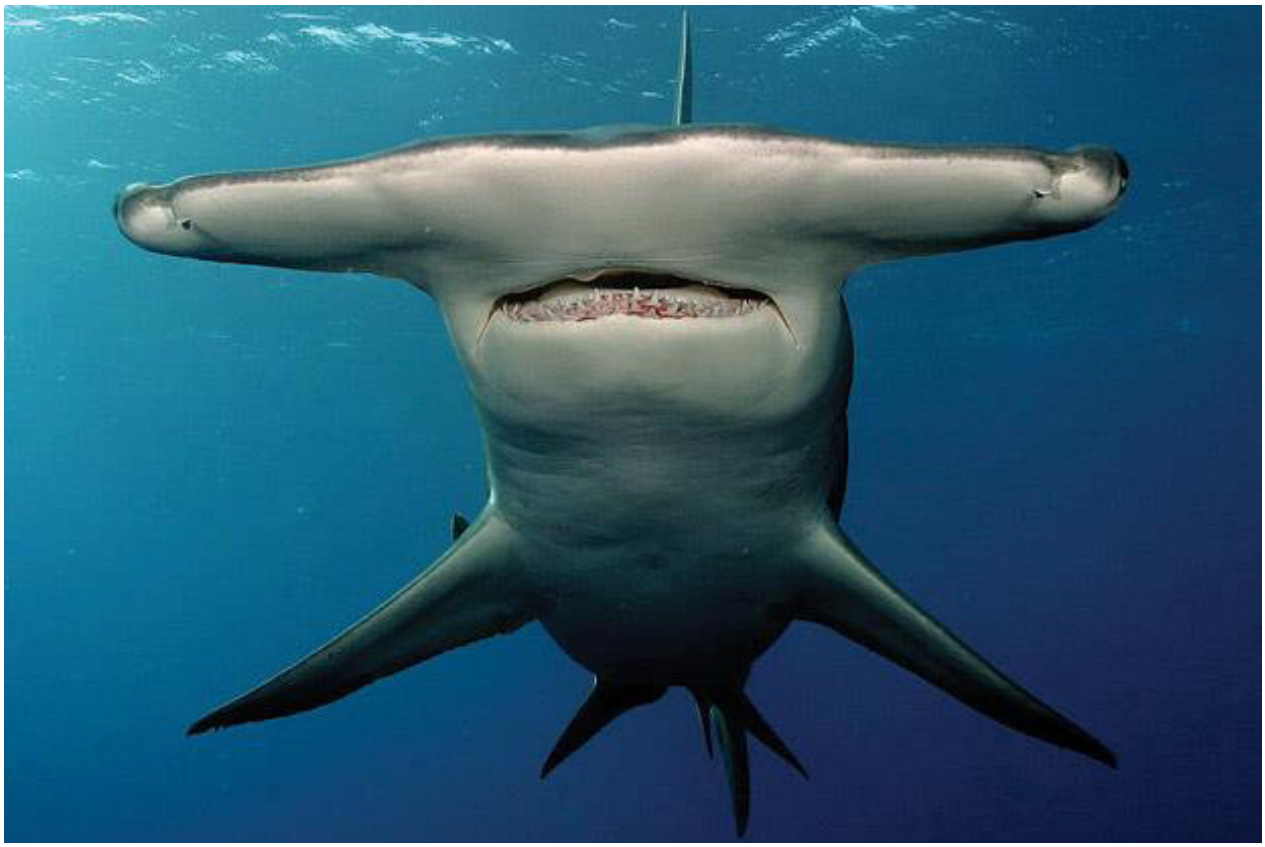
Wiley, D.N., R.A. Asmutis, T.D. Pitchford and D.P. Gannon 1995. Stranding and mortality of humpback whales, Megaptera novaeangliae, in the mid-Atlantic and southeast United States, 1985-1992. Fish. Bull. 93: 196-205.

Williams R, Gero S, Bejder L, Calambokidis J, Kraus S, Lusseau D, Read A, Robbins J. 2011. Underestimating the damage: interpreting cetacean carcass recoveries in the context of the Deepwater Horizon/BP incident. Conservation Letters 4; 228-233

Wilson EO, 1992. Diversity of life. Cambridge, MA: Harvard University Press.

Chondrichthyes in New Zealand waters

By Aniela Reid



Hammerhead shark from the family Sphyrnidae

(Picture by Jim Abernethy from http://www.telegraph.co.uk/earth/earthpicturegalleries/8292997/Sharks-Up-Close-shark-shepherd-Jim-Abernethy-photographs-the-fearsome-predators.html?image=18)

Chondrichthyes within New Zealand

Chondrichthyes or cartilaginous fishes are fish which have skeletons of cartilage rather than bones, have jaws, paired fins, gills and scales (Hutching 2009). The class is divided into two subclasses: Elasmobranchii which includes sharks, rays and skates and Holocephali, the chimaeras (Hutching 2009). New Chondrichthyes species are constantly being discovered, especially those in deep waters (Hutching 2009). New Zealand has a diverse range of sharks, rays, skates and chimeras which occupy habitats ranging from the shore, to the pelagic and deep sea. There are approximately 108 species within New Zealand, of which there are between 15 and 20 sharks and rays that are endemic (Hutching 2009). New Zealand's greatest shark diversity is in the deep water on the upper continental slope (DOC 2006). Many of the dogfish and skate species live below 200 metres depth (DOC 2006). The known sharks, rays and chimaeras in New Zealand waters, sourced and adapted from Cox and Francis (1997) and other sources (Stewart 2001) is as follows:

- Order: Squaliformes (Dogfish sharks)
    - Family: Bramble sharks
        - Species: Bramble shark
          Prickly shark
    - Family: Dogfish
        - Species: Mandarin dogfish
          Spiny dogfish
          Northern spiny dogfish
    - Family: Gulper Sharks
        - Species: Leafscale gulper shark
          Shovelnose dogfish
    - Family: Lantern Sharks
        - Species: Southern lantern shark
          Lucifer dogfish
          Moller's lantern shark
          Smooth lantern shark
    - Family: Sleeper sharks
        - Species: Portugese dogfish
          Longnose velvet dogfish
          Largespine velvet dogfish
          Owston's dogfish
          Plunket's shark
          Whitetail dogfish
          Sherwoood's dogfish

Knifetooth dogfish
Pacific sleeper shark
Little sleeper shark
Velvet dogfish

- Family: Rough sharks
  - Species: Prickly dogfish
- Family: Kitefin sharks
  - Species: Seal shark
    Pygmy shark
    Cookiecutter shark

- Order: Hexanchiformes (Cow and frill sharks)
  - Family: Frill sharks
    - Species: Frill shark
  - Sixgill and sevengill sharks
    - Species: Sharpnose sevengill shark
      Sixgill shark
      Broadnose sevengill shark
- Order: Heterodontiformes (Bullhead sharks)
  - Family: Bullhead sharks
    - Species: Port Jackson shark
- Order: Orectolobiformes (Carpet sharks)
  - Family: Whale sharks
    - Species: Whale shark
- Order: Lamniformes (Mackerel sharks)
  - Family: Sand tiger sharks
    - Species: Sand tiger shark
  - Family: Goblin sharks
    - Species: Goblin shark
  - Family: Crocodile sharks
    - Species: Crocodile shark
  - Family: Thresher sharks
    - Species: Big-eye thresher
      Thresher shark
  - Family: Basking sharks
    - Species: Basking shark
  - Family: Mackerel sharks
    - Species: Great white shark
      Mako
      Porbeagle shark
- Order: Carcharhiniformes (Ground sharks)
  - Family: Cat sharks

        - Species: Carpet shark
            Dawson's cat shark
            McMillan's cat shark
            Cat sharks (6 unnamed species)
    - Family: False cat sharks
        - Species: Slender smoothhound shark
            False cat shark
    - Family: Hound sharks
        - Species: School shark
            Rig shark
    - Family: Requiem sharks
        - Species: Grey reef shark
            Bronze whaler
            Silky shark
            Galapagos shark
            Tiger shark
            Blue shark
    - Family: Hammerhead sharks
        - Species: Hammerhead shark
- Order: Torpediniformes (Electric rays)
    - Family: Sleeper rays
        - Species: Blind electric ray
            Oval electric ray
    - Family: Torpedo rays
        - Species: Electric ray
- Order: Rajiformes (skates)
    - Family: Softnose skates
        - Species: Longtail skate
            Richardson's skate
            Longnose deepsea skate
            Smooth deepsea skate
            Prickly deepsea skate
            Deepsea skates (5 unnamed species)
    - Family: Skates
        - Species: Smooth skate
            Rough skate
- Order: Myliobatiformes (Stingrays)
    - Family: Whiptail stingrays
        - Species: Shorttail stingray
            Longtail stingray
            Pelagic stingray

    - Family: Eagle rays
        - Species: Eagle ray
    - Family: Manta rays
        - Species: Spinetail devil ray
- Order: Chimaeriformes (Chimaeras)
    - Family: Elephant fish
        - Species: Elephant fish
    - Family: Spookfish
        - Species: Smallspine spookfish
          Longnose spookfish
          Pacific spookfish
    - Family: Shortnose chimaeras
        - Species: Dark ghost shark
          Chimaera (4 unnamed species)
          Hydrolagus ghost sharks (4 unnamed species)

Maori and sharks

Several Maori legends and myths relate to sharks. The most famous legend is Ruamano; the ocean taniwha which takes the form of a mako shark (DOC 2006; Hutching 2009). Māori likened their warriors to sharks, refferring to them in battle cries such as: 'Kia mate uruora tātou, kei mate-ā-tarakihi' (let us die like white sharks, not tarakihi fish) (Hutching 2009).

Sharks were, and still are, important in the Māori diet, especially school sharks and rig (DOC 2006; Hutching 2009). Maori also used sharks teeth in necklaces or earrings or were set in wooden handles and used as knives (DOC 2006; Hutching 2009). Mako and great white shark teeth were prized valuable trading items (DOC 2006; Hutching 2009). Shark liver oil was mixed with red ochre to make paint that was used in Maori carvings or mixed with scented shrubs to make scented body oil (DOC 2006; Hutching 2009).

People and sharks

Over the last 50 years, there have been less than 30 reported shark attacks on average each year in the world, of which about seven are fatal (Cox & Francis 1997). Very few shark species attack humans, however the most common species worldwide that have are the Great white, bull shark, tiger shark, blue and oceanic whitetip (Cox & Francis 1997). In New Zealand the species which have attacked humans are the bronze whaler, mako, tiger shark and great white shark. Sharks have attacked humans all over the country for as long as there have been humans. Some of the places where shark attacks have occurred are in Dunedin, Auckland and the Chatham Islands (Cox & Francis 1997).

Around 100million cartilaginous fish worldwide are killed by people each year in recreational and commercial fishing and as bycatch (Cox & Francis 1997). The biggest threat to cartilaginous species in New Zealand is bycatch and fishing, both of which is managed under the Ministry of Fisheries (DOC 2006). The main cartilaginous species caught for fishing in temperate waters over the continental shelves are schooling sharks (spiny dogfish, smooth dogfish, school shark) and skates (Cox & Francis 1997). Oceanic fisheries in warm waters catch mainly blue shark, silky shark, oceanic whitetip, mako and thresher sharks (Cox & Francis 1997). Tropical inshore fisheries catch many hammerheads, sharpnose sharks and rays. The greatest demand for cartilaginous fish is for their meat and fins for shark-fin soup (Cox & Francis 1997). The demand for shark meat and fins poses a serious threat for sharks as the harvest of some species is unsustainable (Perrine 1995). Other reasons sharks are killed is for fear, sport, commercial value for their meat, flesh (for leathers), teeth and jaws for jewellery or ornaments and their liver oil and cartilage for cosmetics and 'medicines' (Perrine 1995).

Anthropogenic noise effects on cartilaginous species

Just like marine mammals, fish also show sensitivity to anthropogenic noise. Most studies looking at the impacts of low frequency active sonar only focus upon cetacean species largely ignoring the effects on sharks and other fish species (Godknecht 2009). Hence, limited research has been conducted on shark, skate and ray responses to boat noise and marine seismic surveys (Environmental Defense Center 2004). As cartilaginous fish have no accessory organs of hearing such as a swim bladder, they are unlikely to respond to acoustical pressure (Myrberg 2001; Environmental Defense Center 2004). The lateral line system does not respond to normal acoustical stimuli or to sound-induced water displacements beyond a few body lengths, even with large sound intensities (Myrberg 2001; Environmental Defense Center 2004). Sharks have an inner ear physiology very similar to terrestrial vertebrates of which their hearing is very acute (Environmental Defense Center 2004; Godknecht 2009) . Their ears function optimally in the low frequency ranges of between 40 and 800 Hz and some species can detect sounds from well below 50 Hz or as high as 1000-10,000 hz (Myrberg 2001; Environmental Defense Center 2004; Godknecht 2009).

Seismic surveys are within the frequencies which sharks hear best, thus have the potential to cause great damage to the sharks, skates and ray's hearing organs (Godknecht 2009). In the presence of loud, high intensity sound sources, sharks will turn and withdraw from the source (Klimley and Myrberg 1979). In response to a sudden sound 40 dB higher than background noises, silky sharks (*Carcharhinus falciformis*), lemon sharks (*Negaprion*

brevirostris) and oceanic whitetip sharks (*C. longimanus*) are scared off and rapidly move away from the area (Godknecht 2009). According to professor Arthur Myrberg from the University of Miami, a renowned shark and acoustic specialist, the critical noise level for sharks is around 180 dB (Godknecht 2009). Within this range, it can be expected that long-term injuries, especially to the inner ear will occur in sharks and other cartilaginous fish (Godknecht 2009).

The available evidence suggests that loud noises from seismic surveys during the prospecting and exploration phases of development, and even noises from large and increased vessel traffic, could threaten individual or population survival, mask biologically important sounds , could result in avoidance of suitable habitat, cause ear tissue damage, cause changes in hearing thresholds and chronic stress in some species (Environmental Defense Center 2004). Popper (2003) states how sharks (and other elasmobranchs) are attracted to the noise prey makes when struggling in the water, however in noisy environments, there is increased difficulty in finding prey as these sounds may be masked and/or difficult to locate. Corwin (1978) hypothesized and found that free-swimming elasmobranchs have larger and a more complex macula neglecta, meaning they have more sensitive hearing, than bottom-dwelling elasmobranchs.

Management measures in Australia involved using soft-start procedures during seismic surveys to allow sharks or rays present within the area to actively move away from the noise source in order to reduce the effects of the seismic surveys on individuals and populations (Environmental Defense Center 2004).

The threat of electromagnetic techniques

Chondrichthyes species are electroreceptive fish, any electric currents, whether generated from other fish or electrical equipment can be detected (Buchanan et al. 2011). The unequal clustering of ampullae of Lorenzini over the bodies of cartilaginous fish enables them to determine, by constant intra-ampullae comparison of microchanges in the surrounding field; the direction, spatial configuration and intensity of the electrical source (Buchanan et al. 2011). Any electromagnetic emissions from equipment used in deep sea oil development are likely to be detected by any cartilaginous fish in the area (Buchanan et al. 2011). Thresholds of effects, primarily behavioural on electroreceptive fish are likely to only occur within a radius of 400 meters (Buchanan et al. 2011). However, this depends on the strength and time of electromagnetic emissions (Buchanan et al. 2011).

Localized effects of deep sea oil development on cartilaginous species

Deep sea oil development will affect the living conditions of any resident cartilaginous species (or those species just passing through) by increasing the amount of sand, grit and sediments in the water (Agri-Food & Biosciences Institute 2009). The increase in sediments has the potential to detrimentally impact many invertebrate species of which many small sharks, rays, skates and chimeras feed upon (Agri-Food & Biosciences Institute 2009). Drilling muds and cuttings from exploration contain many toxic chemicals and heavy metals of which can threaten the health of species within the immediate areas (Agri-Food & Biosciences Institute 2009). These drilling muds, cuttings and debris can settle and build up on the seafloor which can directly harm any egg cases lying on the seafloor (Agri-Food & Biosciences Institute 2009).

Effects of pollution in general:

Wastes from drilling include; drilling muds consisting of various chemicals, cuttings and waste waters are discharged into the water at the drill rig/ship, all of which can cause toxicological effects. Other wastes released include; domestic waste from the ship/rig including sewage, wash water, deck drainage. Drilling rigs typically discharge 80-160m3 of waste muds over 1-2 hours into the water. This causes turbidity from sediment suspension, heavy metal pollution including mercury, lead and arsenic, and the introduction of other debris and chemicals into the environment. Waste discharges from drilling can spread over large areas and stay in the water for a long period of time (Kjeilen-Eilertsen et al. 2004). Given this, and the substantial amounts of discharge, the potential for impacts upon animals can be significant (Kjeilen-Eilertsen et al. 2004).. Eventually, this waste will either sink to the bottom of the seafloor, disperse, erode and/or dilute to non-harmful levels, however it potentially causes localized toxic and harmful effects near the discharge site. Studies have shown that erosion of cutting piles may take a considerable amount of time (Vefsnmo and Lothe 2001) and so these cuttings may be re-suspended again introduced into the water column (Kjeilen-Eilertsen et al. 2004). Both pelagic and benthic organisms near the drilling site can be repeatedly exposed both by “primary” exposure from when waste material is first released, suspended in the water column and firstly settles, and as “secondary” exposure due to re-suspension and repeated settling of particulate materials and wastes (Kjeilen-Eilertsen et al. 2004).

In depth focus on some of the species that are at stake:

Whale sharks (Rhincodon typus)

Whale shark (*Rhincodon typus*)
(Photo by Brian J. Skerry from http://animals.nationalgeographic.com/animals/fish/whale-shark/)

Whale sharks are the world largest fish (12-15 metres long) which inhabit tropical and subtropical coastal waters and the open ocean. This species is highly migratory and venture into New Zealand waters on their annual summer migrations (Martin 2007; Hutching 2009). Whale sharks have been reported around the north of the North Island around Three Kings Island, Bay of Plenty, Northland and the East Cape (Hutching 2009). Their harmless and docile nature has popularised this species for ecotourism (Martin 2007). Whale sharks feed on plankton and invertebrates including coral spawn, snapper spawn, megalopa of a terrestrial crab and schools of anchovy (Martin 2007).

It is thought that whale sharks possess low to moderate visual acuity, acute olfactory sensitivity, and large ears which, although not quantified are suggested to be most responsive to long-wavelength, low-frequency sounds (Martin 2007). Like other elasmobranchs, they possess ampullae of Lorenzini (Martin 2007). The vibratosensory and electrosensory capabilities of this species are unknown (Martin 2007).

In the presence of boats, whale sharks exhibit avoidance behaviour by diving towards the seabed, which may be in response to the low-frequency sound signature of motors (Martin 2007). Boat traffic may disrupt whale shark migration routes and mating and/or feeding behaviours. There is no data on the effect of noise pollution on whale sharks, however, it is likely that if boat traffic increases, whale sharks might possibly avoid these areas excluding them from important feeding or mating grounds or they may change their migration routes

(Anonymous 2004; Norman 2005; Martin 2007). The effects on seismic surveys or sonar on whale sharks has not been documented or researched (Anonymous 2004; Norman 2005; Martin 2007). Due to the fact that their ears may be sensitive to low-frequency sounds it is possible that seismic surveys will be detected by and have an impact on whale sharks.

Whale sharks, like most animals, will be threatened by an oil spill. In 2012, the death of a whale shark off the waters of the Pearl River Delta was believed to be caused by oil pollution (3 News 2012). "No trauma and visceral lesion were found in the whale shark. The main problem is that its respiratory system was affected by oil pollution (3 News 2012). Lots of silt has been washed out and we estimate that there may be some 50kg of silt in its air tube," said Zhang Haiquan, a marine expert (3 News 2012).

Skates and Rays

New Zealand has approximately 26 species of skates and rays (Cox & Francis 1997). They both have similar kite-shaped bodies, of which rays tend to be larger and more venomous (Hutching 2009). Rays and skates are not aggressive, however if attacked or threatened they can inflict serious harm (Hutching 2009). The majority of rays and skates are bottom dwelling and feed on bottom dwelling animals such as crabs, shrimp and other small fish (Agri-Food & Biosciences Institute 2009). Rays give birth to live young, whereas skates lay egg cases of which both only produce a low number of offspring which mature at a relatively late age, making them especially vulnerable to anthropogenic threats (Francis et al. n.d). The biggest threats to ray and skate species are potential overfishing, displacement and/or removal of habitat through such things as habitat destruction by trawls, human development, disturbance or mining (Cox & Francis 1997; Francis et al. n.d; Agri-Food & Biosciences Institute 2009).

The rough skate, (*Dipturus nasutus)* is endemic and the most common skate in New Zealand (Cox & Francis 1997; Francis et al. n.d.). They live on the ocean floor at depths ranging from 10-1,500 metres where they feed on benthic invertebrates and small fish (Cox & Francis 1997; Francis et al. nd.). They are commercially harvested, usually for their wings which are eaten (Cox & Francis 1997; Francis et al. nd.). As shown by Figure 1; much of known habitat of the rough skate overlaps with deep sea oil development plans. The smooth skate, (*Dipturus innominatus*) is larger, lives longer and inhabits deeper waters than the rough skate and is also commercially fished (Forest & Bird 2011).

Image: Rough skate *(Dipturus nasutus)*
(by Amalgamated Ltd from http://www.amalmark.co.nz/rough-skate.html)

The limited research, lack of biological information and unknown sustainability of catch and bycatch levels on these two skates, other skates and rays is of major ecological concern (Forest & Bird 2011). Their habitat is impacted by deepwater trawling (Forest & Bird 2011). Additionally, deep sea oil development will alter and/or destroy their habitat further. Currently, there are no specific conservation actions for skates (Forest & Bird 2011). Due to their slow growth rates, delayed maturity and relatively low reproductive rates, both rays and skates are vulnerable to the various anthropogenic activities associated with deep sea oil development. Although hearing in skates and rays is not as sensitive as sharks, they are still sensitive to and capable of hearing low frequency sounds (Casper et al 2003). Rays and skates living on or near the sea floor may be exposed to the contaminants and pollutants in the drilling muds, cuttings and debris that settle on the seafloor (Agri-Food & Biosciences Institute 2009). Noise disturbance from boats, drilling and seismic surveys may exclude rays and skates from the area (temporarily) or cause behavioural changes. Seismic surveys may cause hearing damage depending only in those species in close proximity and those that are capable of hearing it (Agri-Food & Biosciences Institute 2009).

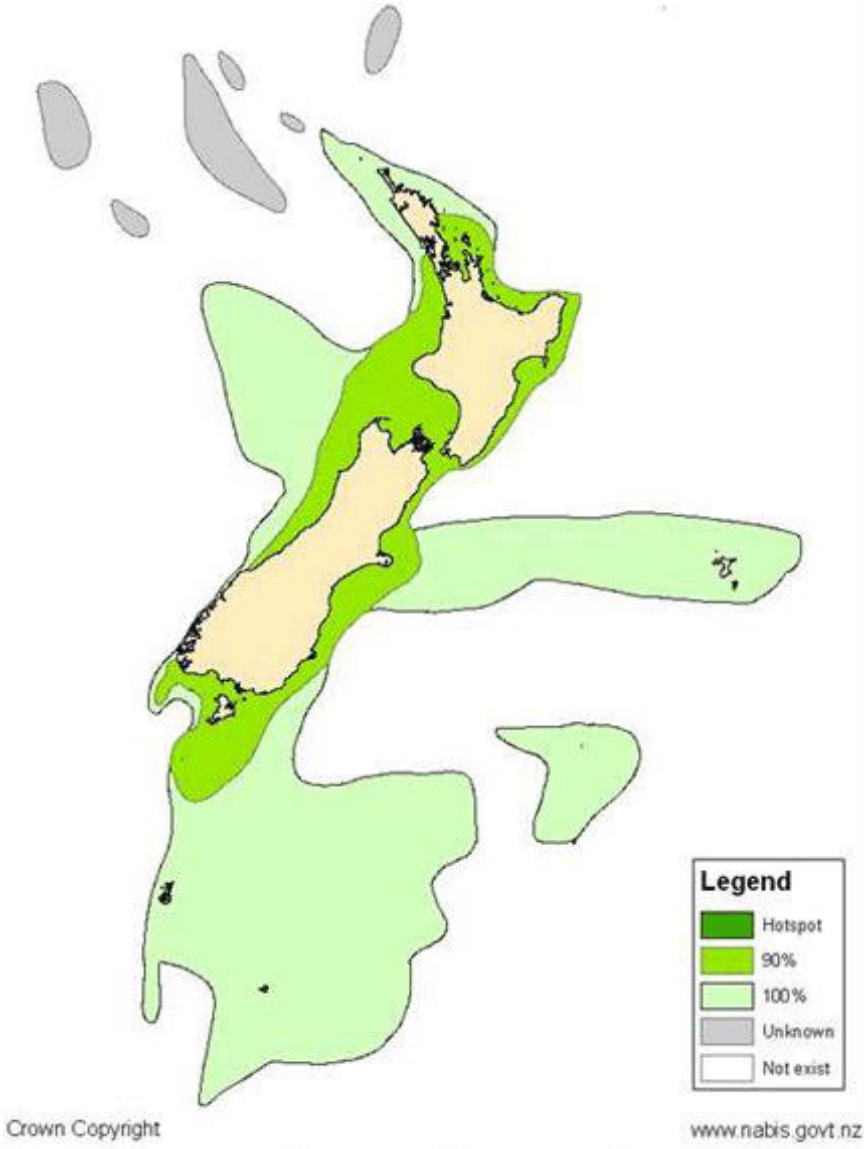


Figure 1: Rough skate Dipturus nasutus annual distribution (Francis et al. nd.)

Great white shark (Carcharodon carcharias)

Image: Great white shark (*Carcharodon carcharias*)
(Photo by David Fleetham/Alamy from http://animals.nationalgeographic.com/animals/photos/great-white-sharks/)

Great white sharks are listed as 'vulnerable' globally by the IUCN, and are fully protected in New Zealand waters under the Fisheries Act 1996 and Wildlife Act 1953 (DOC n.d). It is illegal to kill, injure, harass great whites or trade in great white shark products. If caught as bycatch it must be reported to DOC (DOC n.d). They are distributed worldwide and mainly inhabit temperate and subtropical waters. New Zealand, along with the waters off California, South Africa, Australia and Japan are considered hot spots for great white sharks (Bonfil et al. 2010; DOC n.d). In New Zealand they are found from north of the Kermadec Island to as far as Campbell Island in the subantarctic (DOC n.d). Great white tend to breed around northern New Zealand and will concentrate in spots where seal colonies are located (DOC n.d). They are an apex predator and feed on fish, small sharks, rays, skates, penguins,

otariids, dolphins and blubber scavenged from dead whales (DOC n.d). Satellite telemetry studies have shown that great white spend extended time in preferred coastal wates and also venture thousands of kilometres out into the open ocean (Boustany et al. 2002; Bonfil et al. 2010). They also undertake regular long-distance migrations along the coasts often returning to sites which they show a high degree of fidelity for (Bonfil et al. 2005; 2010)

As they are rare top predators, that are slow growing, mature late in life, are long lived and have low productivity (4-5.6%), therefore, they are vulnerable to a variety of human actions worldwide (WildEarth Guardians 2012). These threats include bycatch in commercial fisheries, decline in abundance of their prey, game and commercial fishing for sharks and poaching (DOC n.d; WildEarth Guardians 2012). In unprotected waters or even in protected waters they are also targeted illegally for their teeth, jaws and fins (WildEarth Guardians 2012). Sometimes sharks are "finned", a cruel technique where their fin is cut off and the living shark is discarded overboard and left to die slowly from starvation or drowning (WildEarth Guardians 2012). In the media, the great white shark tends to portrayed negatively due to its ferocious and sometimes lethal interactions with humans, of which can generate media-fanned campaigns to kill them after a biting or human death occurs (Fergusson et al. 2009). Habitat degradation, such as development, pollution, overfishing, mining also threatens great whites and may exclude them from particular areas of which could be important habitats for nursing or feeding (Fergusson et al. 2009).

"All lifehistory stages may be vulnerable to high body burdens of anthropogenic toxins; how these may impact the population is not known" (WildEarth Guardians 2012; Domeier 2012). Heavy metals and other contaminants, which have been found in high levels in tissues sampled from great whites, may be affecting their survival and reproductive potential and specifically could also cause altered behaviour, weight loss, cerebral lesions and developmental problems (WildEarth Guardians 2012; Mull et al. 2012). As great whites are apex predators they are at high risk of bioaccumulating toxins (WildEarth Guardians 2012). In the California Bright, harbour seals and northern elephant seals have high levels of contaminants, of which great whites are known to prey upon (Blasius and Goodmanlowe 2008). Additional pollutants in wastes from drilling and potential oil spills may further threaten great white sharks, especially in important nursing and pupping areas.

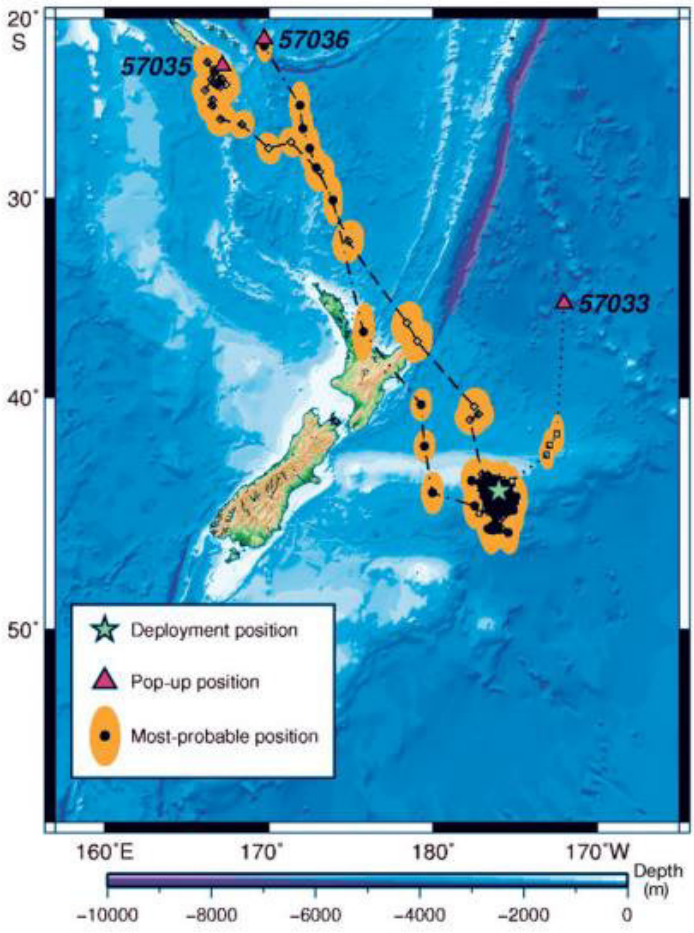


Figure 2: Carcharodon carcharias. 'Most-probable' tracks for three tagged white sharks; confidence regions (2 SE) surrounding each point are shown (orange) from Bonfil et al. (2012)

Elephant fish (Callorhynchus milii)

Image: Elephant fish (*Callorhynchus milii)*

(by Port Elizabeth Deep Sea Angling Club from http://showme.co.za/port-elizabeth/lifestyle/sports-leisure/fishing-in-algoa-bay/

Elephant fish are confined to the Antarctic Basin and South Pacific and are an important commercial fishery in New Zealand. They are commonly caught in set nets or trawls during its annual inshore migration (Cox & Francis 1997). In 2002–3 a total of 1,124 tonnes of elephant fish were caught, mostly in trawl nets off Banks Peninsula (Hutching 2009). Most New Zealanders would have eaten this fish from local fish and chip stores. They are common along the east coast of the South Island and are also found up to the Bay of Plenty. Adults are most often found on bottom habitats, from the close to shore to around 200m depth (Cox & Francis 1997). Other species of chimaera fish are known to penetrate to depths of greater than 2, 000 metres, rarely inhabiting shallow waters less than 800 metres (Francis et al. n.d).

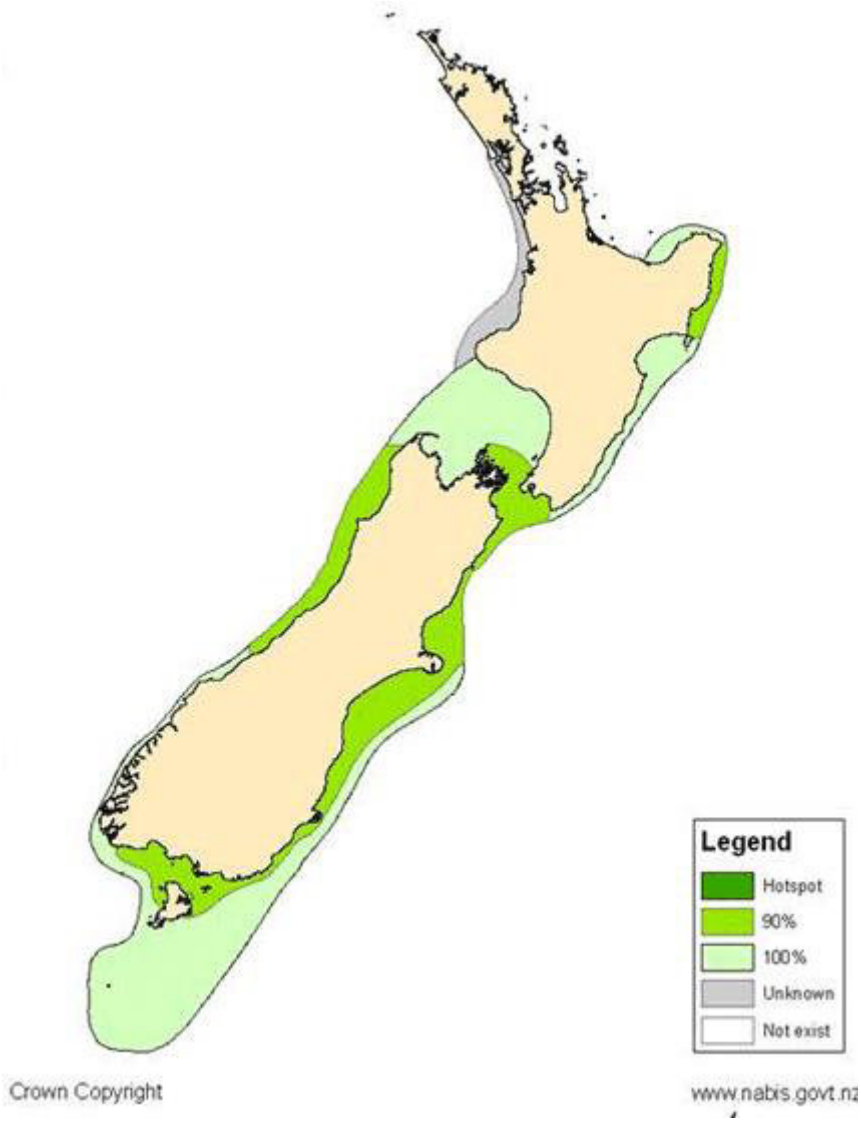


Figure 3: Elephant fish Callorhinchus milii annual distribution (Francis et al. nd.)

Other unique species:

The basking shark, *Cetorhinus maximus*, is a large (5-10+ metre) plankton filter feeder that is the only species in the Cetorhinidae family. From spring to summer it often feeds in surface waters and congregates from Hawke Bay south to the Auckland Islands (Francis et al. nd.). During winter however they are known to inhabit deep water, such as the deep trenches off Westland (Francis et al. nd.).

The pelagic stingray, *Pteroplatytrygon violacea*, is unique for unlike other stingrays it has a pelagic lifestyle in the open waters (Francis et al. nd.).

Short finned mako sharks (*Isurus oxyrinchus*) are the fastest of all the shark species (Tan 2012). They have very honed senses; hearing, sight, smell, their lateral system and ampullae of Lorenzini in order to hunt their prey. Mako sharks have been suspected on attacking sonar equipment that was being used to search for containers from the Rena (Tan 2012). "It would not be out of the ordinary for them to be attacking a 'sonar fish', because that's what the equipment would have looked like to these sharks," said Mr Duffy, a Department of Conservation marine scientist (Tan 2012).

New Zealand has a very diverse range of dogfish species, of which there are approximately over 25 species which mainly occur at depths greater than 300 meters (Francis et al. n.d). These sharks are mostly small and are distinguished by their lack of anal fin and tend to have strong spines in front of their dorsal fin. The continental shelf and areas in the Chatham Rise and Puysegur area west of Stewart Island support a high diversity of dogfishes (Francis et al. n.d).

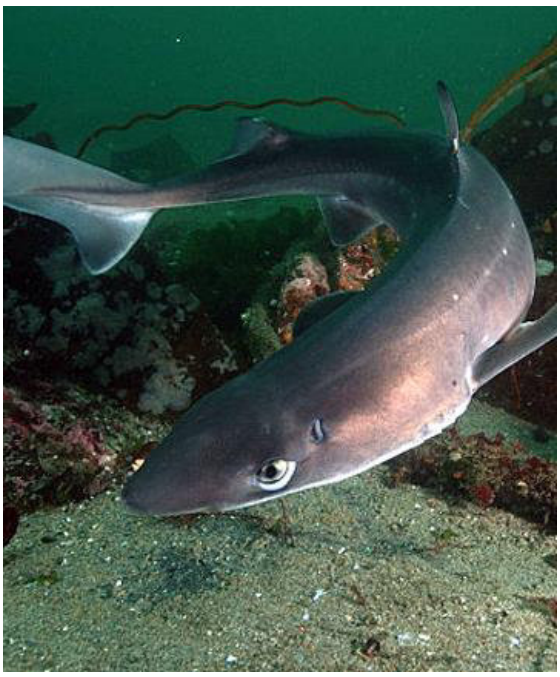


Image: Spiny dogfish *(Squalus acanthias)*
(from http://www.stuff.co.nz/environment/7135711/Dogfish-numbers-hit-plague-proportion)

Most cartilaginous species inhabiting New Zealand occur on the outer continental shelf and upper- to mid-continental shelf and typically live near the seabed (Francis et al. nd.). Those deep sea floor species are likely to be impacted by anything that disturbs their habitat, especially drilling (Cox & Francis 1997). However there has been little exploration of waters over 1,500 meters deep so it is likely that many of the known species and other undiscovered species occur at this depth and greater (Cox & Francis 1997). Due to the difficulty of obtaining biological, behavioural and ecological information of deep sea species it is largely unknown the exact responses these species will have to deep sea oil development.

Some examples of sharks found on the deep sea floor include (Cox & Francis 1997):

- Seal shark
- Dark ghost shark
- Prickly dogfish and other dogfish species
- Goblin shark
- Lucifer dogfish
- Frill shark
- Six and sevengill shark species
- Chimaera species

Conclusion

Most biological and ecological information regarding sharks in New Zealand is poor or non-existent. There are no quantitative stock assessments for the 11 cartilaginous species under the Ministry of Fisheries quota management system. It still remains however that cartilaginous species have slow growth rates and hence have a late maturity, have a low reproductive output and high longevity. Many cartilaginous species are found at depths greater than 1,500 m and hence are likely to be in close proximity to areas that are undergoing or have proposed plans for deep sea oil development. Cartilaginous species have an acute sense of hearing and hence are vulnerable to anthropogenic noise from boats, seismic surveys and drilling.

References

3 News. 2012. Oil pollution key to whale shark's death. Accessed on 22/10/12 from http://www.3news.co.nz/Oil-pollution-key-to-whale-sharks-death/tabid/1160/articleID/249845/Default.aspx#ixzz2A0E5lVJG

Agri-Food & Biosciences Institute (2009) Position statement on sharks, skates and rays in Northern Ireland waters. Northern Ireland Environment Agency Research and Development Series No. 09/03

Anonymous, 2004. Whale shark (*Rhincodon typus*) issues paper. Department of Environment and Heritage, Canberra, world wide web electronic publication. Accessed on 25/10/12 from http://www.deh.gov.au/biodiversity/threatened/publications//recovery/whale-shark/pubs/issues-paper.pdf.

Blasius ME and Goodmanlowe GD. 2008. Contaminants still high in top-level carnivores in the Southern California Bight: Levels of DDT and PCBs in resident and transient pinnipeds. Marine Pollution Bulletin 56: 1973–1982.

Bonfil R, Francis MP, Duffy C, Manning MJ, O'Brien S.2010. Large-scale tropical movements and diving behavior of white sharks *Carcharodon carcharias* tagged off New Zealand. Aquatic Biology 8: 115–123.

Bonfil R, Meÿer M, Scholl MC, Johnson R et al. 2005. Transoceanic migration, spatial dynamics and population linkages of white sharks. Science 310:100–103

Boustany AM, Davis SF, Pyle P, Anderson SD, Le Boeuf BJ, Block BA. 2002. Expanded niche for white sharks. Nature 415:35–36

Buchanan RA, Fechhelm R, Abgrall P, Lang AL. 2011. Environmental Impact Assessment of Electromagnetic Techniques Used for Oil & Gas Exploration & Production. LGL Rep. SA1084. Rep. by LGL Limited, St. John's, NL, for International Association of Geophysical Contractors, Houston, Texas.

Casper BM, Lobel PS, Yan HY. 2003. The hearing sensitivity of the little skate, Raja erinacea: A comparison of two methods. Environmental Biology of Fishes 68:371-379.

Corwin, J.T. 1978. The relation of inner ear structure to the feeding behavior in sharks and rays. Scan. Electron Microscopy. II:1105–1112

Cox G and Francis M. 1997. Sharks and rays of New Zealand. Christchurch: Canterbury University Press.

DOC (n.d). Great white shark. DOC Leaflet. Accessed on 23/10/12 from http://www.doc.govt.nz/documents/science-and-technical/great-white-shark-leaflet.pdf

DOC. 2006. Sharks / mangö in New Zealand waters. Accessed on 22/10/12 from http://www.doc.govt.nz/documents/about-doc/concessions-and-permits/conservation-revealed/sharks-mango-in-nz-waters-lowres.pdf

Domeier ML. 2012. A New Life-History Hypothesis for White Sharks, *Carcharodon carcharias*, in the Northeast Pacific. Chapter 16 in Domeier, M. L. (ed.). Global Perspectives on the Biology and Life History of the White Shark. CRC Press, Boca Raton, FL

Environmental Defense Center. 2004. Anthropogenic Noise and the Channel Islands National Marine Sanctuary. Environmental Defense Center, Santa Barbara, CA.

Fergusson I, Compagno LJV, Marks M. 2009. *Carcharodon carcharias*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. Accessed on 25/10/12 from www.iucnredlist.org

Forest and Bird. 2011. Skates. Forest and Bird. Accessed on 25/10/12 from http://www.forestandbird.org.nz/what-we-do/publications/-best-fish-guide-/skates

Francis MP, Smith F, Duffy C and Patuawa T. (n.d). Sharks, Skates, and Rays (Phylum Chordata, Class Chondrichthyes). Accessed on 25/10/12 from http://www.treasuresofthesea.org.nz/sharks-skates-and-rays#8

Godknecht AJ. 2009. Remote detection sonar threatens the oceans. Shark Info. Accessed on 22/10/12 from http://www.sharkinfo.ch/SI4_02e/lfas.html

Hutching G. 2009. Sharks and rays - Māori and sharks, Te Ara - the Encyclopedia of New Zealand, Accessed on 22/10/12 from http://www.TeAra.govt.nz/en/sharks-and-rays/2

Kjeilen-Eilertsen G, Westerlund S, AKvamiljø RF. 2004. Input from RF-AM to Literature study task 1 toxicity: metals. ERMS Report AM – 2004 / 023.

Klimley AP and Myrberg J. A.A. 1979. Acoustic stimuli underlying withdrawal from a sound source by adult lemon sharks, Negaprion brevirostris (Poey). Bulletin of Marine Science 29: 447–458.

Martin RA. 2007. A review of behavioural ecology of whale sharks (*Rhincodon typus*). Fisheries research 84: 10

Mull CG, Blasius ME, O'Sullivan JB, Low CG. 2012. Heavy Metals, Trace Elements, and Organochlorine Contaminants in Muscle and Liver Tissue of Juvenile White Sharks, *Carcharodon carcharias*, from the Southern California Bight. Chapter 5 in Domeier, M. L.

(ed.). Global Perspectives on the Biology and Life History of the White Shark. CRC Press, Boca Raton, FL.

Myrberg AA. 2001. The acoustical biology of elasmobranchs. Environmental Biology of Fishes. 60: 31-45.

Norman BM. 2005. Whale shark. In: Fowler, S.L., Cavanagh, R.D., Camhi, M.,Burgess, G.H., Cailliet, G.M., Fordham, S.V., Simpfendorfer, C.A., Musick,J.A. (Eds.), Sharks, Rays and Chimaeras: The Status of the Chondrichthyans Fishes. IUCN, Gland, Switzerland, pp. 242–245

Perrine D. 1995. Sharks. Great Britain, Colin Baxter Photography Ltd.

Popper AN. 2003. Effects of Anthropogenic Sounds on Fishes. Fisheries 28(10): 24-31.

Stewart A. 2001. First record of the crocodile shark, *Pseudocarcharias kamoharai* (Chondrichthyes: Lamniformes), from New Zealand waters. New Zealand Journal of Marine and Freshwater Research 35: 1001-1006

Tan L. 2012. Mako sharks get blame for 'sonar fish' attacks. Accessed on 22/10/12 from http://www.nzherald.co.nz/animals/news/article.cfm?c_id=500834&objectid=10774261

Vefsnmo, S. and Lothe, A. 2001. UKOOA Phase II - Task 3: Large scale experiment Report STF81A01848, ISBN 82-14-01828-5.

WildEarth Guardians. 2012. Petition to list the Northeastern Pacific Ocean distinct population segment of Great White Shark (*Carcharodon Carcharias*) under the U.S. Endangered Species Act. Accessed on 23/10/12 from http://swr.nmfs.noaa.gov/gws/WildEarth_Guardian_Great_White_Shark_Petition.pdf

Important invertebrates in New Zealand waters

By Aniela Reid and Lisa van Halderen

Image: Red crayfish (*Jasus edwardsii)*

(Photo by 2008 Copyright Australian Southern Rock Lobster Limited from http://www.southernrocklobster.com/industry/species/species.aspx)

The major invertebrate groups

Invertebrates are organisms which do not have a vertebral column or a backbone. This includes all organisms except those in the subphylum Vertebrata. The majority of all organisms are in fact invertebrates which cover:

- Porifera – the sponges
- Cnideria – corals, sea anemones and jellyfish
- Annelida – segmented worms
- Echinoderms – starfish, sea urchins, sea cucumbers, brittle and feather stars
- Anthropoda – animals which possess an exoskeleton (external skeleton), a segmented body and jointed appendages. The most important marine subphyla within this phylum are the Crustaceans which include the shrimp, barnacles, lobsters, crabs, and more.
- Mollusca - is the largest marine phylum and is incredibly diverse. This phylum is divided into nine or ten classes. The most well-known classes are the Cephalopods – squid, octopus; Bivalves – clams, oysters, mussels and scallops; and Gastropods – snails, slugs, limpets
- Other important general groups in the marine environment are plankton – which refers to any animal which can swim against the current and range in size from microscopic to as large as jellyfish. Plankton are divided up into three main groups: phytoplankton (diatoms, cyanobacteria, dinoflagellates and coccolithophores) which exist where there is sufficient light to photosynthesize), Zooplankton (any animal which feeds on other plankton) which include the larvae of animals such as crustaceans or fish, and Bacterioplankton (bacteria, archaea and some phytoplankton) which are important in recycling nutrients and other materials.

Anthropogenic noise effects on invertebrates

Several studies have reviewed and conducted experiments to establish the effects of sound on invertebrates (Payne et al. 2008). Parry et al. (2002) conducted a seismic testing experiment to address the concerns that local fishermen had regarding the effects that seismic testing may have on scallop survival and physiology. In their experiment, the mortality and adductor muscle strength in scallops suspended in cages beneath a passing seismic airgun array was compared to control scallops which were 20 km from the seismic source (Parry et al. 2002). No difference in mortality or adductor muscle function was found between exposed or control scallops. Parry et al. (2002) also examined plankton populations, including larval scallops. Plankton communities from immediately behind the

seismic vessel were compared with those sampled before and 2 km distant from the seismic testing (Parry et al. 2002). No differences were found in plankton communities behind the seismic array and those before the passage of the vessel or 2 km distant from the vessel (Parry et al. 2002). Only large changes in plankton communities would have been detected, however the available literature suggests that the effects of airguns on plankton would be very small and only confined to regions within 1-10 meters of airguns (Parry et al. 2002; Payne et al. 2008; ExxonMobil 2012). Based on the 26 years of catch rate data on lobsters over off south-eastern Australia, no relationship has been found between catch rates and seismic surveys (Parry & Gason 2006). A review on the experimental exposure of invertebrates (lobsters, shrimps and scallops) to seismic sources has found that only exposure to chemical explosives causes inceased mortality (Parry & Gason 2006; SCAR 2012). Based on available literature, the use of seismic surveys in deep sea oil development is unlikely to have any impact on invertebrate and plankton species.

The effects of pollution from drilling wastes, cuttings and suspended sediment on invertebrates

Chemicals, substances, sediments or oils can directly impact upon invertebrates through surface exposure, ingestion, absorption and can indirectly impact them in the long term by chaning their habitat or ecosystem. Suspended and bedded sediments from natural sources or from drilling can directly impact on biota and the physical environment. Suspended sediments can influence light penetration into the water which hinders photosynthesis in phytoplankton out in the open ocean and the visual clarity of animals (Kjeilen-Eilertsen et al. 2004). They can also interfere with and block filter/suspension feeding or damage the gills in bivalves, corals, fish and other invertebrate species (Kjeilen-Eilertsen et al. 2004). Larger particles can also scour and harm plankton, eggs and other very small organisms. Bedded or settled sediments can smother; habitats, sedentary organisms and spawning beds- killing and suffocating eggs and larvae. When exposed to suspended barite particles; the gills of Cerastoderma edule a suspension feeder and Macoma balthica a deposit feeder were damaged (Barlow and Kingston, 2001). The levels of barite accumulation that caused 100% mortality within 12 days could be expected within 100-500metres from a point of active drill cuttings discharge (Barlow and Kingston, 2001; Kjeilen-Eilertsen et al. 2004).

Bioavailability describes the fraction of an introduced contaminant which can be taken up, absorbed or consumed by the organisms from its environment or food which can be transported, utilised and metabolized by the organism (Kördel et al., 1997; Kjeilen-Eilertsen et al. 2004). Bioavailability is especially important in lower trophic level organisms. Little is

known about the long-term effects of suspended particles from drilling and waste discharges on organisms (Kjeilen-Eilertsen et al. 2004).

The dissolved fraction of a toxic substance in the water and particle bound fractions of a toxic substance (such as metals) can be taken up by an organism (Weltens et al., 2000). These compounds, depending on the physiology of the organism and behaviour and type of contaminant may be assimilated, adsorbed or desorbed where it may exert certain chemical functions, cause toxic effects or lead to high tissue concentration levels (Weltens et al., 2000).

For filter/ suspension feeders such as many bivalve species, the uptake of dissolved metals and food ingestion are both important in metal accumulation (Wang and Fisher, 1999; Kjeilen-Eilertsen et al. 2004). Contaminants that are particle bound can also become bioavailable to fish (Qiao and Farrell, 1996; Van den Belt et al., 2000; Kjeilen-Eilertsen et al. 2004). Pan and Wang (2002) examined the uptake of colloid bound metals (particles that are 1kDa and 0.2micrometer and often included in the dissolved phase of seawater) Colloid metals are more bioavailable than other truly dissolved or bound metals (Pan and Wang 2002). After exposure to colloids, a considerable amount of colloids; chromium and iron were found and distributed in bivalve soft tissue. These colloid bound metals were also found in digestive glands 1-4 hours after exposure which suggested direct ingestion of colloidal particles by the bivalves (Pan and Wang 2002).

In the open ocean or in other environments, the lack of nutrients or vital metals limits the growth of some organisms such as phytoplankton or algae which keeps ecosystems in balance or in a certain state. The introduction of these compounds can vitally change community structure and ecosystem function. For instance, Fe (iron) limits the primary productivity in some phytoplankton species in the Southern Ocean and an increased bioavailability of this or other limiting substances may see an increase or bloom in certain species.

Experiments with filter/suspension feeders have suggested the potential for them to be affected by exposure to suspended particles from drilling muds. Copepods (Acartia spp) that were fed algae exposed to metals (Cd or Hg) had lowered egg production, hatching rate, decreased ovarian development and egg protein content, implying vitellogenesis was affected (Hook and Fisher, 2001; Kjeilen-Eilertsen et al. 2004). Toxic compounds (including metals) present in drilling muds has shown to affect survival, development and growth and/or cause oxidative stress in filter feeding mussel larvae, bivalves such as scallops and other filter feeding organisms (Placopecten magellanicus) (Hansen et al., 1997; Cranford et al. 1999; Wedderburn et al. 2000; Kjeilen-Eilertsen et al. 2004).

The effects of pollution from oil spills on invertebrates

Once crude oil enters the ocean, it can impact upon marine invertebrates in three ways. Volatile compounds evaporate at water's surface or dissolve in the water column. This is most likely to impact invertebrates which live close to the surface, such as phyto-and zooplankton which form the basis of the entire marine food web. Crude oil can coat and smother invertebrates and the environments in which the live. That oil which sinks or attaches to other particles will impact invertebrates on the sea floor. Polycyclic aromatic hydrocarbons which are known carcinogens and neurotoxins in some animals, are not metabolized well in invertebrates and may build up in tissues and affect the food web (Earth Gauge 2010). Some polycyclic aromatic hydrocarbons are phytotoxic, which is a problem for transparent plankton in the upper water column (Earth Gauge 2010). Oils pose a problem for invertebrate species which have external (or even internal cilia) as oil can coat these appendages causing reduced mobility, degraded internal functions (reproduction, digestion, transport, etc.) which can result in death (Earth Gauge 2010). Echinoderms which possess water vascular systems that rely on cilia are especially vulnerable to oil. Oil impairs the ability for bivalves and gastropods to fix themselves or hold onto a substrate; leaving them vulnerable to the current and predators (Earth Gauge 2010). Bivalves and other filter feeders can take in polycyclic aromatic hydrocarbons and other toxic chemicals released from crude oil which can accumulate in their tissues and cause toxicological effects (Earth Gauge 2010). Blue crab larvae; of which are commercially important, that were found on the coasts near the Gulf oil spill had small oil-and-dispersant droplets within their shells (Earth Gauge 2010). After the Gulf spill, in June 2010 less than 12 kilometres from the spill, thousands of pyrosomes (colonial tunicates) which live on the sea floor were found dead floating on the surface of the water (Earth Gauge 2010). Oil and dispersants can impact upon reefs; which are important habitats for many other invertebrate and fish species, by suffocating corals (from causing anoxic conditions), cause toxic and degrading effects, attach to sediments which can sink and smother deep sea reefs (Earth Gauge 2010). These effects were seen in corals after the Bahia Las Minas oil spill in Panama in 1986 (Earth Gauge 2010). Any invertebrates which are near the surface of the water, such as the spawn and larvae of many aquatic organisms will be more exposed and affected by oil spillage.

Habitat alteration

Pipeline building, drilling rigs and infrastructure will all alter the marine habita (Dauterive 2000). Increased sedimentation from drilling muds and cuttings and from the initial disturbance of piping and drilling on the sea bed is one of the major issues in altering the

marine habitat of which its effects is outlined previously. The addition of infrastructure may also alter the surface and subsurface hydrological patterns. Depending on whether these changes occur and their magnitude they can have implications for feeding and drift in invertebrate and plankton species.

Deep sea offshore drilling physically disrupts the seafloor habitat and benthic animals. The drill rig, pipes, platforms, dredging ship channels, cuttings and marine debris leaves a lasting physical impact upon the sea floor. The benthic communities directly within the area of drilling are likely to be physically harmed or killed by the infrastructure. Animals may also eventually die due to contaminants or as a result of the increased predation or altered food availability due to the changed environment.

Some experts suggest that in the long-term, the platforms of rigs can provide an important habitat and substrate for invertebrates (Dauterive 2000). Rigs-to-Reefs (RTR) is a nationwide program under the developed Bureau of Safety and Environmental Enforcement (BSEE) in the United States which turns decommissioned offshore rigs into artificial reefs (Dauterive 2000). RTR recognizes that many species, such as corals, bivalves and more come to settle on the rig and other infrastructure. This in turn supports other marine life such as fish which come to live around the artificial reef (Dauterive 2000). The shape and complexity of oil piping, rigs and platforms may support a large variety of invertebrate life especially, which in turn supports other fish diversity (Dauterive 2000).

In depth focus on some of the species at risk:

Bivalves and Gastropods

Bivalves and gastropods are two of the most diverse and abundant classes within the phylum Mollusca. In New Zealand, there are approximately 3,667 marine molluscs which includes 680 bivalves and 2738 gastropod species (MacDiarmid & Patuawa n.d). Of those species found within New Zealand, 85.5% (589) of bivalves and 86.6% (3183) of gastropods are endemic (MacDiarmid & Patuawa n.d). New Zealand waters are home to the majority of world's species within the bivalve family Spheniopsidae and the glass-sponge eating gastropods in the family Trochaclididae (MacDiarmid & Patuawa n.d). Currently, no living marine bivalve or gastropod species appears threatened by extinction in New Zealand, although some species are known from a single locality or may face regional decline from overexploitation or other factors (MacDiarmid & Patuawa n.d).

Bivalves have a laterally compressed body which is enclosed by a dorsally hinged shell compromising of two parts and usually have a muscular foot. They include scallops, cockles,

oysters, mussels, pipi and other families. Adult shell sizes vary from a millimetre to over a millimetre, however most tend to be smaller than ten centimetres. The majority of bivalves are suspension or deposit feeders (filter feeders) which use their modified gills, called ctenidia for feeding and breathing. Water is drawn into the animal, where particles are filtered out from the water using their ctenidia and then passed to the mouth. Most bivalves feed on small organisms such as phytoplankton, zooplankton and algae. Bivalves will either; bury themselves into sediment on the seafloor, lie on the seafloor, attach themselves permanently to hard substrates or bore hard substrates. Of those species that are not cemented permanently in place, most use their muscular foot to move and dig or rely on wave action for transportation. Some bivalves, like the scallop are quite mobile and use jet propulsion via the opening and closing of their valves to swim. Separate sexes in bivalves is most common, but hermaphroditism also occurs. External fertilization in marine bivalves is the most common mode of reproduction. When the gonads in bivalves are ripe, sperm and eggs are released into the water column, which is called spawning. Spawning may occur continuously or may be triggered from environmental cues such as a change in the water temperature, sun or lunar patterns or chemical cues. The length, timing and trigger of spawning differs between species.

Scallops

Scallops (family Pectinidae) are found all over the world and around New Zealand. New Zealand's endemic and largest species, Pecten novaxelandiae is harvested by commercial and recreational fishermen. They are found in sand and mud banks in harbours and down to 50 metres or deeper in shallow and sheltered embayments. The highest densities of scallops can be found between 10-25 meters of water with a substrate of soft sand and silt (Bull 1991). Spawning occurs during spring and summer and due to variable juvenile survival and recruitment, population sizes fluctuate dramatically from year to year. Natural predators of scallops include bottom feeding fish, starfish and octopus. Unlike other bivalves which are mostly sedentary, scallops are quite mobile and use jet propulsion via the opening and closing of their valves to swim. Scallops may be affected by seismic surveys or by pollution from drilling muds and debris if they are out swimming in the open ocean however this is unlikely as they mostly prefer shallow coastal waters. As they mostly inhabit shallow coastal waters an oil spill poses a great threat.

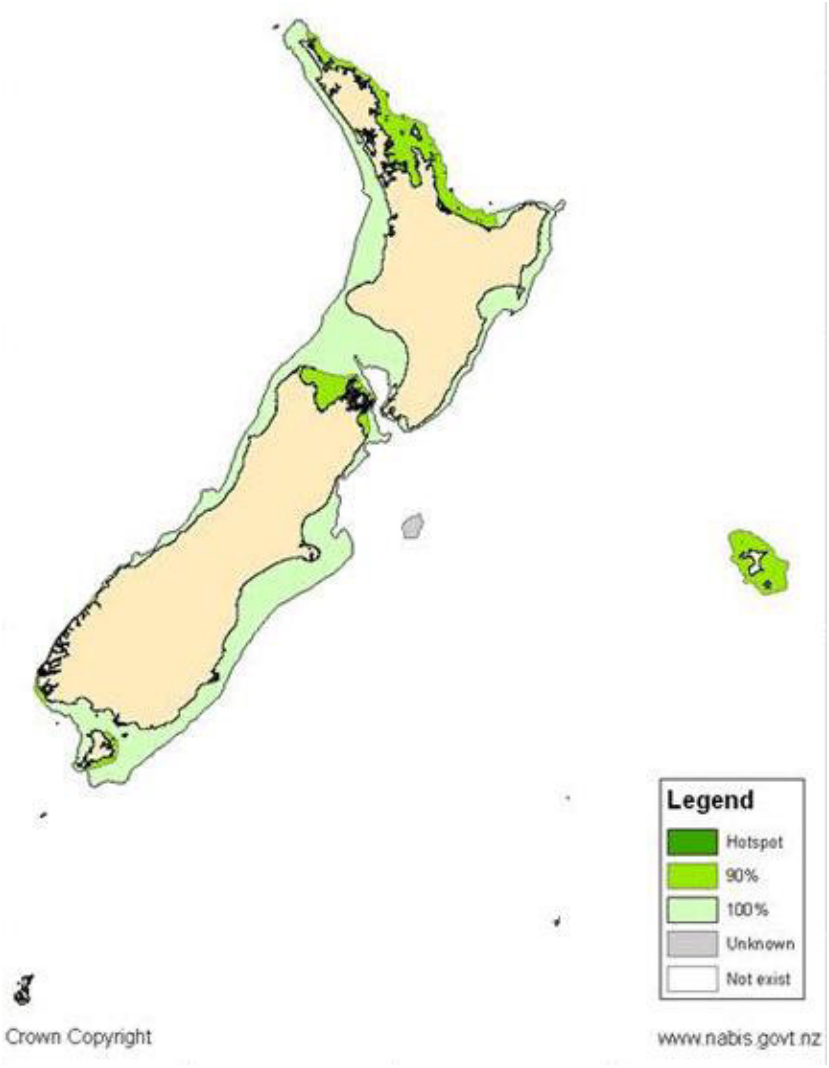


Figure 1: Scallop Pecten novaezelandiae annual distribution (MacDiarmid & Patuawa n.d).

Paua

The Great paua (*Haliotis iris*) is endemic to New Zealand and is distributed around the coastal waters of all main islands including the Chatham Islands (Figure 2). Paua graze nocturnally on algae just below the intertidal zone and inhabit a range that extends to about 15m in depth (Lindsey & Morris 2011).

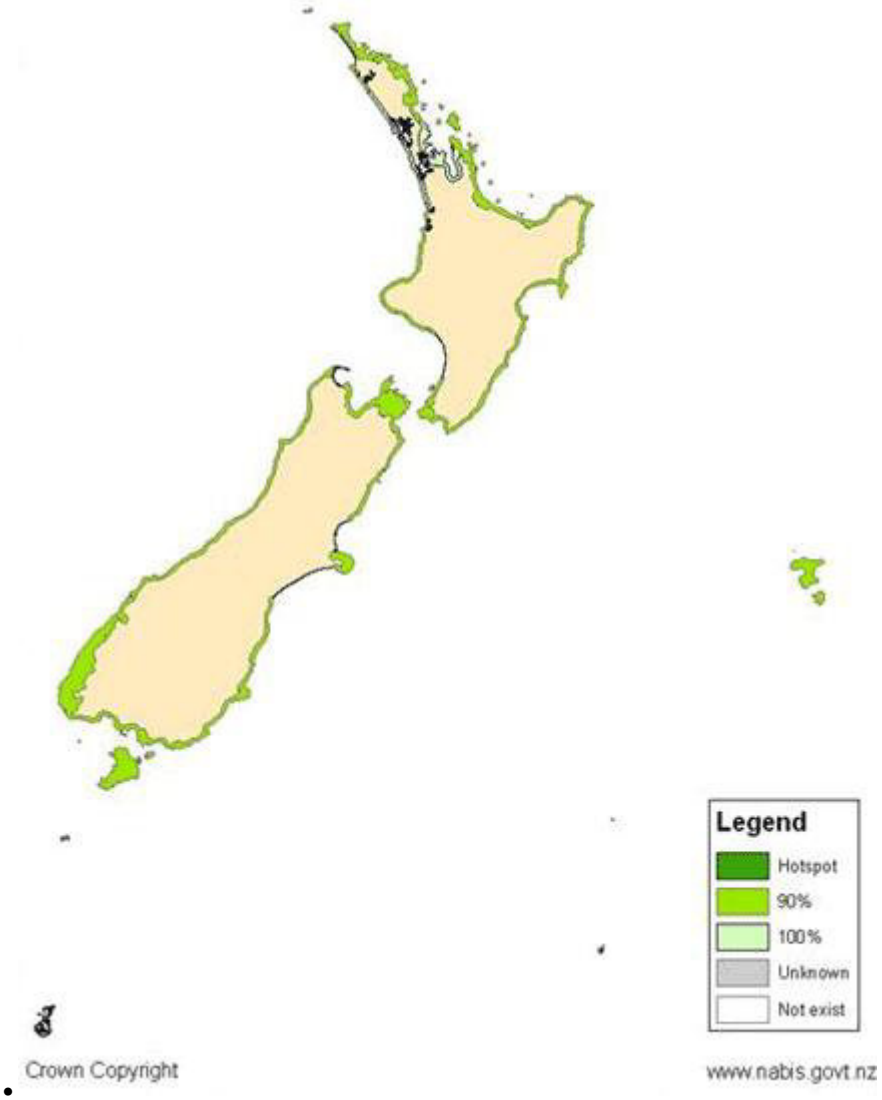


Figure 2: Paua (*Haliotis iris)* annual distribution (MacDiarmid & Patuawa n.d).

Echinodermata – sea urchin, starfish

The New Zealand sea-urchin (*Evechinus chloroticus*),more commonly referred to as the kina, is an echinoderm that is endemic to New Zealand. Found from the intertidal zone to about 80m in depth, this marine invertebrate is commercially and culturally harvested (Lindsey & Morris 2011). Considered a delicacy in many countries the annual value of the harvest in New Zealand is ******

The kina predominantly feeds on kelp and algae; they play an extremely important role in controlling kelp growth in the ocean. In the case of the removal of the kina's predators, kelp forests rapidly become barren rock indicating the importance of the relationships within this ecosystem (Lindsey & Morris 2011).

Important fish species in New Zealand waters

By Aniela Reid and Lisa van Halderen

Image: Anchovies

(from http://fiesta.bren.ucsb.edu/~costello/research/CatchShares/photos.html)

Fish Species in New Zealand

Fish species can be divided according to their position in the water column, the fish species of interest in New Zealand include:

- Demersal fish (deep sea)
    - Flounder
    - Sole
    - Turbot
    - Halibut
    - Dory
    - Cod (red/blue)
    - Orange Roughy
    - Patagonian toothfish/Chilean sea bass
    - Ling/cusk eel (*Genypterus blacodes*)
    - Grouper
    - Hake
    - Bass
    - Silver warahou
    - Red Gurnard
    - Tarakihi
    - Bluenose sea bass
- Pelagic fish (near the surface)
    - Yellow Fin and Albacore tuna
    - Barracuda
    - Mackerel
    - Salmon
    - Herring
    - Anchovy
    - Snapper (*Pagrus auratus*)
    - Grey mullet
    - Barracouta (*Thyrsites atun*)
    - Kahawai (*Arripis trutta*)
    - Moki (blue/red)
    - Butterfish
    - Southern Blue whiting (*Micromesistius australis pallidus*)
    - Hoki
    - Bream (*Brama brama*)

All these species have significant cultural, economic and recreational value in New Zealand are must therefore be protected from the impacts of deep sea oil development.

Anthropogenic noise effects on fish

At close ranges, suffer hearing damage and exhibit alarm behaviour by rapidly moving away from seismic sources (Slotte et al. 2004; McCauley et al. 2003; Payne et al. 2008; SCAR 2012). Such alarm responses are characterized by a typical so-called "C-start" response, of which fish stop all other activity and undergo this escape reflex until its completion. The C-start response or similar responses have been observed in cod, redfish species, the European sea bass and sandeel in response to airguns (Wardle et al. 2001; Pearson et al. 1992; Santulli et al. 1999; Hassel et al. 2004). These responses were observed as far as 2.5 and 5.0 km from the sound source in the European sea bass and sandeel respectively (Santulli et al. 1999; Hassel et al. 2004).

It is considered that due to usual immediate alarm responses of fish to noise, physiological effects will be minimal and behavioural effects will be most important (DNV Energy 2007). Thus the behavioural responses as a result of seismic surveys can have cause variable responses in catch rates (DNV Energy 2007). Observed increases and decreases have been observed which has been attributed to fish movement and behavioural changes which makes them more or less susceptible to fishing methods in the presence of seismic surveys (SCAR 2012). Fish which have an alarm response of diving to the sea floor are more susceptible to being caught in fishing gear on or near the sea floor such as bottom trawls or cages (SCAR 2012). Other alarm responses may send them in the opposite direction to that of fishing gear, into hiding, into different areas or away from important feeding or breeding areas (DNV Energy 2007). For instance during shooting with airguns or during 3D seismic surveys ,it has been observed that the depth distribution of whiting and herring changed (Slotte et al. 2004). Any disturbance to fish in their spawning areas at the time of spawning at worse could reduce the total annual reproduction (DNV Energy 2007).

Studies on wild fish however have been minimal (SCAR 2012). There is little evidence to suggest that increased mortality occurs as a result of seismic airgun exposure (SCAR 2012). Most studies on the response of fish to seismic airgun exposure come from caged fish however this may not reflect what realistically happens in the wild. Again responses of fish to seismic sound sources are variable. McCauley et al. (2003) reported that the ears of pink snapper (Pagrus auratus) held in cages that were exposed to an operating air-gun sustained extensive damage to their sensory epithelia that was apparent as ablated hair cells. The damage to the sensory cells appeared permanent, as there was no evidence of repair up to 58 days after exposure. As pointed out by McCauley et al. (2003) these fish were caged and video monitoring of the behaviour suggests the fish would have fled the sound source if possible. Hence in the wild, perhaps these fish may have been able to remove themselves fast enough from the area as to not suffer hearing damage. McCauley and Kent (2012) in their report discuss the lack of correlation between airgun pressure waveforms and fish hearing damage. In another study by Song et al. (2008) fish exposed to seismic air guns

suffered no damage to their ears, despite the fact that two of the fish species; the adult northern pike and lake chub, had shown a temporary threshold shift in other hearing studies.

There is little concern for pelagic fish as they tend to move away from sound sources (SCAR 2012). But, there is concern for territorial fish as they may not avoid areas with sound sources and are more likely to suffer hearing damage (SCAR 2012). However philopatric tropical fish did not suffer hearing damage as indicated by no damage to ear hair cells, or have a temporary threshold shift when exposed to 3D seismic survey (Hastings & Mikis-Olds 2012; McCauley & Kent 2012; SCAR 2012).

Fish exposed to loud sources of noise such as airguns display abnormal and disorientated swimming behaviour which possibly could indicate that damage to ears may also have a vestibular impact (McCauley et al. 2003). Fish with impaired hearing, in the form of damaged sensory cells or temporary threshold shifts or for other reasons; would have reduced fitness as they would be more susceptible to predation, potential reduced ability to locate and/or catch prey, sense their environment or unable to communicate acoustically in the case of vocal fish (McCauley et al. 2003).

In a report by Det Norske Veritas (DNV Energy 2007) it was concluded that seismic activities on the Norwegian continental shelf have little effect on fish. The report concluded that physical damage cause by the sound would be limited to within a few meters of the air guns (DNV Energy 2007). Most adult fish are likely to avoid and immediately flee from the sound, but eggs, larvae and fry may suffer physiological effects as they have a limited ability to escape the area in the event of various influences. Increased mortality rates in various species were observed in eggs, larve and fry species within 10 metres of airgun or seismic sound sources (DNV Energy 2007). Although some effects may not cause immediate mortality, other effects such as reduced ability to acquire food or increased vulnerability to predation due to altered swimming behaviour can lead to death (McCauley et al. 2003). It is expected that seismic surveys would cause a mortality rate per day of less than 0.03% in eggs and larvae, which is negligible in comparison to the natural mortality rate of 5–15 % per day for most species at these life stages (DNV Energy 2007).

These studies highlight the variable responses of fish to seismic activity. It is likely that the effects of seismic activity on fish will remain very localised and have the potential to cause hearing damage to those fish within close proximity to the sound source. Effects will be unique for each species and will depend on the life stage.

The effects of pollution from drilling wastes, cuttings and suspended sediment on fish

The impacts of chemical pollution on fish can include the poisoning of animals within the marine food chain which accumulates along the chain, biomagnifying and concentrating. Direct poisoning of fish can occur when swimming or inhabiting contaminated waters or sediments. Certain waterborne metals present in drilling wastes have the potential to bind to the gills of fish of which can interfere with their ionoregulatory and respiratory functions and cause histopathological changes in the gills (Playle, 1998; Thophon et al., 2003). The toxic and physiological effects of heavy metals and chemicals on fish in drilling muds may also cause oxidative stress in species such as cod which can lead to impaired cellular functioning. Some of the long-term adverse effects due exposure to toxic chemicals is cancer, development of tumours and lesions, immunosuppression, stress, reduced fitness and reproductive problems (Bolognesi et al., 1999; Kjeilen-Eilertsen et al. 2004). Fish may swallow large quantities of sediment of which can cause blockages, illness, reduced ability to feed, reduced growth, poisoning depending on contaminants and potential eventual death (Kjeilen-Eilertsen et al. 2004).

The effects of pollution from oil spills on fish

Toxicological effects of oil include; burning or blinding eyes, irritating or damaging sensitive membranes in the nose, mouth and eyes. Oil and hydrocarbons can supress the immune system, cause stress, organ damage and reproductive problems (Geraci & Aubin 1988, NOAA).

References

Barlow, M.J., and P.F. Kingston. 2001. Observations on the effects of barite on the gill tissues of the suspension feeder Cerastoderma edule (Linne) and the deposit feeder Macoma balthica (Linne). Marine Pollution Bulletin. 42:71-76.

Bull MF. 1991. Fisheries and Aquaculture: New Zealand. In: Shumway, S. (Ed.). Scallops: Biology, Ecology and Aquaculture. Elsevier. New York. pp 853-860.

Chapman, C.J. and Hawkins, A.D. 1969. The importance of sound in fish behaviour in relation

Clark, S.L., S.J. Teh, and D.E. Hinton. 2000. Tissue and cellular alterations in Asian clam (Potamocorbula amurensis) from San Francisco Bay: toxicological indicators of exposure and effect? Marine Environmental Research. 50:301-305.

Cranford, P.J., D.C. Gordon, K. Lee, S.L. Armsworthy, and G.H. Tremblay. 1999. Chronic toxicity and physical disturbance effects of water- and oil-based drilling fluids and some major constituents on adult sea scallops (Placopecten magellanicus). Marine Environmental Research. 48:225-256

Dauterive, L (2000). "Rigs-To-Reef Policy, Progress, and Perspective". OCS Report(U.S. Department of the Interior): 1–12.

DNV Energy (2007). Effects of seismic surveys on fish, fish catches and sea mammals 2007-0512 rev 01, Cooperation group - Fishery Industry and Petroleum Industry. Accessed on 29/10/12 from http://www.norskoljeoggass.no/PageFiles/6574/Effects%20of%20seismic%20surveys%20on%20fish,%20fish%20catches%20and%20sea%20mammals.pdf?epslanguage=no

Earth Gauge (2010). Gulf Oil Spill Series: Effects on Invertebrates. Accessed on 30/10/12 from http://www.earthgauge.net/wp-content/EG_Gulf_Invertebrates.pdf

ExxonMobil (2012) Coexisting with the Fishing Industry Esso Norge AS: An ExxonMobil Subsidiary. Accessed on 29/10/12 from http://www.exxonmobil.com/Files/PA/Norden/Coexisting_with_Fishing_Industry.pdf

Hansen, B., F.L. Fotel, N.J. Jensen, and L. Wittrup. 1997. Physiological effects of the detergent linear alkylbenzene sulphonate on blue mussel larvae (Mytilus edulis) in laboratory and mesocosm experiments. Marine Biology. 128:627-637.

Hassel, A., Knutsen, T., Dalen, J., Skaar, K., Løkkeborg, S., Misund, O.A., Østensen, Ø., Fonn, M., and Haugland, E.K. 2004. Influence of seismic shooting on the lesser sandeel (Ammodytes marinus). ICES J. Mar. Sci. 61: 1165-1173.

Hastings, M.C. and Miksis-Olds, J., 2012. Shipboard assessment of hearing sensitivity of tropical fishes immediately after exposure to seismic airgun emissions at Scott Reef. In. Popper, A.N. and Hawkins, A., The effects of noise on aquatic life. Advances in experimental medicine and biology, 730, 239-243, Springer.

Kjeilen-Eilertsen G, Westerlund S, AKvamiljø RF. 2004. Input from RF-AM to Literature study task 1 toxicity: metals. ERMS Report AM – 2004 / 023.

Lindsey, T., & Morris, R. (2011). *Collins field guide to New Zealand Wildlife.* HarperCollins*Publishers* (New Zealand) Limited, Shortland Street, Auckland, New Zealand. pp 228,249.

MacDiarmid A and Patuawa T. n.d. Bivalves and Gastropods. Accessed on 29/10/12 from http://www.treasuresofthesea.org.nz/bivalves-and-gastropods#8

McCauley, R.D. and Kent, C.S. 2012. A lack of correlation between airgun pressure waveforms and fish hearing damage. In. In. Popper, A.N. and Hawkins, A., The effects of noise on aquatic life. Advances in experimental medicine and biology, 730, 245-243, Springer.

McCauley, R.D., Fewtrell, J., and Popper, A.N., 2003. High intensity anthropogenic sound damages fish ears. Journal of the Acoustic Society of America, 113, 638-642.

Pan, J.F. and Wang, W.X. 2002. Comparison of the bioavailability of Cr and Fe bound with natural colloids of different origins and sizes to two marine bivalves. Marine Biology 141: 915-924.

Parry, G.D. and Gason, A., 2006. The effect of seismic surveys on catch rates of rock lobsters in western Victoria, Australia. Fisheries Research, 79, 272-284.

Parry, G.D., Heislers, S., Werener, G.F., Asplin, M.D., and Gason, A., 2002. Assessment of environmental effects of seismic testing on scallop fisheries in Bass Strait. Marine and Freshwater Resources Institute, Report, 50, 32 pages.

Payne, J.F., Andrews, C., Fancey, L. Whaite, D. and Christian, J., 2008. Potential effects of seismic energy on fish and shellfish: an update since 2003. Fisheries and Oceans Canada, Canadian Science Advisory Secretariat, Research Document 2008/060

Pearson, W.H., Skalski, J.R. and Malme, C.I. 1992. Effects of sounds from a geophysical survey device on behavior of captive rockfish (Sebastes spp). Can. J. Fish. Aquat. Sci. 49(7): 1343-1356.

Playle, R.C. 1998. Modelling metal interactions at fish gills. Science of the Total Environment. 219:147-163

Qiao, P.W., and A.P. Farrell. 1996. Uptake of hydrophobic xenobiotics by fish in water laden with sediments from the Fraser River. Environmental Toxicology and Chemistry. 15:1555-1563.

Santulli, A., Modica, A., Messina, C., Deffa, L., Curatolo, A., Rivas, G. Fabi, G. and D'Amello, V. 1999. Biochemical responses of European sea bass (Dicentrarchus labrax L.) to the stress induced by offshore experimental seismic prospecting. Mar. Poll. Bull. 36(12): 1105-1114.

SCAR. 2012. Anthropogenic Sound in the Southern Ocean: an Update. Antarctic Consultative Meeting XXXV Hobart 2012.

Song J, Mann DA, Cott PA, Hanna B, Popper A. 2008. The inner ears of Northern Canadian freshwater fishes following exposure to seismic air gun sounds. J. Acoust. Soc. Am. 124 (2).

Teh, S.J., S.L. Clark, C.L. Brown, S.N. Luoma, and D.E. Hinton. 1999. Enzymatic and histopathologic biomarkers as indicators of contaminant exposure and effect in Asian clam (Potamocorbula amurensis). Biomarkers. 4:497-509.

Thophon, S., M. Kruatrachue, E.S. Upatham, P. Pokethitiyook, S. Sahaphong, and S. Jaritkhuan. 2003. Histopathological alterations of white seabass, Lates calcarifer, in acute and subchronic cadmium exposure. Environmental Pollution. 121:307-320

to capture by trawls. FAO Fish. Rep. 62(3): 717-729.

Van den Belt, K., S. Van Puymbroeck, and H. Witters. 2000. Toxicity of cadmium-contaminated clay to the zebrafish Danio rerio. Archives of Environmental Contamination and Toxicology. 38:191-196.

Vefsnmo, S. and Lothe, A. 2001. UKOOA Phase II - Task 3: Large scale experiment Report STF81A01848, ISBN 82-14-01828-5.

Wang, W.X., and N.S. Fisher. 1999b. Delineating metal accumulation pathways for marine invertebrates. Science of the Total Environment. 238:459-472.

Wardle, C.S., Carter, T.J., Urquhart, G.G., Johnstone, A.D.F., Ziolkowski, A.M., Hampson, G. og Mackie, D. 2001. Effects of seismic air guns on marine fish. Cont. Shelf Res. 0: 1-23

Wedderburn, J., I. McFadzen, R.C. Sanger, A. Beesley, A. Heath, M. Hornsby, and D. Lowe. 2000. The Field Application of Cellular and Physiological Biomarkers, in the Mussel Mytilus edulis, in Conjunction with Early Life Stage Bioassays and Adult Histopathology. Marine Pollution Bulletin. 40:257-267.

Weltens, R., R. Goossens, and S. Van Puymbroeck. 2000. Ecotoxicity of contaminated suspended solids for filter feeders (Daphnia magna). Archives of Environmental Contamination and Toxicology. 39:315-323.

Seabirds in New Zealand waters

By Lisa van Halderen

Image: Chatham Petrel (*Pterodroma axillaris*)
(Picture by Colin Miskelly from http://www.iucn.org/?3159/More-Critically-Endangered-birds-on-IUCN-Red-List-than-ever)

Seabird species within New Zealand

Seabirds are a unique group of birds that have evolved many adaptations to successfully exploit a marine environment. Only 2% of the world's bird species successfully inhabit this extreme environment and in doing so have several characteristics that set them aside from terrestrial birds. These include a larger body size, small clutches with extended incubation, and many are extremely long lived (Croxall 1987). The main families of seabird include Sphenisciformes (penguins), Procellariiformes (albatrosses, petrels, storm petrels and diving petrels), Pelecaniformes (pelicans, gannets, boobies, frigatebirds and cormorants/shags), and Charadriiformes (skuas, gulls, terns, skimmers and auks; Croxall 1987).

Globally, New Zealand boasts the most diverse group of seabirds with 84 diferent species breeding on the mainland and many surrounding islands. Of these, 35 do not breed anywhere else in the world and are therefore endemic. The main threats to New Zealand seabirds include predation from introduced mammals, fishing-related mortalities and loss of nesting habitat due to anthropogenic development and activities.

The IUCN Red List has ranked 47 of New Zealand sea birds taxa as threatened which covers the classifications of Critically Endangered (Table 1), Endangered (Table 1) and Vulnerable (Table 2,3,4). Additionally, the New Zealand Department of Conservation classifies species using a different threat system (Molloy and Davis threat category) that is based on priority of conservation effort. The IUCN also ranks species as Data Deficient (Table 5) which means that more research and information is required to classify the species into a threat category (Taylor 2000). The lack of information on these species indicates that the risk of extinction and extent of anthropogenic factors impacting them is unkown, which is a big concern.

All New Zealand seabirds are protected under the Wildlife Act 1953, with the exclusion of the southern black-backed gulls. This protection extends throughout the mainland and includes the Exclusive Economic Zone (EEZ) which covers an area 200 nautical miles (320km) offshore (Ministry for the Environment 2007). This means that any impact that deep sea oil development has on seabirds needs to be monitored, evaluated and mitigated to ensure the sustainability of the populations.

Table 1: New Zealand seabird taxa listed as Critical or Endangered by IUCN Criteria (Taylor 2000).

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Pterodroma magentae	Chatham taiko	Critical	Category A
Pterodroma axillaris	Chatham petrel	Critical	Category A
Sterna nereis davisae	NZ fairy tern	Critical	Category A
Thalassarche eremita	Chatham albatross	Critical	Category B
Diomedea sanfordi	Northern royal albatross	Endangered	Category B
Thalassarche chrysostoma	Grey-headed albatross	Endangered	Category B
Puffinus huttoni	Hutton's shearwater	Endangered	Category B
Eudyptes sclateri	Erect-crested penguin	Endangered	Category B
Eudyptula m. albosignata	White-flippered penguin	Endangered	Category B
Leucocarbo onslowi	Chatham Island shag	Endangered	Category B
Sterna albostriata	Black-fronted tern	Endangered	Category B
Pterodroma cookii	Cook's petrel	Endangered	Category C

Table 2: New Zealand seabird taxa listed as Vulnerable by IUCN criteria (Ranked as Second Prioirity species by Molloy and Davis Criteria; Taylor 2000).

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Diomedea gibsoni	Gibson's albatross	Vulnerable	Category B
Diomedea epomophora	Southern royal albatross	Vulnerable	Category B
Thalassarche impavida	Campbell albatross	Vulnerable	Category B
Thalassarche nov. sp	Pacific albatross	Vulnerable	Category B
Procellaria parkinsoni	Black petrel	Vulnerable	Category B
Procellaria westlandica	Westland petrel	Vulnerable	Category B
Puffinus bulleri	Buller's shearwater	Vulnerable	Category B
Pachyptila crassirostris	Fulmar prion	Vulnerable	Category B
Megadyptes antipodes	Yellow-eyed penguin	Vulnerable	Category B
Eudyptes pachyrhynchus	Fiordland crested penguin	Vulnerable	Category B
Leucocarbo carunculatus	NZ king shag	Vulnerable	Category B

Table 3: New Zealand seabird taxa listed as Vulnerable by IUCN criteria (Ranked as Third Priority species by Molloy and Davis Criteria; Taylor 2000).

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Diomedea antipodensis	Antipodean albatross	Vulnerable	Category C
Thalassarche bulleri	Buller's albatross	Vulnerable	Category C
Thalassarche salvini	Salvin's albatross	Vulnerable	Category C
Thalassarche steadi	White-capped albatross	Vulnerable	Category C
Pterodroma cervicalis	White-naped petrel	Vulnerable	Category C
Eudyptes robustus	Snares crested penguin	Vulnerable	Category C
Stictocarbo featherstoni	Pitt Island shag	Vulnerable	Category C
Leucocarbo chalconotus	Stewart Island shag	Vulnerable	Category C
Leucocarbo ranfurlyi	Bounty Island shag	Vulnerable	Category C
Leucocarbo colensoi	Auckland Island shag	Vulnerable	Category C
Leucocarbo campbelli	Campbell Island shag	Vulnerable	Category C
Sterna striata striata	NZ white-fronted tern	Vulnerable	Category C
Sterna striata aucklandorna	Southern white-fronted tern	Vulnerable	Category C

Table 4: New Zealand seabird taxa listed as vulnerable by IUCN criteria (Species not considered threatened previously by Molloy and Davis Criteria; Taylor 2000).

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Eudyptes chrysocome filholi	Eastern rockhopper penguin	Vulnerable	Category O
Fregetta grallaria	White-bellied storm petrel	Vulnerable	Category O
Pterodroma pycrofti	Pycroft's petrel	Vulnerable	not listed
Procellaria a. aequinoctialis	White-chinned petrel	Vulnerable	not listed
Puffinus a. kermadecensis	Kermadec little shearwater	Vulnerable	not listed
Puffinus assimilis haurakiensis	North Island little shearwater	Vulnerable	not listed
Sula dactylatra fullagari	Masked booby	Vulnerable	not listed
Phalacrocorax v. varius	Pied shag	Vulnerable	not listed
Larus bulleri	Black-billed gull	Vulnerable	not listed
Sterna vittata bethunei	Antarctic tern	Vulnerable	not listed
Sterna fuscata kermadeci	NZ sooty tern	Vulnerable	not listed

Table 5: New Zealand seabird taxa listed as Data Deficient (Taylor 2000).

SPECIES	COMMON NAME	IUCN RANK	MOLLOY & DAVIS RANK
Pelagodroma marina albiclunis	Kermadec storm petrel	Data Deficient	Category B
Procellaria cinerea	Grey petrel	Data Deficient	Category O
Phoebetria palpebrata	Light-mantled albatross	Data Deficient	not listed
Pachyptila crassirostris eatoni	Lesser fulmar prion	Data Deficient	not listed

Effects of oil on seabirds

Deep sea oil development can have a huge effect on bird species worldwide, particularly in the event of an oil spill. Bird feathers are severely affected by oil which causes them to stick together, reducing their insulating and water-proofing abilities. Seabirds affected by an oil spill can subsequently develop hypothermia which causes them to leave cold waters. This can result in dehydration and an increase in energy expenditure (Taylor 2000; Erasmus et al. 1982; Crawford et al. 2000). Oil can also be ingested by preening and can lead to the formation of ulcers in the mouth and stomach. The absorption of oil can also cause red blood cells to rupture which results in anaemia. An additional affect of oil is its immune-suppressant abilities which can increase sea bird species' susceptibility to particular diseases such as pneumonia (Crawford et al. 2000).

Some seabirds are highly vulnerable to oil spills as they spend a large proportion of their time feeding in large groups on the surface of the ocean (Piatt et al. 1990). Many migrating seabirds found in New Zealand have been impacted by oil spills such as sooty shearwaters in the 1989 *Exxon Valdez* oil spill off the coast of Alaska (Taylor 2000). In the October 2011 Rena oil spill in the Bay of Plenty, 1300 birds were killed (McGinnis 2012). While petrels may have the ability to detect and therefore avoid oil, many other species of seabird can be severly impacted by an oil spill (Taylor 2000).

Of particular concern is the treatment of oiled seabirds as there is much debate over the most effective method of cleaning them. A study in North America by Sharp (1996), investigated the effectiveness of treating oiled seabirds and found that the median survival period post-release was only six days. On the other hand, after the 1995 *Iron Baron* oil spill near Tasmania, blue penguins impacted by the spill were successfully treated (Hull et al. 1998). In New Zealand, the cost of an oil clean up is covered by the company or group that

caused the spill and Massey University is responsible for any oiled sea birds along with assisstance from DOC staff (Taylor 2000).

Impact of collisions with deep sea oil rig equipement on seabirds

Another impact that deep sea oil development may have on sea birds is mortality due to collision with the oil rig structures or associated vessels. Seabirds use visual cues for orientation and therefore artificial lights can cause confusion (Merkel & Johansen 2011). Seabirds are also known to be attracted to oil drilling platforms due to artificial lighting at night, food, and flaring (Wiese et al. 2001). This may cause collision and, as many sea birds are migratory, it may also deplete important energy stores required during the long journey. This is particularly relevant for seabirds that migrate at night (Merkel & Johansen 2011; Poot et al. 2008). As a result, deep sea oil development not only impacts local populations but can have serious effects on global breeding populations that rely on migrant seabirds (Wiese et al. 2001).

In depth focus on some of the species that are at stake:

Many threatened sea birds in the Chatham Island area such as the Chatham Island taiko, petrel and shag are not at immediate risk of oil spills or any other dangers that deep sea oil development may present. This is due to low ship traffic and the fact that no permits have been authorized for deep sea oil development near the Chatham Islands (Taylor 2000). These species, therefore, will not be mentioned in this report.

Penguin species (Sphenisciformes)

Image: Yellow-eyed Penguins (*Megadyptes antipodes*)
(Pictured by Penguin Place from http://www.birdingnz.co.nz/directory.php?op=50)

The New Zealand penguin species at particular risk during the different stages of deep sea oil development include mainland penguins such as the Yellow-eyed, Little Blue and Fiordland Crested penguins and many offshore island species, some found exclusively on the sub-Antarctic Islands (e.g. Erect crested and Snares crested).

The Yellow-eyed penguin (*Megadyptes antipodes*) is found on the sub-Antarctic Auckland and Campbell Islands and on the mainland of the South-east coast of South Island, New Zealand (Seddon et al. Unpubl.). A small number of yellow-eyed penguins colonised the mainland several hundred years ago and genetic variation of the mainland population has remained low (Boessenkool et al. 2009). The two populations are genetically and geographically distinct; resulting from a lack of gene flow between the two populations (Seddon et al. Unpubl.). The Yellow-eyed penguin is listed as Endangered on the IUCN Red

List due to its restricted breeding range, decreased habitat availability and extreme fluctuations in population numbers which appear to be declining (BirdLife International 2012). As the Yellow-eyed penguins on the mainland are a genetic subset of the sub-Antarctic population, they are highly vulnerable to potential oil spills; if the population is lost they cannot be replaced. Additionally, with low juvenile survival and therefore recruitment rates, an additional impact such as an oil spill would devastate the population (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012). After fledging, the Yellow-eyed penguin spends several months out at sea. There is limited knowledge on the activities of the penguins during this period and they may be severely affected by deep sea oil development, especially during an oil spill which may reduce prey abundance (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012).

The Little Blue Penguin (*Eudyptula minor*) is found throughout the main islands of New Zealand and across to southern Australia (Dann 1994). Although the national population is as high as 600 000 breeding pairs, particular populations are declining at several locations which will be more at risk of additional impacts such as an oil spill (Newton 2006). These populations are known to be declining due to predation and human disturbance through habitat destruction (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012; Newton 2006). The offshore effects of deep sea oil development on their prey could provide an additional negative impact which may be exaggerated by their small foraging range (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012). A study by Giese et al. (2000) found that oiled Little Blue penguins that had been rehabilitated had 22% lower egg success (probability of successfully fledging chicks) than individuals that had avoided an oil spill. The chicks of Little Blue penguins that are impacted by an oil spill have reduced survival; along with predation, an oil spill could lead to a rapid decline of the Little Blue penguin populations in New Zealand (Giese et al. 2000).

Another mainland penguin species at risk from deep sea oil development is the Fiordland Crested penguin which are highly restricted and only found on the southern coast of the South Island. Although this species has not been extensively studied, estimated put the population at about 5000 individuals and declining. The Fiordland Crested penguin has a pelagic phase where they leave the mainland, like the Yellow-eyed penguin, their whereabouts are unknown which increases their vulnerability. Any deep sea oil development can impact them when they are out at sea, due to collision or impacts on prey species. Additionally, an oil spill could impact their breeding populations on the mainland if oil is washed up onshore (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012).

The sub-Antarctic Islands remain the stronghold of the Yellow-eyed penguin population and are the only location where Erect Crested and Snares Crested penguins are found. Additionally, there is a population of Rockhopper penguins found on Campbell and Antipodes Islands. This species is declining throughout the world and this is attributed to

climate change – with increasing temperatures, prey species are moving further offshore where the penguins are unable to forage for them (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012; Hilton et al. 2006). Any deep sea oil development near the sub-Antarctic Islands can have serious implications on the endemic and range-restricted penguin populations in the area (Phillip Seddon & Yolanda van Heezik, personal communication, July 27, 2012). These penguins spend several months out at sea before returning to colonies to breed; this behaviour may bring them into contact with deep sea oil rigs, causing a decline in numbers of the breeding population due to mortality associated with deep sea oil development (Warham 1974; Wiese et al. 2001).

Albatross and Petrel Species (Procellariiformes)

Image: Royal Albatross (*Diomedea epomophora*)
(Pictured by Royal Albatross Centre from http://www.birdingnz.co.nz/directory.php?op=35)

Image: Cook's Petrel
(From http://www.scoop.co.nz/stories/SC1106/S00001/migration-linked-to-genetic-differences-in-nz-seabirds.htm)

Procellariformes are particularly vulnerable in the case of deep sea oil development as they are highly attracted to light and forage at night on bioluminescent prey (Wiese et al. 2001). In the *Exxon Valdez* oil spill in Alaska, a large proportion of shearwaters and storm-petrels died several months after the spill. These surface feeding birds most likely died from starvation due evidence of low body fat and empty stomachs. This indicates that their food sources were impacted, and therefore depleted, by the spill (Piatt et al. 1990).

The breeding biology of albatrosses and petrels makes them vulnerable to any disturbances. These birds only lay one egg per year and will not relay if the egg or nest is damaged. This means that if an oil spill were to compromise any nesting colonies or produce too much disturbance as to cause the birds to abandon their nests, the population may completely fail a breeding season (Taylor 2000). Additionally, incubation and time until chicks fledge is significantly longer in these species compared to other bird species such as gulls and terns. Incubation is roughly around 40-75 days and chicks are reared for 50-280 days until fledging; this is compared to 20-25 days and 20-40 days, respectively, in other seabird species (Taylor 2000).

Ngai Tahu hold several procellariforme species in high regard and consider them taonga species these include (Taylor 2000):

- Titi (sooty shearwater, Hutton's shearwater, common and South Georgian diving petrel, Westland black petrel)
- Fairy and broad-billed prion
- White-faced storm petrel
- Cook's petrel
- Mottled petrel
- Albatrosses

The titi are particularly significant due to the cultural harvest that occurs on the islands surrounding Rakiura (Stewart Island). This harvest is strictly managed and any impact from deep sea oil development, such as an oil spill or depleted prey, may significantly hinder this cultural harvest (Taylor 2000).

Another vulnerable species is the Black Petrel (*Procellaria parkinsoni*) which is ranked as Vulnerable under the IUCN Red List and Category B (Second Priority) on the Molloy & Davis threat system. Previously distributed throughout the North and South Islands, this seabird is now restricted to Little Barrier and Great Barrier Islands during breeding (Taylor 2000; Oliver 1955). The species continues to face several threats which include predation by introduced mammals, accidental capture by long-line fisheries (Imber 1987; Taylor 2000). Although not a lot is known about the impact of oil on the Black Petrel, this species' main breeding colonies are in the Raukumara Basin area where deep sea oil exploration is already underway. The bird also migrates and forages across the Pacific Ocean and therefore may be at a higher risk to pollution due to bioaccumulation (Taylor 2000).If an oil spill were to occur during the breeding period (between December and February), with only 2500 breeding pairs found on Great Barrier and about 100 pairs on Little Barrier, the population may almost be wiped out (Taylor 2000).

Shag Species (Pelecaniformes)

Image: New Zealand King Shag (*Leucocarbo carunculatus*)
(Picture by C.D Roderick from http://www.teara.govt.nz/en/shags/3/1)

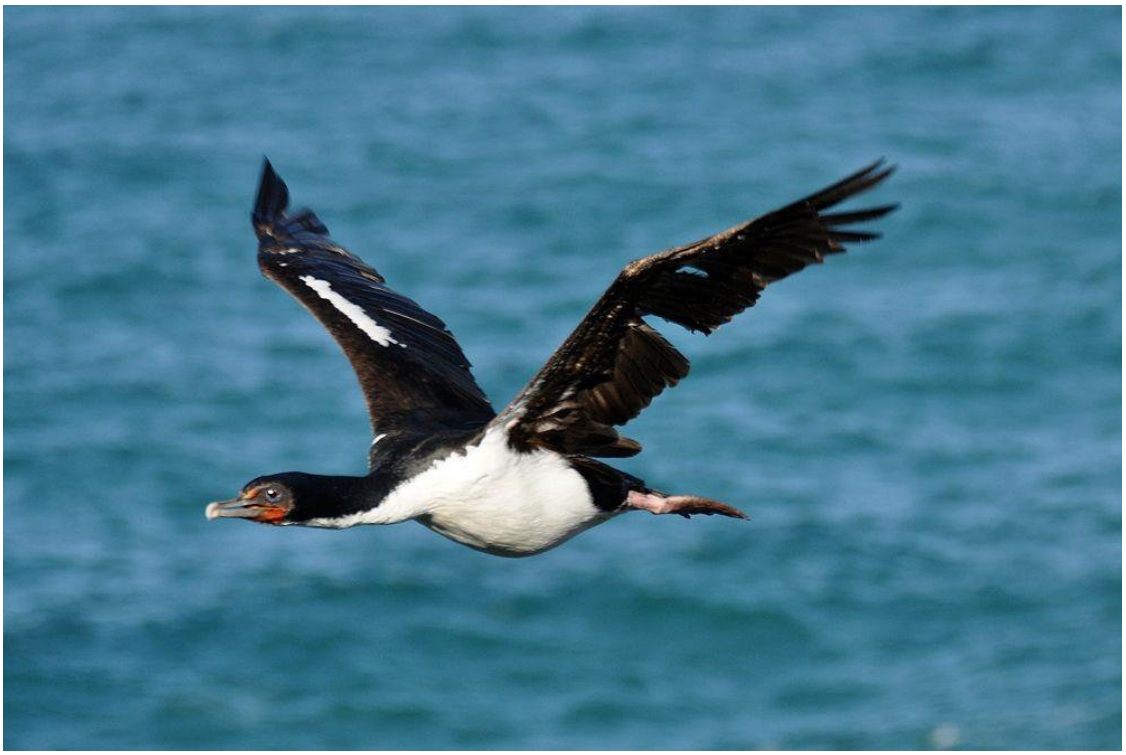


Image: Stewart Island Shag (*Leucocarbo chalconatus*)
(from http://www.albatross.org.nz/taiaroa-head/photo-galleries/taiaroa-wildlife)

The water surrounding mainland New Zealand and the islands nearby, contain about half of the world's shag species (McGinnis 2012). In a study by Piatt et al. (1990), it was found that a proportionately larger number of Pelecaniforme individuals died in the *Exxon Valdez* spill than were present in the area. This suggests that pelagic feeding birds (such as shags) are highly vulnerable to oil spills, implying that these shag species in New Zealand waters may be at significant risk if an oil spill were to occur. Not only could New Zealand potentially lose some of its seabird species, but global biodiversity would also be compromised.

Ngai Tahu also consider the koau (black, pied and little shags) as taonga species, indicating the importance of the protection of these seabirds from the impacts of deep sea oil development in New Zealand (Taylor 2000).

Two species that would be particularly at risk in the case of any impact resulting from deep sea oil development would be the New Zealand King Shag (*Leucocarbo carunculatus*) and the Stewart Island Shag (*Leucocarbo chalconotus*).

The New Zealand King Shag only breeds on the islands of Marlborough Sounds in the South Island of New Zealand and is restricted to areas around the Cook Strait (Taylor 2000). In 1992, a survey indicated that there were only 534 birds remaining (Schuckard 1994). This species is therefore listed as Vulnerable under the IUCN Red List criteria and Category B in the Molloy & Davis rank. The King Shag is highly sensitive to anthropogenic disturbances which can reduce the breeding success of the bird; these disturbances include low flying planes, tourist boats and commercial fishing vessels (Taylor 2000). As deep sea oil development involves significant boat traffic, and is likely to occur on either side of the Cook Strait (Challenger Plateau, Lord How Rise and Pegasus Basin), the King Shag may have compromised breeding success as a result.

The Stewart Island Shag is endemic to New Zealand and only breeds in the South Island from Timaru to the Foveaux Strait. This species is listed as Vulnerable and placed in Category C under the Molloy & Davis criteria (Taylor 2000). The birds forage in coastal waters and therefore an oil spill would be detrimental to the feeding success of the Stewart Island Shag and may result in starvation and death. The population numbers of the Stewart Island Shag have fluctuated significantly over the last few decades as a result of bad breeding seasons and there are an estimated 1000 to 5000 pairs. This wide estimate indicates that more research is required and that the species may be at risk without the added impact of deep sea oil development. Similarly to the King Shag, the Stewart Island Shag is very susceptible to human disturbance and also exhibits low breeding success in the presence of this disturbance. This species will also abandon nesting sites if disturbance is continuous (Taylor 2000). As a result, the Stewart Island Shag population may also be negatively impacted by deep sea oil development that is occurring in the Great South Basin. An oil spill would severely hinder the populations' reproductive success and may cause a significant decline.

Similarly, increased boat traffic to and from a deep sea oil rig would also be a source of disturbance and may also interfere with a colonies breeding behaviour.

Tern Species (Charadriiformes)

Image: New Zealand Fairy Tern (*Sterna nereis*)
(Pictured by John Kendrick from http://www.nzseabirds.com/gallery.php?aid=85)

Image: Black-fronted tern (*Sterna albostriata*)
(from http://www.flickriver.com/places/New+Zealand/Southland/Bluff/)

Ngai Tahu considers all tern species of significant cultural value and therefore it is New Zealand's responsibility to protect these species from any negative impacts (Taylor 2000).

As all tern species are considerably small, they are at large risk from mammalian predators such as rats, cats, stoats, ferrets, pigs and dogs. These introduced predators not only prey on the chicks of tern species but also on the adults – several also target the eggs. Introduced herbivore species also reduce habitat and can destroy nests by trampling on them (Taylor 2000).

Two species that are at risk of deep sea oil development include the New Zealand Fairy tern and the Black-fronted tern. These species are vulnerable to any impact due to their pelagic feeding behaviour and their declining population sizes.

The New Zealand Fairy tern (*Sterna nereis davisae*) is considered the rarest seabird in New Zealand with only 30 individuals recorded (Taylor 2000). This endemic subspecies is classified as Critical on the IUCN Red List and of top priority for conservation by the Molloy & Davis threat system. The New Zealand Fairy tern breeds at Papakanui Spit in Northland and feeds at Kaipara Harbour during the winter months (Parrish & Pulham 1995). Human disturbances to Fairy tern nest's can cause the birds to abandon breeding sites, this may occur in the event of an oil spill if groups during the clean-up cause too much stress. Additionally, any oil spill may significantly reduce nesting habitat if oil washes onshore and also prevent the birds from accessing food.

The Black-fronted tern (*Sterna albostriata*) is listed as Endangered by the IUCN Red List and is in Category B of the Molloy & Davis threat classification system. This species is endemic to New Zealand and no sightings of the birds have been made outside of the country (Taylor 2000). It has been estimated that there are only about 1000-5000 pairs of Black-fronted tern remaining however a thorough census is yet to be carried out (Robertson & Bell 1984). This population size continues to decline, mostly as a result of introduced mammalian predators (Sanders 1997).

While Black-fronted terns breed on braided rivers in the South Island, they spend the winter feeding along the coast of New Zealand's main islands. This bird forages over the shallow waters of estuaries and mudflats from Stewart Island to southern North Island, which makes them vulnerable to oil spills as their food sources would be significantly affected (Lindsey & Morris 2011; Taylor 2000). The birds will only be at threat from deep sea oil development during the winter when they inhabit coastal areas.

Conclusion

Oil spills and collision with rig equipment or vessels are the biggest threat to seabirds in New Zealand when it comes to deep sea oil development. New Zealand has the largest diversity of seabirds in the world and therefore it is important to reduce negative impacts to maintain global biodiversity. Of particular concern are seabird species that have low populations that are continually declining. These species may face extinction with present threats and additional threats from deep sea oil development may exacerbate this decline.

References

BirdLife International. (2012). *Megadyptes antipodes*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.1. www.iucnredlist.org. (Downloaded on 27 August 2012.)

Boessenkool, S., Star, S., Waters, J.M., & Seddon, P.J. (2009). Multilocus assignment analyses reveal multiple units and rare migration events in the recently expanded yellow-eyed penguin (*Megadyptes antipodes*). *Molecular Ecology*, 18(11), 2390-2400.

Crawford, R.J.M., Davis, S.A., Harding, R.T., Jackson, L.F., Leshoro, T.M., Meÿer, M.A., Randall, R.M., Underhill, L.G., Upfold, L., van Dalsen, A.P., van der Merwe, E., Whitington, P.A., Williams, A.J., & Wolfaardt, A.C. (2000). Initial impact of the Treasure oil spill on seabirds off western South Africa. *South African Journal of Marine Science*, 22(1), 157-176.

Croxall, J.P. (1987). *Seabirds feeding biology and role in marine ecosystems.* Cambridge University Press, UK.

Dann, P. (1994). The abundance, breeding distribution and nest sites of Blue Penguins in Otago, New Zealand. *Notornis*, 41(3), 157-166.

Erasmus, T., Randall, R.M., & Randall, B.M. (1981). Oil pollution, insulation and body temperatures in the jackass penguin *Spheniscus dermersus*. *Comparative Biochemistry and Physiology*, 69, 169-171.

Giese, M., Goldsworthy, S.D., Gales, R., Brothers, N., & Hamil, J. (2000). Effects of the *Iron Baron* oil spill on little penguins (*Eudyptula minor*). III. Breeding success of rehabilitated oiled birds. *Wildlife Research*, 27(6), 583-591.

Hilton, G.M., Thompson, D.R., Sagar, P.M., Cuthbert, R.J., Cherel, Y., & Bury, S.J. (2006). A stable isotopic investigation into the cases of decline in a sub-Antarctic predator, the rockhopper penguin *Eudyptes chrsocome*. *Global Change Biology*, 12, 611-625.

Imber, M.J. (1987). Breeding ecology and conservation of the black petrel (*Procellaria parkinsoni*). *Notornis,* 34, 19-39.

Lindsey, T., & Morris, R. (2011). *Collins field guide to New Zealand Wildlife.* HarperCollins*Publishers* (New Zealand) Limited, Shortland Street, Auckland, New Zealand. pp 91.

McGinnis, M. (2012). Living up to the brand, Greening Aotearoa's Marine Policy. *Policy Quaterly,* 8(1), 17-28.

Merkel, F.R., & Johansen, K.L. (2011). Light-induced bird strike on vessels in Southwest Greenland. *Marine Pollution Bulletin,* 62, 2330-2336.

Newton, N. (2006). Natural foraging and breeding behaviours of the Little Blue Penguin *Eudyptula minor* including recommendations for captive population. GCAS 8. University of Canterbury, Christchurch, New Zealand.

Oliver, W.R.B. (1955). *New Zealand birds*. Second Edition. Reed, Wellington, New Zealand.

Parrish, R. & Pulham, G.A. (1995). Population size, productivity and post-breeding movements of the New Zealand fairy tern. *Tane,* 35, 175-181.

Piatt, J.F., Lensink, C.T., Butler, W., Kenziorek, M., & Nysewander, D. (1990). Immediate impact of the 'Exxon Valdez' oil spill on marine birds. *The Auk*, 107(2), 387-397.

Poot, H., Ens, B.J., de Vries, H., Donners, M.A.H., Wernand, M.R., & Marquenie, J.M. (2008). Green light for nocturnally migrating birds. *Ecology and Society*, 13(2), 47-60.

Robertson, C.J.R., & Bell, B.D. (1984). Seabird status and conservation in the New Zealand region. *In* J.P. Croxall, P.G. Evans, & R.W. Schreiber (eds), *Status and conservation of the world's seabirds.* Reserves Series. Department of Lands and Survey, Wellington, New Zealand. pp 70-74.

Sanders, M.D. (1997). Video monitoring of banded dotterel nests in braided rivers. *In* J. Sims & A. Sanders (eds), *National predator management workshop 1997*. Department of Conservation, Wellington, New Zealand. pp 93-97.

Schuckard, R. (1994). New Zealand shag *(Leucocarbo carunculatus*) at Duffers Reef, Marlborough Sounds. *Notornis*, 41, 93-108.

Taylor, G.A. (2000). *Action Plan for Seabird Conservation in New Zealand, Part A: Threatened Seabirds*. Threatened Species Occasional Publication No. 16. Biodiversity Recovery Unit, Department of Conservation, Wellington, New Zealand.

Warham, J. (1974). The breeding biology and behaviour of the Snares Crested Penguin. *Journal of the Royal Society of New Zealand*, 4(1), 63-108.

Wiese, F.K., Motevecchi, W.A., Davoren, G.K., Huettmann, F., Diamond, A.W., & Linke, J. (2001). Seabirds at risk around offshore oil platforms in the North-west Atlantic. *Marine Pollution Bulletin*, 42(12), 1285-1290.

Pinnipeds in New Zealand waters

By Lisa van Halderen

Image: New Zealand fur seal (*Arctocephalus forsteri)*
(Pictured by Lloyd Spencer Davis from http://www.teara.govt.nz/en/seals/5/1)

Pinniped species within New Zealand

Pinnipeds are a unique group of marine mammals that are part of the Carnivora order. Three families, including Otariidae (fur seals and sea lions), Odohenidae (walruses) and Phocidae (earless seals), comprise this group (MARINE MAMMAL BOOK***). As only species belonging to the Otarridae family inhabit New Zealand waters, species from the other families will not be included in this report (Robertson & Chilvers 2011).

Otariids have several distinguishable features which include external ears (pinnae), as well as the ability to walk by turning their hindflippers forward. New Zealand has two species of otariid – the New Zealand fur seal (*Arctocephalus forsteri*) and the New Zealand sea lion (previously named the Hookers sea lion; *Phocarctos hookeri;* Chilvers 2008). While the New Zealand fur seal is found around the coasts of New Zealand, Australia and the sub-Antarctic islands (Figure 1), the New Zealand sea lion is endemic to New Zealand. This species is restricted to two sub-Antarctic islands and the Otago Peninsula on the South Island of New Zealand (Figure 2; Robertson & Chilvers 2011; Goldsworthy & Gales 2008).

The effects of deep sea oil development on pinnipeds would mainly cover noise disturbance from drilling and increased ship traffic, and mortality from oil spills (NMFS 2009).

Anthropogenic noise effects on pinnipeds

The negative impacts of noise on pinnipeds would predominantly occur during the construction of oil rigs, the production phase and drilling. Permanent or temporary hearing impairment can occur in marine mammals as a result of loud acoustic disturbance (NMFS 2009). It has been found that pinnipeds are displaced and found in lower densities during periods of construction and exploratory activities as a result of deep sea oil development (Green & Johnson 1983; Frost & Lowry 1988). With deep sea oil development, comes an increase in vessel activity as boats transport supplies to oil rigs and carry oil back to the mainland. It has also been noted that with increased vessel activity there is decreased pinniped abundance, indicating avoidance behaviour (NMFS 2009).

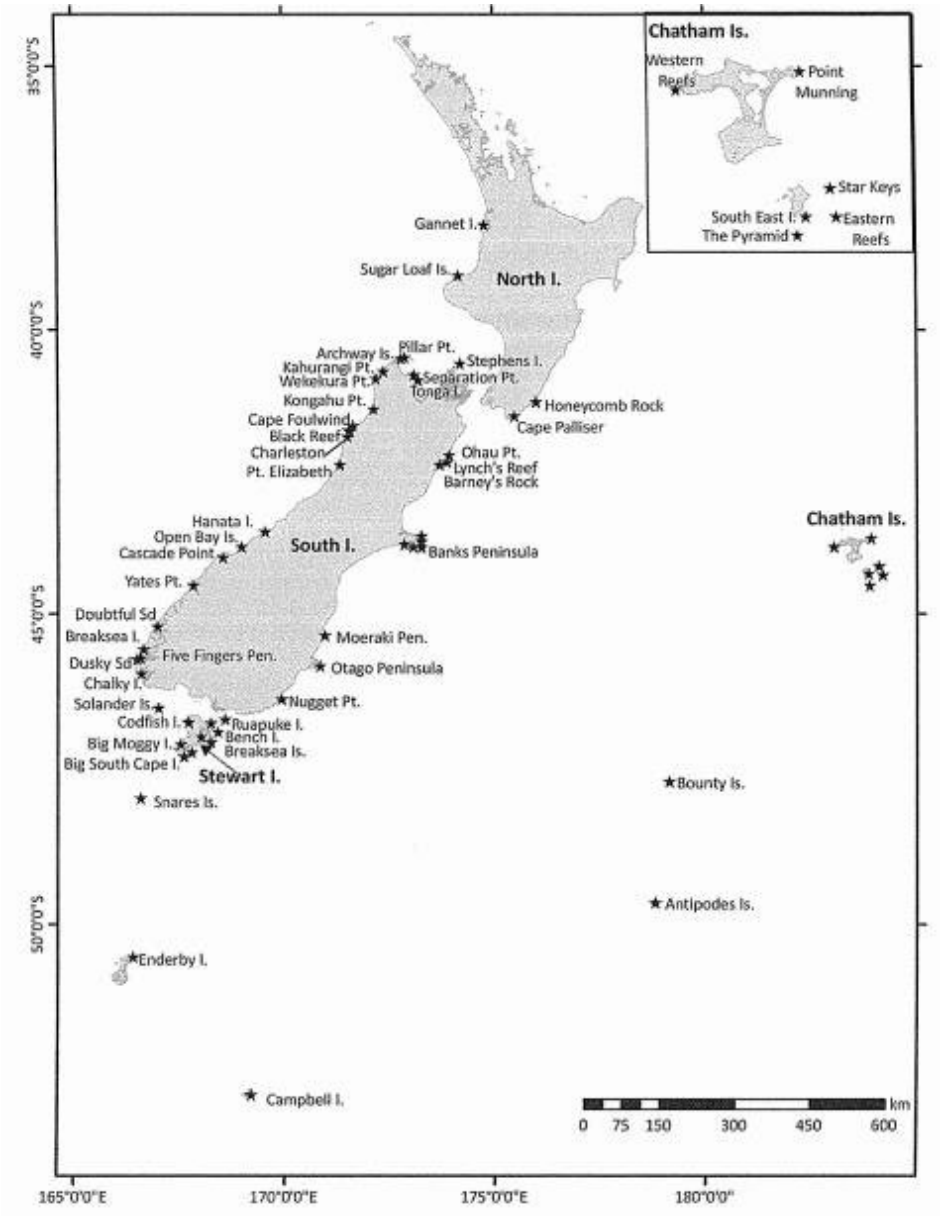


Figure 1: Locations of the main New Zealand fur seal rookeries, based on information at http://www.nabis.govt.nz (Baird 2011).

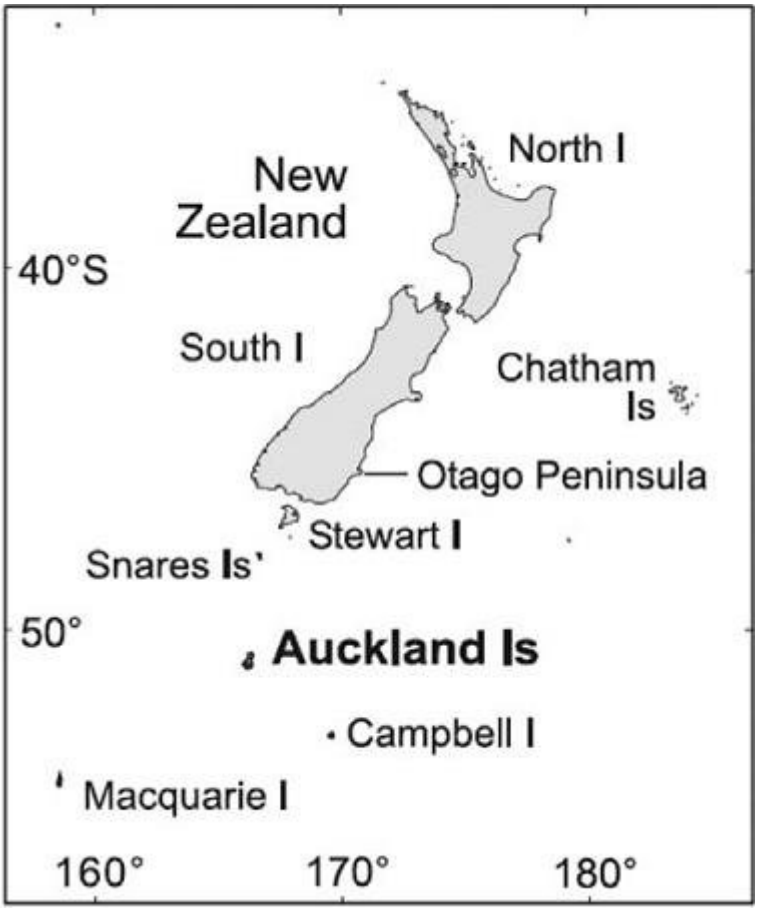


Figure 2: New Zealand mainland and sub-Antarctic showing Otago Peninsula, Stewart Island, Snares Islands, Auckland Islands and Campbell Island (Robertson & Chilvers 2011).

Effects of oil on pinnipeds

An oil spill can have severe effects on pinnipeds which range from skin and eye infections to death due to ingestion. Newborn seal pups can die from hypothermia due to loss of insulation as a result of being oiled. The additional stress of oiling can cause death if pinnipeds are already subject to natural stressors such as low prey abundance or extreme environmental conditions (NMFS 2009). In the event of an oil spill, the clean up process can impact pinniped species through increased disturbance from response staff and aircraft (NMFS 2009).

In depth focus on some of the species that are at stake:

The New Zealand sea lion (Phocarctos hookeri)

Image: New Zealand sea lion (*Phocarctos hookeri)*
(Picture by JK Overgaard from http://www.biopix.com/hooker-new-zealand-sea-lion-phocarctos-hookeri_photo-65176.aspx)

The New Zealand fur seal has a rising population numbering around 200,000 across both New Zealand and Australia and is regarded by the IUCN Redlist as Least Concern (Goldsworthy & Gales 2008). On the other hand, the endemic New Zealand sea lion is at particular risk if deep sea oil development were to become widespread in New Zealand.

Under the New Zealand threat classification system, this species is considered 'nationally critical' with extreme population declines. The species is New Zealand's only endemic pinniped and it mainly breeds on the sub-Antarctic islands – the majority are found on Auckland Islands (Robertson & Chilvers 2011).

The decline of the Auckland Island population is attributed to competition with fisheries and fisheries-related by-catch. NZ sea lion pup production has declined significantly since 1996 and continues to do so (Figure 3). The added impacts that may result from deep sea oil development could increase the rate of decline and lead to the extinction of this population (Robertson & Chilvers 2011). The NZ sea lion was eliminated from the mainland about 200 years ago from overhunting and habitat degradation. More recently, several females have re-colonised the Otago Peninsula which is significant as it may remove the threatened status if new breeding sites are established away from the sub-Antarctic Islands (Chilvers & Wilkinson 2008). The re-colonisation is highly important as it spreads the risk of the NZ sea lion to rare catastrophic events, such as disease outbreaks, which could cause the local extinction of populations (Chilvers & Wilkinson 2008). Deep sea oil development may interrupt this re-colonisation if disturbance, or an oil spill, were to act as a barrier to the movement of additional female sea lions onto the mainland. It has been found that colonial pinnipeds will move to less suitable breeding sites in the presence of repeated disturbance such as noise from increased vessel traffic and seismic activities (Geraci & St. Aubin 1980). Hence, the impacts of deep sea oil development may increase the susceptibility of the NZ sea lion to extinction.

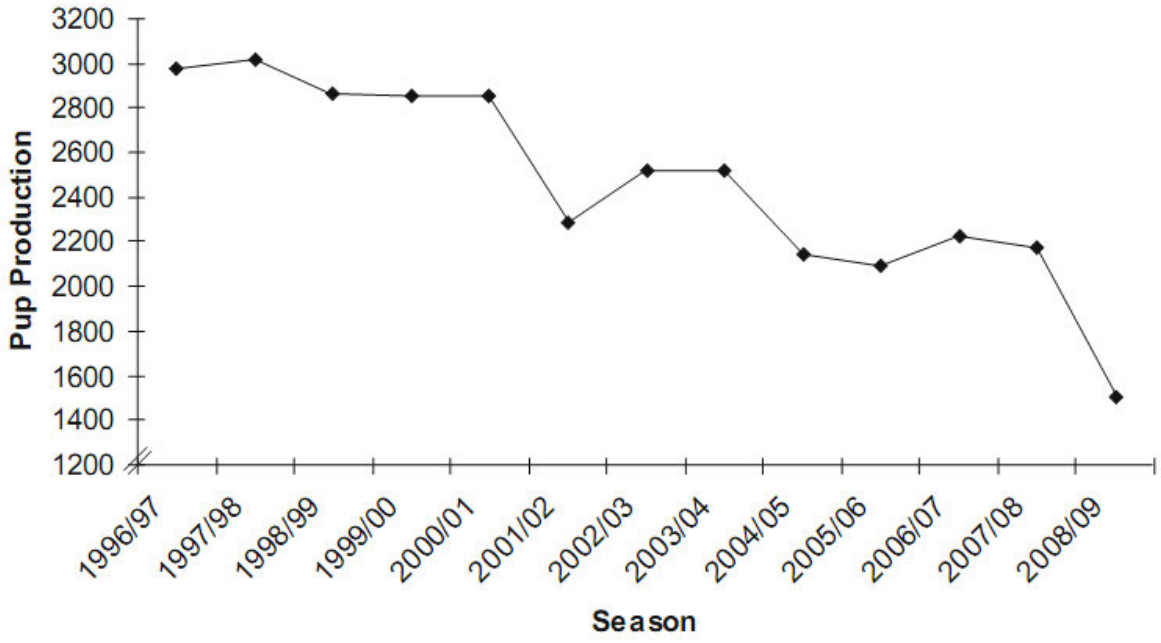


Figure 3: Pup production on the Auckland Islands, 1996/97 to 2008/09 (Department of Conservation 2009).

Conclusion

While New Zealand fur seals are likely to be impacted by deep sea oil development, of particular concern is the declining New Zealand sea lion. As this species faces multiple harmful impacts, predominantly fishing-related mortality, any other impacts which may arise from deep sea oil development may have significant effects on the population and may lead to complete extirpation of the species.

References

Baird, S.J. (2011). New Zealand fur seals – summary of current knowledge. New Zealand Aquatic Environment and Biodiversity Report No. 72.

Chilvers, B.L., & Wilkinson, I.S. (2008). Philopatry and site fidelity of the New Zealand sea lions (*Phocarctos hookeri*). *Wildlife Research*, 35, 463-470.

Department of Conservation. (2009). New Zealand sea lion species management plan: 2009-2014. Publishing Team, Department of Conservation, Wellington, New Zealand.

Geraci, J.R. & St. Aubin, D.J. (1980). Offshore petroleum resource development and marine mammals: A review and research recommendations. *Marine Fisheries Review,* November 1980, 1-12.

Goldsworthy, S., & Gales, N. (IUCN SSC Pinniped Specialist Group). (2008). *Arctocephalus forsteri*. In: IUCN 2012. IUCN Red List of Threatened Species. Version 2012.2. www.iucnredlist.org. (Downloaded on 27 August 2012).

Greene, J.E., & Johnson, S.R. (1983). The distribution and abundance of ringed seals in relation to gravel island construction in the Alaskan Beaufort Sea. In L.B.J. Gallawayd (ed.), *Biological studies and monitoring at Seal Island, Beaufort Sea, Alaska 1982.* Report form LGL Ecological Research Associates Inc, Bryan, TX for Shell Oil Company, Houston, Texas, USA. pp 1-28.

Frost, K.J, & Lowry, L.F. (1988). Effects of industrial activities on ringed seals in Alaska, as indicated by aerial surveys. In: W.M. Sackinger, M.O. Jeffries, J.L. Imm and S.D. Treacy (eds.), *Port and Ocean Enginerring under arctic conditions, vol II.* Geophysical Insitute, University of Alaska, Fairbanks, AK, USA.

NMFS (National Marine Fisheries Service). (2009). Request for a letter of authorization pursuant to Section 101 (a) (5) of the Marine Mammal Protection Act covering taking of marine mammals incidental to operation of offshore oil and gas facilities in the U.S. Beaufort Sea (50C.F.R. Part 216, Subpart R) submitted by BP Exploration (Alaska) Inc., Department of Health, Safety, and Environment, Anchorage, AK, USA.

Robertson, B.C., & Chilvers, B.L. (2011). The population decline of the New Zealand sea lion *Phocarctos hookeri*: a review of possible causes. *Mammal Review*, 41(4), 253-275.