IMBeR West Pacific Symposium 2021

Session 7: Connectivity of the West Pacific and Southern Ocean: the Importance of Oceanic Top Predators

November 24, 2021

Session Introduction

Oceanic top predators are an important link between the West Pacific and Southern Ocean and function as indicators of ecosystem change across the region. The main determinants of predator movements are the distribution and abundance of their prey, which are not distributed homogeneously. Prey distribution is determined and influenced by oceanographic processes that influence biological productivity and/or increase the availability of prey, thus creating areas where foraging is more energetically efficient. The spatio-temporal scales on which these processes operate vary greatly, from vertical mixing at centimeters to meters over time scales of seconds-hours-days, to climate features such as El-Niño Southern Oscillation and Southern Annular Mode that occur over hundreds of thousands of kilometers at time scales of years to decades. Consequently the impact on trophic structure and predator responses also varies greatly; from localised and short-term changes in foraging efficiency and prey availability to long-term population trends. This session aims to further disentangle the relationship and relevant lag-times between oceanographic processes in the West Pacific and Southern Oceans, and predator responses from foraging behaviour to large-scale demographic trends and future population viability under plausible climate scenarios. While focussed on this region, we also invite submissions from elsewhere which can provide valuable lessons that can be applied to understanding predator responses in the West Pacific and Southern Oceans. The session will feature both talks and posters, and the authors will have the opportunity to publish their works in a special volume of a renowned peer-reviewed international journal. We particularly encourage submissions from ECR and members from underrepresented groups in science.
This session represents a joint ICED (Integrating Climate and Ecosystem Dynamics in the Southern Ocean) CLIOTOP (CLimate Impacts on Oceanic TOp Predators) initiative.

Co-moderators: Luis Huckstadt (University of Exeter / University of California Santa Cruz) and Jaimie Cleeland (University of Tasmania / Australian Antarctic Division),
Co-conveners: Emma Carrol (The University of Auckland) and Pia Ricca (The University of Hong Kong)
Rapporteurs: Jaimie Cleeland and Leena Riekkola (University of Auckland)
Number of participants: 63

Major highlights from each presentation

Keynote: Dr Michelle LaRue, University of Canterbury

- This project combined crowd-sourcing and high resolution satellite images to provide the first ever population estimate of Weddell seals in Antarctica.
- Citizen scientists were asked to look at satellite images and to first identify whether there were any seals ('presence-absence'), and then later to count (by 'clicking on') seals in the same images.
- "CrowdRank" algorithm was used to translate crowd based estimates into a population estimate using a 'consensus' approach: the more people that agreed on a feature in an image being a seal, the more likely that it actually was one.
- Investigated the entirety of fast ice around Antarctica - ~260,000km^2, seals present on 0.55% of available fast ice - so very patchily distributed. First ever population estimate: 202,135 breeding Weddell seals - not as many as expected. The Ross Sea area had the most seals (42% of all seals) and the Amundsen Sea had the fewest seals.
- Weddell seal presence was more likely farther away from Adelie penguin colonies, seal presence was more likely when nearby an emperor penguin colony (as long as the colony was not too big).

Invited talk: Dr Mao Mori, Tokyo university of Marine Science and Technology

- Key toothfish habitat occurs on the continental slopes, shelves and seamounts. In the Southern Ocean food web system, toothfish are an important prey to other species during e.g. the egg and larval stages, therefore understanding toothfish life cycle is essential.
- Access during winter is hard, therefore no samples of small larval fish have yet been collected, however an earlier study found potential toothfish spawning grounds. Ocean currents are important for successful transport of early life stages, but they are not well known in the East Antarctic region.
- SAM is the dominant atmospheric circulation variability mode in the Southern Hemisphere, and it can affect toothfish egg and larval transport around the continental slope-shelf region in the East Antarctic. This was studied using ocean-sea-ice-coupled model (COCO).
- Toothfish larvae settling occurs on northern slopes in positive SAM phases - greater distribution under these conditions. Most particles successfully settled in local regions in negative SAM phases. Unsuccessful eastwards transport under positive SAM phases.

Oral Presenter 1: Sophia Volzke (Institute for Marine and Antarctic Studies - University of Tasmania)

- There are complex relationships between climate and predator population dynamics - shifts in prey availability will affect top predator survival long term, but studying the lower trophic levels can be hard.
- The Macquarie Island elephant seal populations have been declining while other populations have been stable/increasing. Capture-Marck-Recapture

datasets exist for early (60s) and modern (90s to early 00s) time periods, but we only now have the computing ability to do complex matrix population models equipped to deal with: life history (developmental stages) and imperfect data (resight effort).

- The modelling incorporated climate lags (SAM/SOI), with the best fit occurring with lagged SAM and unlagged SOI. SOI had a negative relationship with juvenile and adult survival (direct effect, no time lag). +SOI = La Nina year/event → negative odds of survival. During El Nino events - small positive contribution to juvenile survival. In contrast, SAM, lagged SAM1 = strong relationship with juvenile survival.
- Not all individuals are affected equally, perhaps, because juveniles remain closer to breeding grounds. Or, SAM is indirectly influencing prey and adults can compensate for poor conditions by moving away from the island (lag effect - one year for impacts to manifest in food web).

Oral Presenter 2: Peng Lian (University of Chinese Academy of Sciences)

- Eastern yellowfin tuna are highly migratory and have connections across the Pacific. This work used longlining fishery data, different scale climate indices and local-scale environmental parameters, Argo, remote sensing and ocean model data to study spatiotemporal distribution of yellowfin tuna.
- Decadal shift was identified in CPUE throughout the year. Semilunar pattern in spatiotemporal distribution arose during the last ten years. Increased mixing and rainfall during El Nino == high CHLa. Zonal wind, upwelling also increased.
- For decadal scale, under the circumstances of more Central Pacific types in EPO, yellowfin tuna seem to concentrate within a preferred temperature range from 18-25°C.
- Central Pacific El Nino type often brings the SST fronts which provide a more suitable habitat for tuna. For seasonal scale, zonal wind and precipitation play an important role in periodic variation in tuna's spatiotemporal distribution, and the mechanistic understanding may give us a valuable insight into physical/biological processes in EPO ecosystems.
- Finer spatio-temporal scales can help detect fluctuation of yellowfin tuna in a timely manner, which facilitates risk assessment. Tuna CPUE and environmental factors are to be analysed on the same time scale.

Oral Presenter 3: David Green (Institute for Marine and Antarctic Studies - University of Tasmania)

- The Southern Ocean is experiencing rapid changes. Important to understand the links between predators and their prey, which can be limited by our understanding of biophysical connections. We can overcome this knowledge gap by using ocean circulation and biogeochemical models.
- Aim of this project is to predict how much mid-trophic level prey can be produced, where would it be distributed based on underlying circulation.

- Part 1a&b of the work - Matching modelled prey fields to elephant seal tracking data. How well does variability in modelled prey biomass predict fitness outcomes of marine predators? Important habitat matched quite well with known Macaroni penguin habitat.
- Part 2 of the work - reconfigure SEAPODYM framework for Antarctic krill (modelling krill spawning habitat). Model had pretty good match with what expected to be good spawning habitats
- Prey models already provide meaningful biological signals, but they can be and are being improved as well. Prey models will be globally applicable.

Oral Presenter 4: Stuart Corney (Institute for Marine and Antarctic Studies - University of Tasmania)

- Changes are occurring in the SO and the impacts are felt both across species and within populations. For example, the Macquarie Island (MI) elephant seal population is declining (~1.5% per year), but the population drivers are unclear.
- This work used dynamic energy budget models (already showcased to work on southern elephant seals) to understand the population change. Four hypotheses were considered: H1 climate variability, H2 reduction of yearling survival, H3 reduction in fecundity of mothers, H4 density dependence. DEB-IBM allows testing of hypotheses over >10 generations.
- Three main questions: 1. Can the results from the hypothesis reproduce the exponential decline as observed on Macquarie Island? 2. How well does the emergent change in the population dynamics match the MI data? 3. Is the change in population projection from the modelled data realistic given the changes in emergent individual behaviour and population dynamics?
- The modelled population trajectory for three of the scenarios closely followed the observed trend in the decline of southern elephant seals. Each of these scenarios (in isolation) was considered too simplistic and did not match interannual variability well. H1 climate scenarios were too extreme in variation. H2 yearling survival scenario created unrealistic transition ages between sexual and physical maturity stages and also affected the fecundity of mothers (increased). H3 fecundity scenario did not cause decline despite quite severe changes in variables.H4 density dependence scenario is a blunt instrument but closely matched that of MI. Likely a combination of drivers has resulted in population change at MI.

Oral Presenter 5: Pauline Machful (Oceanic Fisheries Programme, The Pacific Community)

- Tuna are top predators in the food chain and key target species for fisheries worldwide. Biological sampling program run by SPC. 15,928 stomachs sampled of 3 tuna species (yellow fin, big eye and skipjack), 8,089 examined at SPC laboratory
- The aim was to understand trophic dynamic and trophic ecology of tuna using an informative index to quantify ingested food. But, there are metric problems

(biases: fish size, thickness of the stomach walls), and subjectivity. So the alternative is to include fish size in the metric.

- Tested whether spatial patterns in fullness are driven by ecological, fishery and/or environmental components? Effects of fishing gear (significant effects): fuller stomachs in pole and line fishery, significantly emptier stomach when caught by purse seine gear. Significant effect of fish school association: fuller stomachs in free schools (tuna feed better in free schools), seamounts (mostly targeted by pole+line). Emptier stomachs in drifting FADs (purse seine target the most).

Oral Presenter 6: Julie McInnes (Institute for Marine and Antarctic Studies - University of Tasmania)

- Predator-prey interaction can be very hard to monitor at sea. But, we are starting to see that fish and squid pathways especially in the sub-Antarctic are important (in addition to traditional krill food web pathways) -- key to include in models.
- This work used DNA metabarcoding - scat DNA to see what prey is in it. Universal markers give broad signatures (fish, squid, krill), or group specific to identify species. But we must first ensure we have the reference sequences. Lack of recent dietary info from Australian sub-Antarctic islands (Heard and Macquarie).
- Aim 1: Develop a marine ecosystem monitoring framework using scat DNA from predators to assess species composition in the Subantarctic - select candidate species - want to represent different areas of the water column, but also different distances from the islands.
- Aim 2: Apply the diet monitoring framework using a multi-species predator case study - Macquarie Island; figure out what we need to collect in future; are the species changing over time?
- Starting to see the prevalence of jellyfish in the diet of some animals; in more pelagic species (penguins) krill becoming more prevalent in diet; not a lot of difference in diet between locations around MI. Next stage is to look at fish, krill and cephalopod species, and then might see more variability around the island in the individual species.

Poster/Speed-talk Presenter 1: Silvia Olmastroni (Università degli Studi di Siena)

- The aim of this work was to improve measurements of a series of genetic and physiological parameters of Adelie penguins, and to compare neighbouring colonies.
- Three colonies of different sizes were located within 70km. Breeding biology showed similar trends at the different sites, but colonies were genetically structured (low migration rates).
- Satellite tracking of breeders found breeders foraged near fast and pack ice, which was in line with previous research and confirms that prey availability in

front of a colony may help adults to cope with reproductive output and time constraint (more opportunity for chicks to survive).

Poster/Speed-talk Presenter 2: Won Young Lee (Korea Polar Research Institute)

- A large piece of drift sea ice was found 10km from an Adelie penguin colony in Terra Nova Bay, blocking the path of the penguins' foraging route.
- The sudden appearance of large drift ice didn't cause penguins to change their foraging path direction, instead they crossed the sea ice to get to the opposite edge to forage.
- The large drift ice affected penguin foraging behaviour compared to a neighbouring population: foraging trips were longer in duration and penguins conducted shallow dives by the drift sea ice.
- Presence of the large drift sea ice was not permanent (~1 week) and therefore had no long term effects, but in the short term it had slightly negative effects on penguin foraging behaviour (spending more energy and time).

Poster/Speed-talk Presenter 3: Benjamin Viola (Institute for Marine and Antarctic Studies - University of Tasmania)

- Currently, there is a deficit in Snow Petrel habitat use research (especially during winter, and beyond breeding colony areas)
- This work aims to improve our understanding of snow petrel habitat use by focusing on three core areas: i) Use ship based surveys to understand habitat at sea habitat use during Austral summer, ii) Use GLS tracking data to understand habitat use during non-breeding period (Austral winter), iii) Use the outputs of the first two steps to project year-round habitat suitability under different CMIP6 climate scenarios.
- Preliminary results of GLS tracking data: Foraging occurs throughout night/nocturnal hours during winter months (in East Antarctica). Individuals can cover 10s of thousands of km in the winter periods.

Poster/Speed-talk Presenter 4: Anna Kurnosova (Pacific branch of Russian Federal Research Institute for Fisheries and Oceanography)

Poster presenter not present.

Panel discussion

Convener: Jaimie Cleeland

Panelists: Natalie Kelly (Australian Antarctic Division), Jeong-Hoon Kim (Korea Polar Research Institute - KOPRI), Nobuo Kokubun (National Institute of Polar Research - NiPR), Emma Carroll (Whale DNA Lab, The University of Auckland)

The panel discussion aimed to highlight current research in the Western Pacific nations, to provide a glimpse of future voyages being planned, as well as to provide an opportunity for ECRs to learn about what work is currently being done and what open data streams are being used.

The panel discussed and provided their insights and personal experiences on the following topics:

- What is the focus of your research, how does it contribute to our understanding of SO ecosystem functioning and to your national Antarctic Program?
- Sharing experience and advice for successful international collaborations.
- Information and background on the Antarctic stations and facilities.
- Plans and capabilities of the new Australian Antarctic Division icebreaker, Nuyina.
- The use of remote devices and technology when answering questions about top predator ecology in remote regions or during winter.
- Advice for planning field work in data poor and hard to access regions. Challenges encountered and lessons learned from remote field work.
- What motivated you to become a scientist?

Session summary

The IMBeR West Pacific Symposium 2021 session Connectivity of the West Pacific and Southern Ocean: the Importance of Oceanic Top Predators was jointly developed by ICED (Integrating Climate and Ecosystem Dynamics in the Southern Ocean) CLIOTOP (CLimate Impacts on Oceanic TOp Predators). The session brought together over sixty scientists and post-graduate researchers from thirty countries to show how population assessments, demographic analysis, tracking, ecological modelling and diet studies can be used to investigate the influence of climate change and other key threatening processes on top predators within the region. Scientists illustrated how citizen science, big data, new technology and advanced modelling techniques enabled comprehensive investigation at high spatial and temporal resolutions. The session culminated in a panel discussion which highlighted the research stations, ships and technology currently supporting top predator science in the Western Pacific sector of the Southern Ocean. Attendees were also imparted with personal experiences and advice from senior Antarctic research scientists from Japan, Korea, Italy, Australia and New Zealand.