Styles Group
Underwater Acoustics

CASE STUDY

Researching Hector's Dolphins in Lyttelton Harbour

Channel deepening and cruise berth project in Lyttelton Port.

Client: Lyttelton Port Company

PROJECT OVERVIEW

Lyttelton Harbour in New Zealand is a special marine environment within the Banks Peninsula Marine Mammal Sanctuary and provides habitat for the endangered Hector's Dolphin.

To keep up with growing demand, The Lyttelton Port Company (LPC) needed to deepen the approach channel for large vessels and construct a new cruise berth terminal. They needed Underwater Acoustic expertise to help them proceed without negatively impacting the marine environment.

OUR SUPPORT

Over the 6 years of the development project, we worked closely with the team at Lyttelton Port Company and Cawthron Institute to monitor and study the local Hector's dolphins around the Harbour, to minimise the impact of the dredging and pile-driving on the marine environment in Lyttelton Harbour.

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During the course of the project we provided:

UNDERWATER NOISE MEASUREMENT

Through collaboration with LPC, Vision Environment and Enviser, eight listening stations (comprising of SoundTraps and/or CPODs), were installed and regularly maintained each month between 2017 and 2021 (before, during and after construction).

UNDERWATER NOISE MODELLING

A comprehensive assessment of underwater noise effects from the dredging and pile driving on the endangered Hector's dolphin within Lyttelton Harbour was delivered.

MITIGATION RECOMMENDATIONS

We assisted in the development of the Marine Mammal Management Plan (MMMP) which sets out the project management response in relation to marine mammals.

MARINE MAMMAL MONITORING

The presence of Hector's dolphins was determined from >100,000 hours of passive acoustic data using our automated detectors and classifiers. The detectors perform a series of advanced signal processing algorithms before the AI engine classifies the acoustic signals. Our in-house built acoustic analysis software integrates parallel computing and so the processing is several orders of magnitude quicker than other software.

DATA ANALYSIS

The underwater acoustic data collected is the largest dataset of its kind in New Zealand. Our intelligent data analysis systems allowed for fast and automated data processing while fully incorporating LPC's construction records, marine mammal observer logs and other datasets into the acoustic data analysis.

ONGOING SCIENTIFIC RESEARCH

A scientific investigation into the noise effects after the cruise berth construction and channel deepening project was required. This is a collaborative project with Cawthron Institute, LPC and Styles Group.

The acoustic data gathered is being used to inform wider scientific research, and ultimately, will be used to inform the development of underwater noise standards to manage impacts on not only Hector and Maui dolphins, but many dolphin species around NZ's coastline and abroad.

Our data analysis allows us to gain new insights into:

- How dredging and pile driving alters the harbour's natural underwater soundscape and
- How any changes to that soundscape may impact Hector's dolphins.
- We are in the process of publishing the results in scientific journals.

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CASE STUDY

Protecting Indo-Pacific humpback dolphins in Hong Kong waters

Investigating dolphin and porpoise movements within high speed ferry lanes, Hong Kong SAR

Client: World Wildlife Fund - Hong Kong (WWF- HK)

PROJECT OVERVIEW

Developments within the Pearl River Estuary (PRE) have caused underwater ambient sound levels to rise – to the point where communication between marine mammals could be masked and lead to stress. These developments include the Hong Kong-Zhuhai-Macau bridge construction, the HKIA Third Runway Project and Guishan offshore wind farm demonstration project.

Marine survey data between 2011 and 2016 showed that Indo-Pacific humpback dolphins had moved to southwest Lantau waters and the Soko Islands, away from the construction activity near their previous core-habitat north of Lantau Island.

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The high-degree of marine traffic (particularly high speed ferries and fishing vessels) in the waters SW of Lantau Islands and south Lantau was creating two main risks to the dolphins' health: auditory masking (potentially leading to reduced feeding efficiency, group cohesion and navigation) and dolphin-vessel collisions (leading to serious injury and death).

In 2016, World Wildlife Fund - Hong Kong (WWF-HK) started a comprehensive investigation into the diurnal occurrences of cetaceans along the busy ferry fairway in southwestern Lantau waters, including the Soko Islands. The aim of this investigation was to support conservation action to protect the Indo-Pacific humpback dolphin (Sousa chinensis) which is iconic for Hong Kong, as well as Indo-Pacific finless porpoises (Neophocaena phocaenoides).

OUR SUPPORT

WWF - HK required scientific services to inform their conservation directions for the dolphins in the region. They also required monitoring of Indo-Pacific finless porpoises, which also reside around Hong Kong waters.

With extensive experience in marine mammal detection in Chinese waters, we were able to work around the numerous issues in undertaking acoustic investigations in extremely busy seas and successfully monitor and report on marine mammal movements.

The technical reports from this monitoring program are being used by WWF-HK to justify and encourage the establishment of new marine protected areas around Lantau and Soko Islands to protect the last core area for Indo-Pacific humpback dolphins – a cause we are very proud to be directly involved in.

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During the course of the project we provided:

DATA ANALYSIS

New signal processing software plugins for the PRE and Hong Kong was written to process the recordings and amplify dolphin clicks while reducing background noise. This proved essential for the successful detection of echolocation click signals in very noisy environments.

That software was incorporated into specific classifiers for Indo-Pacific humpback dolphins and validated against our datasets from the Beidu Gulf, Yangtze River (for finless porpoises) and mainland waters of the PRE.

PASSIVE ACOUSTIC MONITORING AND UNDERWATER NOISE MEASUREMENT

This multi-year (2016-2021) large-scale passive acoustic monitoring programme involved 10 hydrophones, at 10 independent listening stations. To record the complete spectrum that covers both vessel noise, dolphins and porpoises, 288 kHz sampling rates were required, recording over 4TB of data per month.

The western waters of Hong Kong in the PRE are very hazardous, with intense trawling, typhoons and zero water visibility creating significant challenges in retrieving each hydrophone every month (undertaken by our collaborators Oceanway Corporation Limited, Hong Kong). Despite these challenging circumstances not one recorder was lost.

We successfully recorded over 3000 hours of data per year. In 2017 alone, we recorded a total of 4533 marine mammals around SW Lantau Island – 3368 were of Indo-Pacific humpback dolphins and 1165 were of Indo-Pacific finless porpoises.

PREDICTIVE NOISE MODELLING

Several aspects of this project have required advanced propagation noise modelling, from informing hydrophone placement to decision making by WWF-HK. With high resolution bathymetry for the study area and multiple sources for environmental data, we have built advanced range-dependent noise models for both shipping and ferries, as well as other sources, such as percussive pile-driving within the study area. These models are allowing us to investigate how noise exposure inside the dolphin's core-use areas can be reduced.

We now regularly advise WWF-HK on underwater noise issues in their waters and continue to provide scientific services such as predictive noise modelling, and data analysis to assist in their public outreach.

Find out more about this project:

https://www.wwf.org.hk/en/?20040/Marine-Traffic-Poses-Numerous-Threats-to-Chinese-White-Dolphin-WWF-Study-Finds
https://www.scmp.com/news/hong-kong/health-environment/article/2123569/noise-hong-kong-marine-traffic-poses-threat-rare
https://wwfwhales.org/news-stories/securing-a-future-for-the-chinese-white-dolphin

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CASE STUDY

Automated detection of Baleen Whales off Nova Scotia

Automated classification of baleen whales in the North Atlantic Ocean.

Client: Department of Fisheries and Oceans Canada

PROJECT OVERVIEW

The Department of Fisheries and Oceans Canada (DFO) has been undertaking Passive Acoustic Monitoring in the North Atlantic Ocean. They wanted to detect and classify all baleen whales off Nova Scotia, but did not have access to multi-species detectors and classifiers.

OUR SUPPORT

DFO engaged our bioacoustics expertise to train a specific classifier that could detect and classify calls from any species of baleen whales and allow the results to be easily verified themselves.

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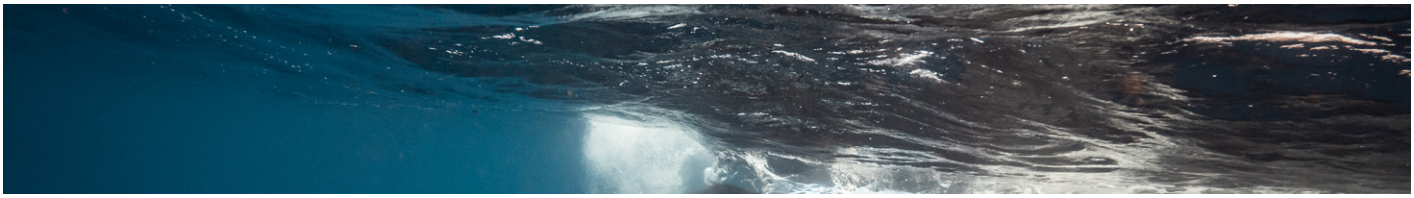
DATA ANALYSIS

DFO provided us with several months of raw acoustic data that was uploaded to our analysis systems where automated detectors processed the data.

All baleen species were to be detected so species classification was achieved using four interconnected detection algorithms that used energy fluxes, spectral entropies, contour tracing and edge detection and harmonics. Cross-correlation between outputs and predetermined templates based on our bioacoustics library and literature lead to species classification.

These detectors produced 2-min audio snippets of each detection as well as an image file of the spectrogram containing the detection. This was a standard data product provided to clients to give them confidence in the results because they can self-verify and check the outputs.

Various calls from blue whales, fin whales, sei whales, humpbacks and North Atlantic right whales were detected, with bioacoustics properties and datetimes of calls provided to DFO.



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CASE STUDY

Understanding the impact of tourism operations on Cetaceans in the Hauraki Gulf

How COVID created a unique opportunity to explore the acoustic wellbeing of Cetaceans

Client: Hauraki Gulf Cetacean Fund, Department of Conservation

PROJECT OVERVIEW

The aim of this project was to quantify the effects of boat noise, like those used by the tourism industry, on soundscape and dolphin and fish communication. The parameters of the project were changed due to COVID (see Endnote) making it uniquely possible to observe the impact of the reduction of boat noise on cetacean activity.

This collaborative scientific research project was run in conjunction with University of Victoria in Canada, University of Auckland, and Herriot-Watt University in Edinburgh.

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OUR SUPPORT

Background on the Hauraki Gulf

The biodiversity of this marine park is regarded as internationally outstanding and is consequently protected through its own legislation, the Hauraki Gulf Marine Park Act 2000 (Pine et al. 2016). At least 25 species of marine mammals visit the Hauraki Gulf (nearly a third of all marine mammal species worldwide) throughout the year of which 6 are considered to be resident (Hauraki Gulf Forum 2011, 2014).

Noise pollution from vessel traffic has the potential to substantially degrade cetacean habitats around the Hauraki Gulf Marine Park (among other factors). Cetaceans (whales, dolphins and porpoises) depend on underwater sound for activities that are critical to their survival. Those activities include, but are not limited to, ensuring group cohesion, maintaining communication between individuals, locating prey, and predator/ hazard avoidance. Their ability to communicate and sense their environment using underwater sound is highly reliant on the ambient acoustic environment, whereby the biologically-important signals must be audible over the background ambient sound level.

Vessel traffic in the Hauraki Gulf Marine Park is capable of causing ambient sound levels to rise to the point where communication between marine mammals may be masked creating the potential for deleterious impacts on marine mammals. Approximately 1,400 ships per annum transit the Gulf to gain access to the country's largest port (Constantine et al. 2015), as well as 132,000 recreational boats being owned by Auckland's residents (Beca, 2012).

In addition to these two types of marine traffic, a variety of other vessel-types operate daily, from charter fishing vessels and ferries to cruise liners, harbour cruise boats, tugs and barges, trail-suction hopper dredgers, coastal bunkers, as well as marine mammal tourism vessels.

Vessel noise is highly variable and can be of high intensity, with the capacity to impact cetaceans primarily through elevating ambient sound levels and thereby inducing auditory masking which is the most pervasive impact of vessel noise (McWhinnie et al., 2017) and capable to extending over large areas of the Hauraki Gulf for noisy vessels (Pine et al. 2016; Putland et al. 2018). The noise from most motorised vessels overlaps with the frequency range of cetaceans and can frequently propagate over several kilometres (Pine et al. 2016; Halliday et al. 2017; Pine et al. 2018).

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SCIENTIFIC RESEARCH

Passive Acoustic Monitoring and Noise Modelling

Our aim was to get passive acoustic monitoring data over 2 years to study vessel traffic volumes and marine mammal detections near Auckland City (where only sighting data exists and was sparse - i.e. only collected during daytime, or when people were on the water).

Five passive acoustic monitoring sites were set up in the inner Gulf – inside the Rangitoto Channel, off Auckland's North Shore, Shearer's Rock near Tiritiri Matangi Island, the middle of the Hauraki Gulf and the Aahaha Rocks near the Noises Islands.

The monitoring sites, each containing a SoundTrap (the deeper water at the Noises and Mid-Gulf sites also had an acoustic release for retrieval), recorded the soundscape continuously. This meant that vessel activity and counts of vessel transits through the Rangitoto Channel could be quantified which could not be done if recorders were running on duty cycles.

Noise modelling would be done on AIS data of ships and tourism vessels to get cumulative sound levels over each month. Modelling would also be used to model communication ranges of dolphins when exposed to vessel noise compared to times without vessel noise present.

The arrival of COVID

When COVID arrived in 2020, NZ was one of the first countries to enter into strict L4 lockdown. This lockdown extended to the oceans, meaning non-essential vessels were banned from operating while shipping was dramatically reduced.

This allowed us to study the cumulative effects of small boat traffic on shallow water soundscapes near Auckland City in a very unique way – through the collection of novel baseline data. It also illustrated the power of long-term Passive Acoustic Monitoring (PAM) because it was the only form of monitoring that was able to happen during the total ban. Other survey and monitoring methods could not happen, and acoustics was the only type of data that could be used to study lockdown effects.

The PAM programme showed that the immediacy and severity of the lockdown restrictions had a dramatic effect on the marine soundscape, with ambient sound levels dropping as much as 8 dB re 1 µPa over the first 12 hours.

On the first day of lockdown (26 March 2020), the presence of vessel noise in the Rangitoto Channel dropped to 34%, down from 63% the day before (25 March). By the 1st of April, daily vessel presence had dropped to 8% within the Rangitoto Channel, capturing only port-related vessels passing through.

Out near the Noises Islands, vessel activity dropped even further, with no vessels being detected some days. The ambient soundscape and broadband noise levels were the lowest ever recorded in New Zealand, reaching just 102 dBrms re 1 µPa (over a whole day) inside the Rangitoto Channel – levels below the maximum levels recorded during the remote Arctic summer (these range between 73 and 103 dBrms re 1 µPa (Insley et al. 2017)).

With dolphins (and some fishes) heavily relying on their vocalisations and hearing, the sudden drop in ambient sound levels led to them experiencing an immediate increase in estimated communication ranges by up to 65%.

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OUR RESULTS

Dolphins were detected throughout the weeks leading up to and during the lockdown period. A hotspot for dolphins (bottlenose and common dolphins) is near the Noises Islands, and changes in detection durations before and during lockdown were most noticeable there than at other sites. For example, in the 31 days before lock-down, dolphins were acoustically present off the Noises Islands for 1341 minutes compared to 2031 minutes in the first 31 days of lockdown. Notwithstanding, dolphins were detected for longer durations at all monitoring sites during lockdown than before it.

The key value in the data collected during 2020 is that it provided hard evidence for the impact of small vessel noise on underwater soundscapes and how marine animals will have to adapt to ever-growing noise pollution.

Statistical testing of the data collected before, during and after lockdown, has revealed relationships between the vessel activity and the ambient noise levels. For example, generalised linear models revealed 2 dB increases in daily sound pressure levels for every 10% increase in vessel presence over 24 hour periods – a measured cumulative effect that vessel noise has on the soundscape. These relationships were not obtainable before lockdown.

These data empirically demonstrate that small vessels, when in sufficient numbers, directly influence ambient noise levels and are not an acute noise source with limited impact as sometimes believed by regulators. Data from during the lockdown has shown that the current volume of small vessel traffic operating within the HGMP is enough to raise the median daily ambient sound levels by least 6 dBrms re 1 µPa in habitats at least 45km from downtown Auckland. Closer to the city, the contribution of vessel traffic to ambient sound levels is even higher – approximately 8 dBrms re 1 µPa within the Rangitoto channel. These data are unprecedented in showing how small vessels have already contributed the ambient sound levels within the HGMP, providing statistically strong relationships that can be used to better predict future noise levels from a recreational vessel fleet that is expected to reach 183,000 by 2041 – meaning an approximate 3 dBrms re 1 µPa increase to existing daily SPLs could be expected.

Recording of High Speed, Foiling Vessels

Endnote: The impact of COVID on the project

The COVID pandemic enhanced the power and conclusions of this project. COVID lockdowns meant we could really investigate how small vessel noise changes a soundscape without theory but through observation. We were therefore also able to study rather than only model the impact of small vessel noise on the acoustic wellbeing of the Gulf's cetaceans.

COVID and the lockdowns provided unprecedented novel data that allowed us to quantify the effects of boat noise, like used by the tourism industry, on soundscape and dolphin and fish communication. This resulted in us publishing these results and presenting these findings in a series of media stories, radio interviews and podcasts, as well as Matt Pine becoming a scientific consultant on BBC's The Year Earth Changed documentary with David Attenborough.

Explore more here:
https://blog.doc.govt.nz/2020/10/03/unexpected-upside-to-lockdown-listening-in-to-dolphin-chatter/
https://hakaimagazine.com/news/the-tranquility-of-lockdown/