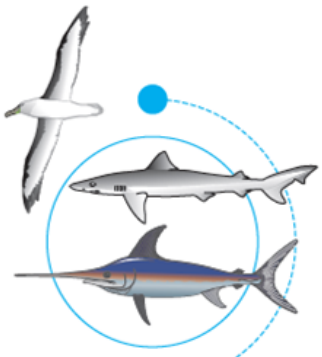
4TH CLIOTOP Symposium

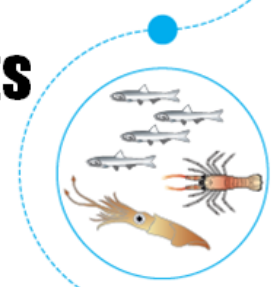
CLimate Impacts on Oceanic TOp Predators

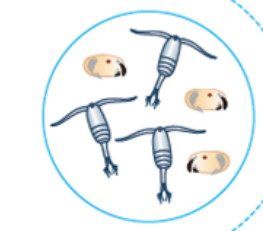
National Taiwan Ocean University, Keelung, Taiwan, 15-19 October 2018

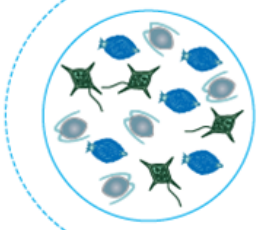
Oceanic biodiversity under climate change: shifts in natural and human systems



Program and abstracts







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PROCEEDINGS OF THE ROYAL SOCIETY B
BIOLOGICAL SCIENCES

IMBeR Integrated Marine Biosphere Research

Fourth CLIOTOP Science Symposium

National Taiwan Ocean University, Keelung, Taiwan

15 – 19 October 2018

PROGRAM AND ABSTRACTS

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Welcome

Welcome to the 4th CLIOTOP symposium, in the seaside city of Keelung!

CLIOTOP (CLimate Impacts on Oceanic TOp Predators) is an international program that began under the Global Ocean Ecosystem Dynamics (GLOBEC) project in 2004, and now operates under the umbrella of the Integrated Marine Biosphere Research (IMBeR) project.

The overall objective of IMBeR is: *To provide a comprehensive understanding of, and accurate predictive capacity for, ocean responses to accelerating global change and the consequent effects on the Earth System and human society.*

CLIOTOP is one of four regional programs that deliver to IMBeR's objective. CLIOTOP's vision is to: *organise large-scale comparative efforts to elucidate key processes involved in the interaction between climate variability and change and human uses of the ocean on the structure of pelagic ecosystems and large marine species. CLIOTOP seeks to develop predictive capability for these socio-ecological systems and evaluate adaptation options to ensure future sustainability*.

The first CLIOTOP science symposium in La Paz, Mexico in 2007 was attended by delegates from 25 nations and over 25 papers arising from the symposium were published in a special issue of Progress in Oceanography (vol 86) in 2010. The second CLIOTOP science symposium was held in Noumea, New Caledonia in 2013. The special issue arising from this meeting was published in Deep-Sea Research (vol 113) in 2015, and featured close to 100 authors in 26 contributions. The third CLIOTOP science symposium was held in San Sebastián, Spain, the proceedings from which were published in Deep Sea Research (vol 140) in 2017. Thank you to many in the community who were reviewers for submissions and to our co-editors who shaped what is turning out to be an excellent series of special issues documenting CLIOTOP's science.

During the first and second symposiums, many presenters reported how climate change is affecting the pelagic ocean, with a range of impacts detected or predicted for open ocean biology, and provision of ecosystem services such as food. In recent years CLIOTOP research spotlight has advanced from a focus on documenting impacts, to exploring the socio-economic consequences, and in some cases, evaluating the adaptation options that can reduce the vulnerability to climate change. We hope that this leads to a range of improved outcomes for socio-ecological systems in the pelagic marine environment.

This 4th symposium marks the third year of a third phase of CLIOTOP, during which science teams supported under CLIOTOP have been tasked with undertaking comparative approaches to solving particular science or engagement questions. More information on these task teams and their projects can be found at http://imber.info/en/projects/imber/science/regional-programmes/cliotop/task-teams. We hope that many of you will continue or begin engagement in the third phase and in

particular contribute to discussions focused around each of the key themes for this symposium and the special issue in Deep Sea Reseach II to be organised from the symposium.

Most importantly, with regard to this fourth symposium, we appreciate the financial support of the Symposium sponsors. We would like to thank the National Taiwan Ocean University, the Ministry of Science and Technology, the Fisheries Agency, Council of Agriculture, Executive Yuan, The Proceeding of the Royal Society B, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and IMBeR. We would also like to especially thank the local members of the organising committee, Ming-An Lee, Kuo Wei Lan and Nan-Jay Su. We believe the teamwork of the organising committee will show through in this event! Have a great week.

Karen Evans (CLIOTOP co-chair)

Kevin Weng (CLIOTOP co-chair)

Sponsors

We gratefully acknowledge the sponsors of this symposium profiled below. Their kind support has allowed us to attract an international group to Keelung and will help to ensure that the fourth CLIOTOP symposium is a success.

CSIRO – Commonwealth Scientific and Industrial Research Organisation, Australia. CSIRO is Australia's national science organisation conducting research on animals and plants, astronomy and space, terrestrial and marine environments, climate and the atmosphere, farming and food production, health, information technology, mining and manufacture, renewables and energy. Scientists involved in the Oceans and Atmosphere Business Unit work to provide knowledge to manage Australia's marine areas and atmospheric environment, delivering significant economic, social and environmental benefits for Australia and the region. For more information, please visit www.csiro.au/en/Research/OandA

Fisheries Agency, Council of Agriculture, Executive Yuan – Taiwan, Republic of China.

The Fisheries Agency (FA) is in charge of fishery development, conservation of fisheries resources, and additionally, the practice of responsible fisheries in Taiwan. They focuses on the maintenance of orderly coastal and offshore fishing in parallel with fishery resources enhancement, and the promotion of aquaculture that is in harmony with the environment. Further, in order to maintain sustainable operation of the fishery industry, such issues on trade liberalization, industry globalization, maintenance of industry competitiveness, and minimization of operation costs are managed by the Fisheries Agency. For more information please visit www.fa.gov.tw/en/index.aspx

IMBeR – Integrated Marine Biosphere Research, Norway.

IMBeR is an international project that promotes integrated marine research through a range of research topics towards sustainable, productive and healthy oceans at a time of global change, for the benefit of society. For more information please visit www.imber.info

Ministry of Science and Technology – Taiwan, Republic of China.

The Ministry of Science and Technology (MOST), as the government's dedicated scientific and technological development agency, is charged with three main missions of promoting the nation's overall Science and Technology development, supporting academic research, and developing the science parks. By fostering an innovative and entrepreneurial spirit and encouraging creativity in science and technology, the MOST will boost academic and industrial competitiveness at the international level for Taiwan. For more information, please visit https://www.most.gov.tw/?l=en

PROCEEDINGS
OF THE ROYAL SOCIETY B
BIOLOGICAL SCIENCES

Proceedings of the Royal Society B – United Kingdom.

Proceedings B is the Royal Society's flagship biological research journal, publishing original articles and reviews of outstanding scientific importance and broad general interest. The main criteria for acceptance are that a study is novel, and has general significance to biologists. Articles published cover a wide range of areas within the biological sciences, many have relevance to organisms and the environments in which they live. The scope includes, but is not limited to, ecology, evolution, behavior, climate change, molecular ecology and evolution, environmental science and global change biology. The journal has a high profile international editorial board with expertise across the biological sciences. *Proceedings B* publishes regular Special Features on timely and important topics and has recently started publishing Evidence synthesis articles For more information, please visit rspb.royalsocietypublishing.org

General Information

Taiwan

Famed for centuries as Ilha Formosa (Beautiful Isle), its landscapes comprise towering sea cliffs, marble-walled gorges, tropical forests, as well as alpine areas as high as 3952m in Yushan. Taiwan lies on the western edge of the Pacific “Rim of Fire” and continuous tectonic movements have created majestic peaks, rolling hills and plains and basins. In Taiwan you can criss-cross mountains on colonial-era hiking trails or cycle a lone highway with the blue Pacific on one side and green volcanic arcs on the other.

Taiwan contains 9 national parks and 13 national scenic areas that showcase the countries best natural environments and cultural sites. Within these areas you might find rare or endangered species such as the land-locked salmon, Taiwan serow, Formosan rock monkey, Formosan black bear, blue magpie, Mikado pheasant and Hsuehshan grass lizard. Trek in the magnificence of the Taroko Gorge, take a ride on the Alishan Forest Railway and experience the breathtaking sunrise and sea of clouds, hike up to the summit of northeast Asia’s highest peak Yushan, soak up the sun in Kending, stand at the edge of Sun Moon Lake wander through the East Rift Valley or visit the offshore islands of Kinmen and Penghu.

Taiwan has an endless variety of cultural and artistic wonders, including folk festivals, religious practices, traditional skills and modern art. Taiwanese temples (all 15,000) combine worship hall, festival venue and art house under one roof. Food is definitely at the top of Taiwan’s priority list with small bistros, large restaurants and night markets selling any food you virtually think of. Its cities are cosmopolitan, contrasting with the countryside villages, blending the old with the new

Keelung

Situated in the northern part of the island of Taiwan, Keelung was originally named Jilong, which means hencoop in Chinese. The name was changed by the court of the Ching Dynasty in 1875 to Keelung which means "rich and prosperous land".

The city occupies 132.7589 square kilometers of land, and is separated from the neighbouring counties and cities by the mountains in the east, west and south (95% of the port cities area is made up of hilly terrain). Facing out to sea, it has a natural deepwater harbour and includes seven islands off its coast: Hoping Island (lit. “Peace Island”), Zhongshanzi Islet, Tongpan Islet, Keelung Islet, Pengjia Islet, Mianhua Islet, and Huaping Isle. Hoping Island (once known as Sheliao Island), Zhongshanzi Islet, and Tongpan Islet are now all connected by land and commonly collectively referred to as Hoping Island.

A rich heritage of commerce and trade sees many historical and cultural sites located within Keelung including Ershawan Fort (also called Haimen Tianxian), Heping Island, and Lovers Lake, not including the numerous relics and monuments scattered around the city. Given its proximity to the port, Keelung is the centre of Northern Taiwan's fishing

industry, hosting hundreds of fishing ships catching all kinds of fresh seafood from the sea.

When you visit Keelung, don't miss the Miaokou Night Market to see one of Taiwan's more traditional night markets containing vendors producing delicious seafood snacks and meals. Miaokou is located adjacent to Keelung Harbour and forms the downtown area of the city. The entrance is located at the intersection of Aisan and Rensan Roads Be sure to plan a trip to visit the emplacements, the tunnels, the beak head, the bay, the fishery harbor and the fishing market in Keelung.

Keelung's climate varies, ranging from a low in January when average temperatures are approximately 16˚C to a high during July/August when average temperatures are approximately 33/34˚C. Keelung's nickname is the "rain port", so remember to pack an umbrella!

Keelung City's downtown area is very small and easily walkable. The train/bus station is directly adjacent to the port and easily accessible from the downtown area. Keelung Tourism Service Information website is http://tour.klcg.gov.tw/Index.aspx

Practical information

Money

The currency in Taiwan in the New Taiwanese dollar (NT$). ATMs are widely available (except in villages) and accept most major credit cards. Small stalls and night markets don't take credit cards, while most midrange and top end restaurants do although it is always wise to check. Travellers cheques are not widely accepted with banks providing the best exchange rates, noting that many banks will on change US dollars. Tipping is not customary (but is appreciated).

Health and safety

Drugstores can be found in cities, with most major cities also containing a hospital. To see a doctor costs around NT$400; most hospitals have a volunteer desk to help foreigners fill in the forms needed to see a doctor. Most hotels will provide filtered hot and cold water from dispensers and it pays to boil or filter tap water. Ice is usually fine in restaurants.

Electricity

Taiwan has the same electrical standard as the US and Canada

Voltage: 110V/60Hz.

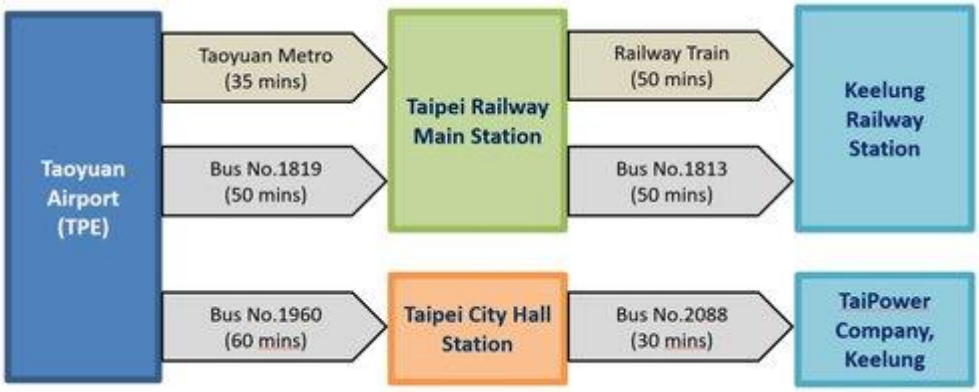
Adaptors are available at most airports and in selected shops. Your hotel may also be to provide you with an adaptor.

Transport

Taiwan has the most complete and safest transport network, taking care of people's land, sea and air travel needs. There are four international airports, two of which are located close to Taipei (the Taiwan Taoyuan International Airport and Taipei Songshan Airport), one in the south-west (Kaohshing International Airport) and one in the west

(Taichung International Airport). In addition there are 16 domestic airports servicing the main island of Taiwan and a number of Taiwan's offshore islands.

Taiwan's rail system includes a high speed rail system, servicing 12 stations along the 'western corridor' of Taiwan. Taipei is also serviced by the Taipei Rapid Transit Corporation (the MRT). Most areas in Taiwan are serviced by long-distance highway buses run by a number of companies. Many buses depart daily and provide a convenient way of getting around the island. Information on buying tickets either for rail or bus can be found at https://eng.taiwan.net.tw/m1.aspx?sNo=0024039. Travelling from Taipei to Keelung can be done either by rail or by bus (see figure).



Taxis (services can be found in most cities, with starting and meter rates varying depending on the city and local laws. Most drivers do not speak English, so it's best to ask hotel staff to write your destination in Mandarin and estimate costs before departing. Keep the address of your hotel handy in Mandarin too.

Important phone numbers

The country code for Taiwan is +886.

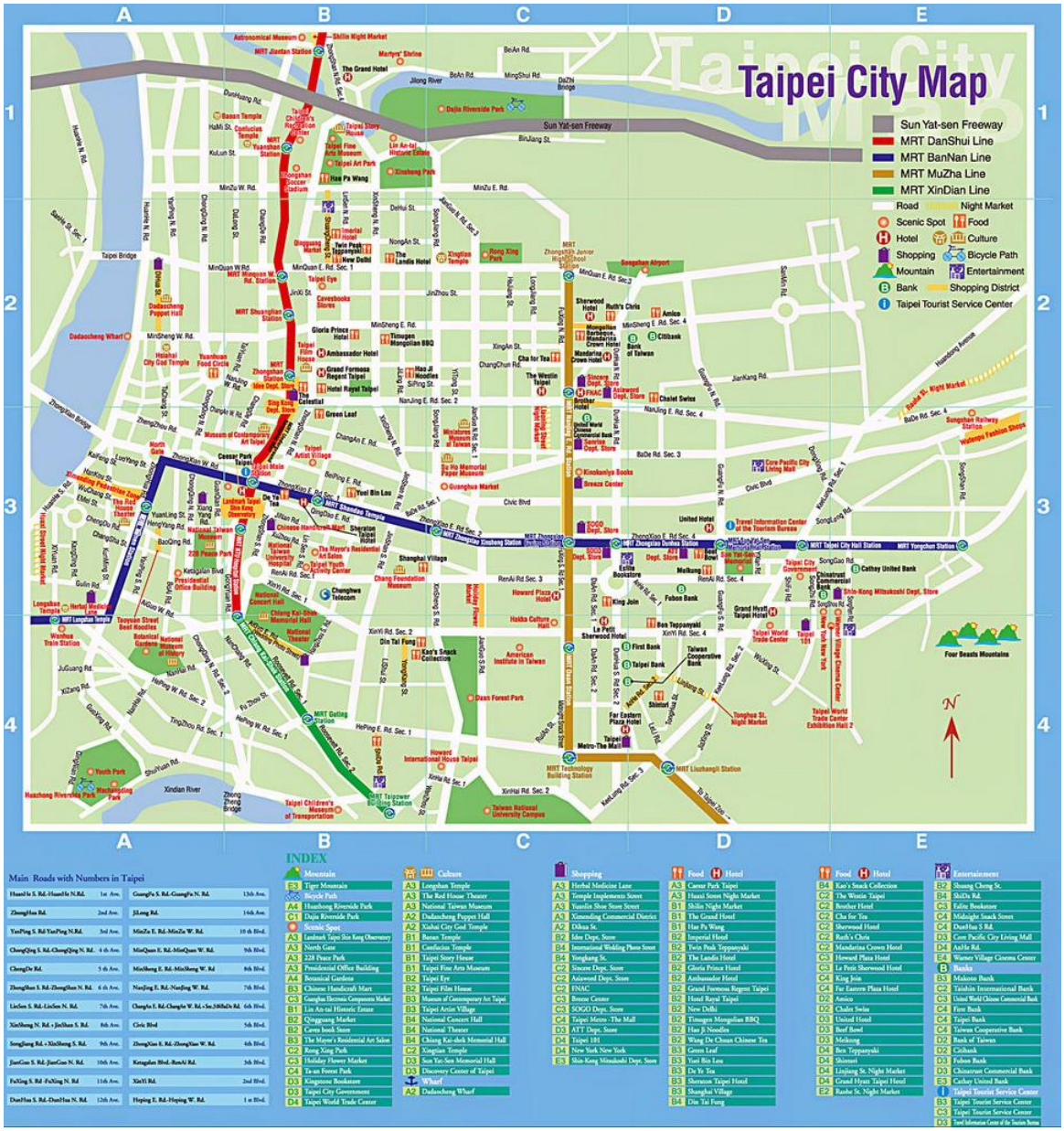
Most mobile phones can use local SIM cards with prepaid plans, available for purchase at the airport arrivals terminal and can be topped-up at outlets or convenience stores.

24 hour toll free travel information hotline: 0800-011765

Fire and ambulance: 119

Police: 110

Maps


Taipei City Map
Sun Yat-sen Freeway
MRT DanShui Line
MRT BanNan Line
MRT MuZha Line
MRT XinDian Line
Road
Night Market
Scenic Spot
Food
Hotel
Culture
Shopping
Bicycle Path
Mountain
Entertainment
Bank
Shopping District
Taipei Tourist Service Center
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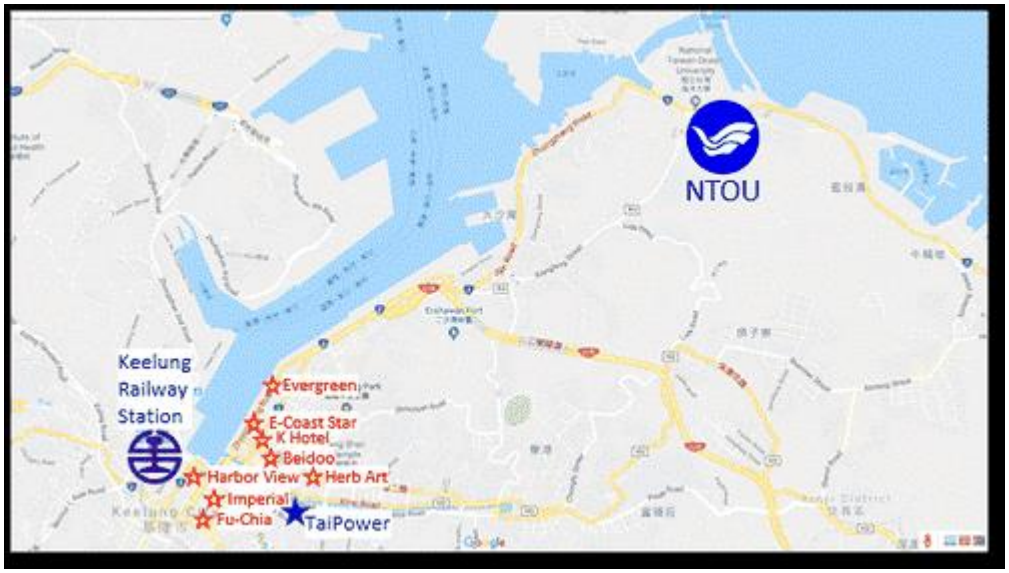
Main Roads with Numbers in Taipei


NTOU
Keelung
Railway
Station
Evergreen
E-Coast Star
K Hotel
Beidoo
Harbor View
Herb Art
Imperial
Fu-Chia
TaiPower


NTOU CAMPUS MAP
Exhibition Hall
Conference Room
1.Administration Building Lecture Hall 1
2.Exhibition Hall · Ocean Hall
3.Library · Grobest Reading Room
4.Library 2 · General Propose Building 1F
5.Mechanical and Mechatronic Engineering Building A 1F
6.Recreation Building 1F
7.Dept. of Merchant Marine 1F
8.Fen-Ping Technology Building 1F
9.Ivy Huang Hall 1F
10.Dept. of Shipping and Transportation Management Building 1F
11. Hai-Kong Building 2F
12.Swimming Center 2F
13.2nd Restaurant (Brave-Fountain Restaurant)
14.Student Activity Center
15.Gymnasium
16. 1st Restaurant
17.Ocean and Mountain View Corridor
18.Dept. of Ocean Environmental Informatics Building 1F
19.Fisheries Science Building 1F
20.College of Life Science Building 1F
21.Food Engineering Building 1F
22.Harbor and River Engineering Building 2
23.Harbor and River Engineering Building 1
24.Dept. of Systems Engineering Naval Architecture Building 1F
25.College of Engineering B1 Restaurant
26.Electrical Engineering Building 1
27.Electrical Engineering Building 2
28.Guard Room

General meeting information

Venue

The fourth CLIOTOP symposium is being held at the National Taiwan Ocean University, situated on the coast to the east of the port area. The University is recognized as one of the nation's most important centres of high learning and scholarship, especially in the marine sciences, maritime studies and fisheries.

Morning tea, lunch and afternoon tea will be provided on each day of the plenary sessions of the symposium. For eating in the evenings, there are a number of restaurants and cafes located around the port area and in the vicinity of the University and don't forget the night market!

Registration

Registration will occur at the symposium registration desk located in the hall just outside the main plenary room. Any general questions regarding the symposium should be addressed to the registration desk staff. The registration desk will be open during the following hours:

Monday 14 September: 08:00-17:00
Tuesday 15 September: 08:30-17:00
Thursday 17 September: 08:30-17:00
Friday 18 September: 08:30-12:30

Oral presentations

Plenary sessions will be held on the Monday, Tuesday, Thursday and Friday of the symposium. Oral presentations should be delivered on a clean USB memory stick to symposium staff coordinating presentations well in advance of assigned presentation times. Presenters scheduled in morning sessions must submit their presentations by 17:00 on the day before their presentation and those scheduled in afternoon sessions must submit their presentations by morning tea on the day of their presentation. The exceptions to this will be presenters on the Monday morning of the symposium. Presentations for the Monday morning must be submitted during registration between 08:00-08:30 on Monday 15 October.

Please ensure that your presentation does not exceed the allocated 15 minutes – you will be asked to leave the podium after 15 minutes regardless of whether you have finished your presentation or not.

The conference auditorium contains data and video projection capabilities linked to a PC laptop computer. Special audio-visual requests that are not supported by the listed equipment should be directed to the conference organisers.

The preferred format for oral presentations will be Microsoft PowerPoint for either PC or Mac platforms. Please bring your presentation and associated files in a self-contained folder. The folder and files must be clearly labelled in the following convention:

Author surname_Presentation Date_Presentation Time.

Files containing video or audio clips must be located in the same folder as the Powerpoint presentation itself otherwise they will not be uploaded to the Conference computer and therefore will not work. Do not use online hyperlinks in your presentation as there will be no external internet connectivity.

Poster presentations

Posters are recommended to be designed and printed out in A0 portrait format (1.189m x 0.841m). The maximum size posters may be is 1.2m (H) x 0.9m (W). Posters larger than this or produced in a landscape format will not be displayed.

Posters will be on display for the week of the symposium. Posters may be hung on the morning of Monday 15 October from 08:00 until morning tea. All poster presenters should bring all equipment required for hanging their posters. All posters must be hung in their allocated positions by the start of morning tea on Monday 15 October. A cocktail function will be held on Tuesday evening between 17:00 and 19:00 during which all symposium delegates presenting posters should attend their posters. All posters must be removed from the poster room prior to 17:00 on the last day of the Symposium. The symposium organisers cannot take responsibility for any posters remaining in the poster room after Friday afternoon.

Early career mentoring program

The fourth CLIOTOP Symposium mentoring program is organised to assist students and early career researchers to meet and interact with other researchers in their field. Matching students and early career researchers with a "mentor" - an established scientist working in a similar field - provides the opportunity to get advice on research ideas and assistance with fine-tuning presentations for the Symposium. During the course of the Symposium, mentors can help by introducing students and early career researchers to others with similar research interests and thereby help increase networks within the CLIOTOP community and the research community in general.

"Lunch with the scientists" will be held on Tuesday 16 October. As part of a dedicated opportunity to help students and early career researchers increase their network within the CLIOTOP community, a number of established scientists will be identified by the mentors and asked to sit at reserved tables to have lunch with those taking part in the mentoring program, allowing meetings to take place, research interests to be discussed and relationships to be established.

Social events

Please ensure that you wear your name badges to all conference functions – your name badge entitles you to admission to the welcome reception, the poster evening and the conference dinner. All guest tickets to social events (welcome reception and conference dinner only) must be organised and paid for prior to the symposium as there will be no payment facilities provided at the symposium.

Welcome reception

A welcome cocktail function will be held on Monday 15 October at Le Jardin Ballroom, Keelung from 18:00 to 20:00. A free bus will transport symposium delegates to the function from the National Taiwan Ocean University.

Poster evening

See poster presentations section above.

Field trip

A field trip to visit the Gong Liaoi Aqua Center, the Da-Xi local fish market and the Animoto set-net fish market has been arranged for Wednesday 17 October from 13:00 to 19:00. This excursion is sponsored by the National Taiwan Ocean University. Delegates can register for the field trip during registration on Monday 15 October. This event is open to registered symposium delegates only and is free of charge.

Symposium dinner

The conference dinner will be held at the National Museum of Marine Science and Technology, Keelung on Thursday 17 September from 18:00-22:00. The dinner will be preceded by a tour of the museum from 16:00-18:00. A bus will transport attendees to and from the National Taiwan Ocean University to the museum. There will be no other transport provided, so delegates are encouraged to ensure they are ready at the University for a 16:00 departure.

Symposium proceedings

The symposium organising committee would like to encourage delegates to consider papers arising from the fourth symposium for publication in a CLIOTOP Special Issue to be published in Deep Sea Research II. This journal publishes papers online as they are accepted, so there is no waiting for the last paper to be completed in the special issue for papers to be released for publication. Further details on submission will be provided

during the conference. Please also check the symposium website for updates and details on requirements for contributions.

SCIENTIFIC PROGRAM

Theme sessions

1. Global and regional trophic pathways and connectivity – trophic responses to variability and change in the marine environment

There is growing evidence that climate variability affects primary producers in marine systems, imparting bottom-up forces on food webs via trophic pathways. Simultaneously, fisheries removals of upper-level predators can have cascading effects on the underlying trophic levels. The largest gap in our knowledge of trophic pathways in pelagic ecosystems remains the intermediate trophic levels. The small fishes, cephalopods, and crustaceans that occupy intermediate trophic levels comprise the forage base of upper-level predators and therefore shifts in the abundance and community composition of intermediate trophic levels have implications for upper-level predators. In delineating the key trophic pathways linking primary production to the upper trophic levels through the forage groups, there is a need for better understanding of how intermediate trophic groups and associated trophic pathways vary among productivity regimes, ecosystems and as a result underlying changes in these. This theme will focus on understanding of mid-trophic communities and drivers of variability in these communities.

Moderator: Haritz Arrizabalaga

2. Integrated modelling of systems based on shared socio-economic scenario pathways – projection and exploration of future patterns in marine ecosystems

Models are increasingly available to evaluate future patterns in pelagic ecosystems. For example, quantitative indicators that characterize ecosystem status and the ongoing performance of oceanic management systems can forge links between resource managers, stakeholders, and scientists. Further, understanding the relationships between ecological, economic and social objectives and the trade-offs between each is important in designing policies to manage, conserve or restore marine ecosystems. Managing these multiple uses, some with often conflicting objectives, to ensure sustainable ecosystems, industries and communities is a major challenge globally. Papers in this theme explore the key needs and resulting decisions and actions that should guide oceanic resource management under climate change.

Moderator: Masashi Kiyota

3. Adaptive approaches to biodiversity and resource management –strategies for incorporating climate variability and long-term change

A range of species in the ocean are either recovering from past exploitation, or continue to be subject to ongoing direct or indirect population threats. Conservation policy and management of pelagic species has led to some successes in terms of population recovery, while in other cases no recovery has been observed. Models now allow the

generation of scenarios of future trajectories for populations under climate change to be generated, but to date utilisation of scenarios beyond hypothesis generation and exploration has been lacking and as a result management strategies lack the ability to account for responses of populations to long-term change. This theme will explore some of the requirements for incorporation of scenarios of marine populations under climate change and what might be required to build adaptive management mechanisms to inform conservation and resource management in the future.

Moderator: Mary Gasalla

4. Responses of top predator life history dynamics to natural and anthropogenic drivers of variability and change

The life history dynamics of oceanic top predators are likely driven by a combination of density-dependent and -independent processes, each of which effect survival, growth, movements and reproductive success. These life history dynamics are tightly linked to environmental processes, many of which are demonstrably influenced by climate variability. For example, changes in climate can impact ocean temperature distribution, timing and depth of stratification, the formation of mesoscale structures such as fronts and gyres, upwelling and consequently production. Changes in production can directly influence rates of growth and mortality of life stages of top predators, impacting their survival. Modelling frameworks can include simple response variable models, models of intermediate complexity through to complex ecosystem models capable of exploring changes in life history dynamics under various scenarios. Papers in this theme will discuss findings from a range of taxa.

Moderator: Joel Llopiz

5. Implications of variability in and change to the spatial dynamics of top predators for food security, species conservation and ecosystem functioning

Observed or projected responses in the distribution and abundance of pelagic species will have flow-on effects for ecosystem management and on societies that depend on natural resources. Changes in the distributions of harvested species can lead to changes in access to resources, disadvantaging some communities and therefore impacting food security and providing new access benefits in others. Changes in distribution of bycatch or protected species can also lead to new conflicts with stressors such as shipping, oil and gas exploration, or fishing and may require new management interventions. The implications of these changes are the focus of this theme.

Moderator: Alistair Hobday

6. Management strategies for whole of systems – moving from biophysical systems to biophysical-socioeconomic systems – what are the key needs for guiding decision making into the future?

Models developed for marine species and ecosystems have now developed to include many physical forcing factors, the effects of which propagate up the food web. The challenge now is to move these modelling frameworks forward to include socio-economic systems and how changes in these systems influence biophysical systems and the decision making processes when planning resource use within marine ecosystems. Scenarios generated are not only important for investigating changes in species populations but also for the evaluation of management effectiveness into the future and for informing adaptations that might be required in achieving socio-economic or conservation objectives, efficiencies or trade- offs within the framework of a changing world. This theme will explore the emerging area of focus as part of CLIOTOP and other activities.

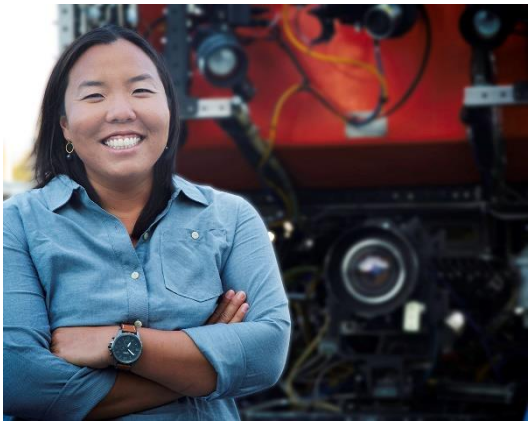
Moderator: Joe Scutt-Phillips

Keynote speakers

John Claydon, Integrated Marine Biosphere Research International Project Office, Institute for Marine Research, Norway.

John has a background as a marine ecologist focusing on tropical marine systems, and has worked in a range of roles that includes research, teaching, management, policy, and governance. His most recent position was Director of the Department of Environment and Coastal Resources for the Turks and Caicos Islands Government.

Anela Choy, Scripps Institution of Oceanography, University of California, USA.



Dr. Anela Choy is an assistant professor at the Scripps Institution of Oceanography at the University of California, San Diego, with the Biological Oceanography group of the Integrated Oceanography Division. Previously, Anela was a Postdoctoral Research Fellow at the Monterey Bay Aquarium Research Institute. Anela's research centers on the structure and function of open ocean and deep-sea food webs, uniquely applying a targeted combination of biochemical tracers (stable isotopes, fatty acids, trace metals) alongside in-situ observations and traditional diet methods. Anela received a Ph.D. (2013) and M.S. (2008) in Oceanography from the University of Hawaii, and has recently been recognized for her research and outreach efforts with the 2018 UNESCO-L'Oréal International Rising Talents Award, and the 2016 AAAS-L'Oréal USA For Women in Science Fellowship.

Chih-hao (Zac) Hsieh, Institute of Oceanography, National Taiwan University, Taiwan.

Chih-hao (Zac) Hsieh is a professor and the deputy director at the Institute of Oceanography, National Taiwan University. Zac received his Master degree from the Department of Zoology, National Taiwan University and Ph.D. degree from the Scripps Institution of Oceanography, University of California-San Diego. He is a theoretical ecologist as well as biological and fisheries oceanographer. His research targets range from microbes, plankton, to fish. His research integrates field observations, experiments, data analyses, and mathematical modeling. His research interests include forecasting dynamical systems, plankton food webs, and ecosystem-based approach to fisheries management.

Inna Senina, Collecte Localisation Satellites (CLS), Ramonville, France.

After obtaining a PhD in applied mathematics at Rostov State University, Russia in the field of mathematical modelling, numerical methods and software, Inna has 16 years of experience in numerical modelling of complex spatio-temporal dynamics of biological populations. She is most interested in movement dynamics as well as in integrating multiple types of data within models to improve their predictive skills. In 2004 Inna obtained a post-doctoral position at the University of Hawaii with the Pelagic Fisheries Research Program. Since then she has been working on the development of a spatially explicit model describing oceanic mid-trophic and top predator population dynamics, driven by physical-biogeochemical ocean variables (SEAPODYM). In 2009 she joined the Space Oceanography Division at Collecte Localisation Satellites, France where she is actively involved in development of operational models for forecasting of spatial distributions of tuna populations. Inna is a co-author of more than 30 scientific peer-reviewed articles.

Keynote abstracts

CLIOTOP, IMBeR, and ocean sustainability under global change for the benefit of society

John Claydon

Executive Officer, IMBeR International Project Office, Bergen, Norway

CLIOTOP is a Regional Programme under the Integrated Marine Biosphere Research (IMBeR) project. Collectively, IMBeR's Regional Programmes and Working Groups strive towards the vision of "ocean sustainability under global change for the benefit of society". Research is coordinated under IMBeR's Science Plan and Implementation Strategy (SPIS) which outlines three Grand Challenges: (1) understanding and quantifying the state and variability of marine ecosystems, (2) improving scenarios, predictions and projections of future ocean-human systems at multiple scales, and (3) improving and achieving sustainable ocean governance. IMBeR's portfolio of diverse Regional Programmes and Working Groups encourages productive inter- and transdisciplinary collaboration. Within this structure, CLIOTOP science leads to enhanced real world impact, through policy, governance, and behavioural change, and ultimately through advancing ocean sustainability.

Disentangling a web of feeding interactions connecting surface and deep-sea ecosystems

C. Anela Choy

Scripps Institution of Oceanography at the University of California, San Diego. Integrated Oceanography Division, 9500 Gilman Drive, La Jolla, California 92093 - USA.

Collectively, marine ecosystems are fueled by the networks of feeding interactions, or food webs, that bridge primary and secondary producers up through top predators. Parameterizing predator-prey interactions across a diversity of consumers (e.g., fishes, cephalopods, crustaceans, gelatinous animals), and tracing the subsequent flow(s) of energy through an ecosystem is a longstanding, formidable challenge for marine ecologists. However, large-scale ecosystem management (or, of individual species or resources within an ecosystem) amidst the backdrop of climate change and increasing anthropogenic pressures, depends on robust understanding of the composition and flexibility of trophic links that bind and fuel an ecosystem. By merging a targeted combination of traditional empirical tools (stomach content analysis and in situ observations) alongside integrative biochemical tracers (bulk and compound-specific isotopes, trace metals), we have yielded surprising new trophic insights about how pelagic animals feed, and subsequently connect surface communities with those found at mesopelagic and bathypelagic depths. This talk presents vignettes of open ocean and deep-sea food web studies across the central North Pacific and the California Current, including new efforts to coordinate and scale-up toward global food web understanding across diverse biogeochemical provinces.

Empirical dynamical modeling toward ecosystem-based fisheries managements

Chih-hao Hsieh

Institute of Oceanography, National Taiwan University, Taiwan

Mechanistic understanding is important for effective policy and management recommendations on fisheries, particularly in the ecosystem context. Two classic approaches have been commonly used for this purpose: correlation analysis and parametric models using a set of assumed equations. For approach 1, we face the long-lasting problem that correlation does not imply causation. For approach 2, we encounter the difficulty that we do not know the exact set of equations and ecosystems are complex. Here, we show that the objective is better addressed using an alternative equation-free approach based on nonlinear state space reconstruction using time series data, known as Empirical Dynamic Modeling. This approach can distinguish causality from correlation and provide better forecasting skills for fish abundance in the complex environmental context, thus leading to mechanistic understanding. We demonstrate the methodology using Pacific sardines, Fraser River sockeye salmons, and Maizuru Bay fish community.

Developing Predictive Models to Estimate the Impact of Climate and Fisheries on Tuna Stocks

Inna Senina

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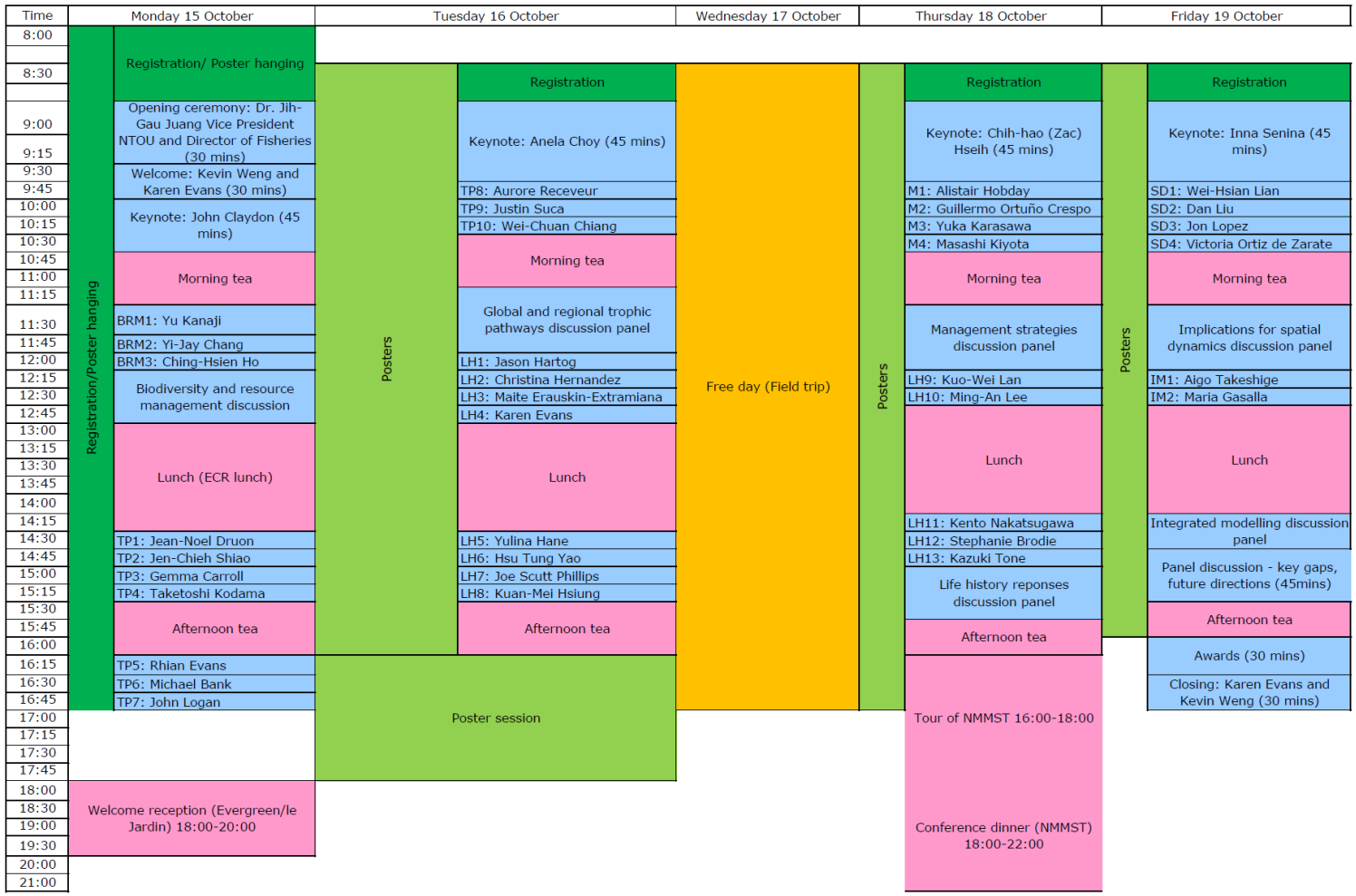
Today about two-thirds of tuna and billfish catch world-wide is made of skipjack, yellowfin, bigeye and albacore tuna; besides 70% of these tunas are withdrawn from the tropical areas of Indian and the western and central Pacific oceans. High fishing pressure coincides with rapidly growing atmospheric CO2 concentrations that follow the trend of the worst RCP8.5 scenario assumed by IPCC in 2011. It is evident that sustainable ecosystem management requires the use of a comprehensive approach that involves tools incorporating the impact of both climate and fisheries on the fish stocks. The Spatial Ecosystem And Population Dynamics Model (SEAPODYM) is one of such tools describing spatial and temporal population dynamics while integrating relationships between the dynamical processes and the environmental variables. The model predictive skills are gained from the use of a robust estimation approach of population dynamics and fisheries parameters. Several types of data can be included in the Maximum Likelihood Estimation approach: catch, fishing effort and size frequencies of catch, tagging data, acoustic biomass estimates, eggs and larvae densities. The resulting model with data assimilation can be used for various management applications that are based either on historical reconstruction of stock dynamics, operational real-time modelling, or long-term projections. A recent study relying on SEAPODYM applications for four tuna species provided projections over the 21st Century under the environmental forcings from five different Earth System models with RCP8.5 scenario. The new envelope of projections confirms previous results and shows an eastward shift of skipjack and yellowfin biomass over time, with a large uncertainty for the second half of the century. The negative impact is weaker for bigeye tuna and albacore due to geographic extension of favorable spawning habitats. The historical fishing pressure is estimated to have reduced the adult stocks of these tuna species by 30-55 % by the end of 2010, depending on species and region. This is much more than a decrease attributed to climate change only. With current levels of fishing effort the fishing will likely remain the dominant driver of tuna populations decrease until mid-century; however the fish abundance redistribution associated with climate change could have strong implications regionally, particularly for the Asian and Pacific countries and the management of the resource at basin scale.

Oral presentation schedule



Time	Monday 15 October	Tuesday 16 October	Wednesday 17 October	Thursday 18 October	Friday 19 October
8:00	Registration/Poster hanging				
	Registration/ Poster hanging				
8:30		Registration		Registration	Registration
	Opening ceremony: Dr. Jih-Gau Juang Vice President NTOU and Director of Fisheries (30 mins)	Keynote: Anela Choy (45 mins)		Keynote: Chih-hao (Zac) Hseih (45 mins)	Keynote: Inna Senina (45 mins)
9:00					
9:15	Welcome: Kevin Weng and Karen Evans (30 mins)	TP8: Aurore Receveur		M1: Alistair Hobday	SD1: Wei-Hsian Lian
9:30		TP9: Justin Suca		M2: Guillermo Ortuño Crespo	SD2: Dan Liu
9:45		TP10: Wei-Chuan Chiang		M3: Yuka Karasawa	SD3: Jon Lopez
10:00	Keynote: John Claydon (45 mins)			M4: Masashi Kiyota	SD4: Victoria Ortiz de Zarate
10:15		Morning tea			
10:30				Morning tea	Morning tea
10:45	Morning tea				
11:00		Global and regional trophic pathways discussion panel			
11:15				Management strategies discussion panel	Implications for spatial dynamics discussion panel
11:30	BRM1: Yu Kanaji				
11:45	BRM2: Yi-Jay Chang	LH1: Jason Hartog		LH9: Kuo-Wei Lan	IM1: Aigo Takeshige
12:00	BRM3: Ching-Hsien Ho	LH2: Christina Hernandez		LH10: Ming-An Lee	IM2: Maria Gasalla
12:15	Biodiversity and resource management discussion	LH3: Maite Erauskin-Extramiana			
12:30		LH4: Karen Evans			
12:45				Lunch	Lunch
13:00	Lunch (ECR lunch)	Lunch			
13:15					
13:30					
13:45				LH11: Kento Nakatsugawa	Integrated modelling discussion panel
14:00				LH12: Stephanie Brodie	
14:15				LH13: Kazuki Tone	Panel discussion - key gaps, future directions (45mins)
14:30	TP1: Jean-Noel Druon	LH5: Yulina Hane			
14:45	TP2: Jen-Chieh Shiao	LH6: Hsu Tung Yao		Life history reponses discussion panel	
15:00	TP3: Gemma Carroll	LH7: Joe Scutt Phillips			
15:15	TP4: Taketoshi Kodama	LH8: Kuan-Mei Hsiung			
15:30					Afternoon tea
15:45	Afternoon tea	Afternoon tea		Afternoon tea	
16:00					Awards (30 mins)
16:15	TP5: Rhian Evans				
16:30	TP6: Michael Bank				Closing: Karen Evans and Kevin Weng (30 mins)
16:45	TP7: John Logan				
17:00		Poster session		Tour of NMMST 16:00-18:00	
17:15					
17:30					
17:45					
18:00	Welcome reception (Evergreen/le Jardin) 18:00-20:00				
18:30					
19:00				Conference dinner (NMMST) 18:00-22:00	
19:30					
20:00					
21:00					

Posters

Free day (Field trip)

Posters

Posters

Oral presentation listing

Time	Allocation	Lead author	Title
Monday 15 October			
10:00	Keynote	John Claydon	CLIOTOP, IMBeR, and ocean sustainability under global change for the benefit of society
Theme 3: Adaptive approaches to biodiversity and resource management –strategies for incorporating climate variability and long-term change			
11:00	BRM1	Y. Kaniji	Long-term trends in distribution and abundance of small cetaceans estimated in relation to oceanographic and topographic variables in the waters off the Pacific coast of Japan
11:15	BRM2	Y-J. Chang	Evaluation of the status and rebuilding timeline of the Pacific billfish stocks under climate change
11:30	BRM3	C-H. Ho	Impact and adaptation of coastal fisheries under climate change - a case study of set-net fishery in Taiwan
11:45			Discussion panel: Theme 3
Theme 1: Global and regional trophic pathways and connectivity – trophic responses to variability and change in the marine environment			
14:30	TP1	J-N. Druon	Satellite-based indicator of zooplankton distribution for global monitoring of marine living resources
14:45	TP2	J-C. Shiao	Demographic structure, natal origins and feeding grounds of adult Pacific Bluefin tuna (*Thunnus orientalis*) landing in Taiwan
15:00	TP3	G. Carroll	How does spatial predator-prey overlap mediate trophic interactions?
15:15	TP4	T. Kodama	Feeding habits of the larval Pacific Bluefin tuna *Thunnus orientalis* in the two nursery grounds
16:15	TP5	R. Evans	Characterising little penguin behaviour in relation to bio-physical drivers in a continental shelf region of the south-east Australia hot-spot
16:30	TP6	M. Bank	Contaminant exposure profiles and isotopic niches in marine top predators
16:45	TP7	J. Logan	Investigating drivers of spatial patterns and decadal shifts in marine food webs: results from global meta-analyses of nitrogen and carbon isotopes in tunas

Time	Allocation	Lead author	Title
Tuesday 16 October			
09:00	Keynote	Anela Choy	Disentangling a web of feeding interactions connecting surface and deep-sea ecosystems
Theme 1: Global and regional trophic pathways and connectivity – trophic responses to variability and change in the marine environment			
09:45	TP8	A. Receveur	Acoustic characterization of micronekton vertical distribution related to the environment around New Caledonia (south-west Pacific)
10:00	TP9	J. Suca	Bottom-up drivers of sand lance distribution on Stellwagen Bank and the northeast US shelf
10:15	TP10	W-C. Chiang	Feeding ecology and trophic position of black marlin in the northwestern Pacific Ocean
11:15			Discussion panel: Theme 1
Theme 4: Responses of top predator life history dynamics to natural and anthropogenic drivers of variability and change			
12:00	LH1	J. Hartog	Seasonal and decadal forecast development for a multi-species pelagic longline fishery
12:15	LH2	C. Hernandez	Distribution of larval tunas in the Phoenix Islands Protected Area and estimated spawning sites during multiple phases of an ENSO cycle (2015-2017)
12:30	LH3	M. Erauskin-Extramiana	Large-scale distribution of tuna species in a warming ocean
12:45	LH4	K. Evans	Long in the tooth? Insights into environmental drivers of energy budgets in marine mammals
14:30	LH5	Y. Hane	Identifying natal origin of Pacific bluefin tuna using otolith oxygen isotopes measured by SIMS
14:45	LH6	H-T. Yao	Perdition and validation for potential fishing grounds of skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean
15:00	LH7	J. Scutt Phillips	The effect of environment on the use of animal tagging data
15:15	LH8	K-M. Hsiung	Impacts of global warming scenarios on larval and juvenile transport process of Japanese eel (*Anguilla japonica*)

Time	Allocation	Lead author	Title
Thursday 18 October			
09:00	Keynote	Chih-Hao Hseih	Empirical dynamical modeling toward ecosystem-based fisheries managements
Theme 6: Management strategies for whole of systems – moving from biophysical systems to biophysical-socioeconomic systems – what are the key needs for guiding decision making into the future?			
09:45	M1	A. Hobday	Moving from impacts to adaptation in fisheries and conservation of top predators
10:00	M2	G. Ortuño Crespo	The environmental niche of the global high seas pelagic longline fleet
10:15	M3	Y. Karasawa	Quantitative evaluation of ecosystem services supporting the growth of Japanese chum salmon
10:30	M4	M. Kiyota	Comparative evaluation of ecosystem characteristics and fishery impacts based on Ecopath foodweb models
11:30			Discussion panel: Theme 6
Theme 4: Responses of top predator life history dynamics to natural and anthropogenic drivers of variability and change			
12:15	LH9	K-W Lan	Influence of oceanographic variability on catch rate of yellowfin tuna (*Thunnus albacares*) cohorts in the Indian Ocean
12:30	LH10	M-A Lee	Detection of potential habitat hotspots of albacore tuna (*Thunnus alalunga*) in the South Indian Ocean using the satellite and longline fishery data
14:15	LH11	K. Nakatsugawa	Distribution shift of albacore tuna (*Thunnnus alalunga*) associated with environmental changes in the Pacific Ocean
14:30	LH12	S. Brodie	Integrating dynamic subsurface habitat metrics into species distribution models
14:45	LH13	K. Tone	How do ectothermic fishes use different temperature conditions?
15:00			Discussion panel: Theme 4

Time	Allocation	Lead author	Title
Friday 19 October			
09:00	Keynote	Inna Senina	Developing predictive models to estimate the impact of climate and fisheries on tuna stocks
Theme 5: Implications of variability in and change to the spatial dynamics of top predators for food security, species conservation and ecosystem functioning			
09:45	SD1	W-H. Lian	Marine environmental effects on the spatio-temporal distribution of swordfish (*Xiphias gladius*) in the Indian Ocean
10:00	SD2	D. Liu	Long-term variability of piscivorous fish in exploited China Seas under climate change with implication for fisheries management
10:15	SD3	J. Lopez	Developing alternative conservation measures for bigeye tuna in the eastern Pacific Ocean: a dynamic ocean management approach
10:30	SD4	V. Ortiz de Zárate	Is the SST a driving force on the annual variability of Northeastern Atlantic albacore (Thunnus alalunga) catches ?
11:30			Discussion panel: Theme 5
Theme 2: Integrated modelling of systems based on shared socio-economic scenario pathways – projection and exploration of future patterns in marine ecosystems			
12:15	IM1	M. Gasalla	Cost structure of pelagic fisheries under climate change
12:30	IM2	A. Takeshige	Comparison and integration of different ecosystem models for appropriate use of model characteristics
14:15			Discussion panel: Theme 5

Poster presentation listing

Allocation	Lead author	Title
TP1	Q-X. Chang	Feeding ecology of blue marlin (*Makaira nigricans*) in waters off eastern Taiwan
TP2	S. Yonezaki	Changes in demersal marine ecosystem structure off northeastern Japan before and after the Great East Japan Earthquake revealed by Ecopath modeling
LH1	C-T. Chang	Vertical movement and behavior of *Mola mola* in eastern Taiwan
LH2	S-J. Lin	Diel vertical movements of bigeye tuna (*Thunnus obesus*) off eastern Taiwan
LH3	Y-L. Yu	Application of time series analysis to detect the effect of multi-scale climate indices on global yellowfin tuna population
LH4	V. Hamilton	Spatial variability in responses to environmental conditions in long-finned pilot whales
LH5	T. Kodama	Temperature-dependent vertical distribution of larval Pacific bluefin tuna, *Thunnus orientalis*, in the spawn fields
LH6	Y. Tian	Interannual-decadal variability in the abundance of large predatory fish in the Japan Sea during 1964-2010 in relation to climate regime shifts
LH7	K. Kawai	Spawning biology of the black sea bream *Acanthopagrus schlegelii* in Hiroshima Bay, revealed from spatiotemporal distribution of pelagic eggs
LH8	Y.J. Zheng	Age estimates for fourfinger threadfin in coastal waters off western Taiwan based on length frequency analysis
SD1	S. Asai	Construction of wide area tracking system of skipjack using ultrasonic biotelemetry system and ICT network
SD2	Y. Nakamura	Horizontal and vertical movement of greater amberjack around Taiwan
SD3	S-Y. Teng	Potential impacts of climate variability on the *Eleutheronema rhadinum* habitat in the coastal waters of Taiwan
SD4	S-F. Yu	A rapid ontogenetic shift in the diet of juvenile yellowfin tuna from southwestern waters off Taiwan
SD5	L.I. Dahlet	Comparative study of skipjack tuna (*Katsuwonus pelamis*) fishery stocks from South Atlantic and Western Indian Oceans

ABSTRACTS

Construction of wide area tracking system of skipjack using ultrasonic biotelemetry system and ICT network

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The behavior of skipjack tuna in upstream of the Kuroshio Current of Japan are researched using the ultrasonic biotelemetry system in this study. The ultrasonic biotelemetry system records the fish individual ID and the swimming depth in the receiver by receiving ultrasonic signals transmitted from the ultrasonic transmitter (pinger). By attaching the mooring type receiver to the surface type FADs, the vertical diurnal behavior and staying around of that FADs of skipjack tuna were clarify. However, this method limits the tracking range. It is unknown what kind of behavior the fish is doing after leaving that FADs. As a method to solve this problem, we developed the fishing boat mounted system. This system consists of a pinger receiver, GPS and mobile phone network. When this system receives a pinger signal during fishing operation, it sends the receiving data in real time through a mobile phone network.

With the introduction of the fishing boat mounted system, it became clear that skipjack is staying in the middle layer type FADs installed in the surrounding sea of Yonaguni Island, Okinawa, Japan. In addition, we succeeded to get the pinger signals of skipjack released at Yonaguni Island a middle layer type FAD in the surrounding sea of Miyako Island, about 250 km from Yonaguni Island. As a result, it was suggested that skipjack is traveling while staying at the same place for a period of time with FADs as a relay point for migration. We believe that if the fishing boat mounted system will spread in the future, valuable information useful for the ecology and the resource management of skipjack can be provided. We also believe that this system can also contribute to catch efficiency because fishermen can obtain real-time information needed for catch such as depth of skipjack at which depth.

Contaminant exposure profiles and isotopic niches in marine top predators

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Contaminant exposure in marine predators is often interconnected with global environmental change factors, including climate variability, increases in terrestrial runoff and shifts in ocean biogeochemistry and circulation patterns. Food web dynamics are also related to changes in the environment and exert important controls over contaminant bioaccumulation and biomagnification regimes. This presentation will address questions and promote ideas to further understand the complex relationship between contaminants such as, but not limited to, heavy metals, persistent organic pollutants and microscale and nanoscale plastic particles and global environmental change and human dimensions across a wide array of spatial and temporal scales. Data on a broad range of topics will be considered, including single and multiple species contaminant exposure assessments, food web analyses and isotopic niches, effects of climate and/or habitat change on marine predator population dynamics, socio-economic dimensions of marine fisheries as well as human health risk assessments. Additional empirical, theoretical and modelling contributions relevant to these themes will also be considered.

Integrating dynamic subsurface habitat metrics into species distribution models

S. Brodie, Jacox M. G., Bograd S .J., Welch H., Dewar H., Scales K .L., Maxwell S. M., Briscoe D. M., Edwards C. A., Crowder L. B., Lewison R. L., Hazen E. L.

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Species distribution models (SDMs) have become key tools for describing and predicting species habitats. In the marine domain, environmental data used in modelling species distributions are often remotely sensed, and as such have limited capacity for interpreting the vertical structure of the water column, or are sampled in situ, offering minimal spatial and temporal coverage. Advances in ocean models have improved our capacity to explore subsurface ocean features, yet there has been limited integration of such features in SDMs. Using output from a data-assimilative configuration of the Regional Ocean Modeling System, we examine the effect of including dynamic subsurface variables in SDMs to describe the habitats of four pelagic predators in the California Current System (swordfish, blue sharks, common thresher sharks, and shortfin mako sharks). Species data were obtained from the California Drift Gillnet observer program (1997-2017). We used boosted regression trees to explore the incremental improvement enabled by dynamic subsurface variables that quantify the structure and stability of the water column, isothermal layer depth and bulk buoyancy frequency. The inclusion of these dynamic subsurface variables significantly improved model explanatory power for most species. Model predictive performance also significantly improved, but only for species that had strong affiliations with dynamic variables (swordfish and shortfin mako sharks) rather than static variables (blue sharks and common thresher sharks). Geospatial predictions for all species showed the integration of isothermal layer depth and bulk buoyancy frequency contributed value at the mesoscale level (<100 km). We further explored the influence of environmental variability on pelagic predators in the California Current by temporally decomposing model covariates to determine how different scales of environmental variability relate to species distributions. Identifying which scales of variability impact the distribution of top pelagic predators has implications for seasonal forecasts and climate projections designed to aid marine resources management.

How does spatial predator-prey overlap mediate trophic interactions?

G. Carroll, Holsman K. K., Brodie S., Thorson J., Hazen E., Bograd S., Haltuch M., Kotwicki S., Samhouri J., Spencer P., Willis-Norton E., Selden R.

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There is a growing need to understand how interactions between species are changing. For example, the distributions of predators and their prey may shift in non-uniform ways in response to climate-induced changes in habitat. These changes in spatial overlap between predator and prey populations have the potential to profoundly alter food web dynamics. A number of "overlap metrics" have been developed for application in an ecological context, with different ways of defining the overlap between two populations. It is often unclear which of these metrics may be most appropriate for describing different types of changes in spatial overlap, and whether overlap as defined by these metrics accurately reflects ecological processes such as predation intensity. Here we outline a suite of overlap metrics and illustrate their behaviour when applied to various scenarios of changing predator and prey distributions. We show how different metrics may be useful for different applications, e.g. for inferring changes in encounter probability for ecosystem modelling, or for assessing important geographic regions of overlap for spatial conservation planning. We then use a case study of four predators of juvenile walleye pollock in the Eastern Bering Sea, Alaska, to characterise changes in spatial predator-prey overlap in this rapidly changing system over the past 36 years. Then, using stomach content data collected over the same period, we determine whether inferences from the overlap metrics match observed changes in trophic interactions between these species. We assess these trends for more specialist vs more generalist predators, to understand how spatial overlap is related to predation intensity for species with different ecological niches. By reviewing these predator-prey overlap metrics and assessing their utility at describing important ecological changes, we hope to contribute to an improved understanding of how shifting species distributions may alter ecosystem dynamics.

Feeding ecology of blue marlin (Makaira nigricans) in waters off eastern Taiwan

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Blue marlin, as a top predator, is a pelagic migratory species distributed throughout tropical and subtropical waters. Trophic level and feeding ecology for this species was studied to understand the long-term trophic relationships using stomach content analysis (SCA) and short-term by stable isotope analysis (SIA). Samples of blue marlin were collected by month at the Shinkang fishing port in eastern Taiwan from January 2017 to June 2018. In total, 451 individuals (38-286 cm in eye fork length; 27-411 kg in round weight) were measured, of which 116 stomach with prey identifiable and 400 tissue samples were collected. Results from the index of relative importance (IRI) showed that the most important prey species were sand lances (Cephalopoda spp., IRI=1996.7), followed by *Katsuwonus* spp. (IRI=775.4), *Auxis rochei rochei* (IRI=442.7), *Trichiurus lepturus* (IRI=51.5) and *Coryphaena hippurus* (IRI=27.53). Results from this study suggest that blue marlin could be considered opportunistic pelagic predators.

Evaluation of the status and rebuilding timeline of the Pacific billfish stocks under climate change

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Due to the highly migratory nature, widespread distributions, and global economic importance of billfishes, the Regional Fisheries Management Organizations (RFMOs) are in charge of their assessment, management, and conservation. Current billfish stock assessments by the RFMOs tend to quantify uncertainty, particularly in relation to the status of the stock in recent years relative to reference points. Stock productivity may shift with future climate change, with unknown consequences for sustainable harvesting, reference points, and recovery timeline. Here we develop a stochastic modelling framework to characterize variability in the intrinsic productivity parameter (r) and carrying capacity (K) for the three Pacific billfish stocks (striped marlin, Kajikia audax; blue marlin, *Makaira nigricans*; and swordfish *Xiphias gladius*) that formally assessed on a regular basis by the International Scientific Committee for Tuna and Tuna-like Species in the North Pacific Ocean. We use models of dynamic stock productivity fitted via Bayesian inference to evaluate of future risk of overexploitation and rebuilding timelines of the stocks. This work reveals how climate change could impose challenges for the determination of stock status and delay the rebuilding timeline of the billfish stocks in the Pacific Ocean.

Vertical movement and behavior of *Mola mola* in eastern Taiwan

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Sunfishes (Molidae) comprise the largest bony fishes inhabiting the epipelagic to mesopelagic realms in tropical through temperate ocean regions. One ocean sunfish, *Mola mola*, was tagged with pop-up satellite archival tag (PSATs) off eastern Taiwan in December 28th 2017 to examine horizontal and vertical movements. The tag remained attached for 150 days, reaching depths to 602 m, and recording water temperature from 7 to 29 °C. The tagged fish traveled northward around Taiwan and then to the South China Sea. The overall depth distribution showed that the sunfish spent little time (2%) in surface waters <50m. The majority of time (83%) was spent between 100 and 350 m. The fish presented a clear diel pattern, it spent only 10% of the nighttime below 350 m in comparison to 58% during the day. Temperatures also differed. During the day it spent 80% of its time between 12 to 14 °C in comparison to 14 to 24 °C at night. It suggested that the depths of tagged fish in nighttime are closer to the thermocline (100 ~ 300 m). Average night depth of tagged fish was related to the lunar illumination that went shallower in the period of full moon and deeper in new moon.

Feeding ecology and trophic position of black marlin in the northwestern Pacific Ocean

W-C. Chiang, Hsu H. H., Chang C. T., Chang Y. C., Tsai F.Y., Chang Q. X., Musyl M. K., Sun C. L., Madigan Daniel J, Carlisle Aaron B., Ho Y. S., Tseng C. T.

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Black marlin (*Istiompax indica*) are a large, highly migratory, pelagic predator of tropical and subtropical Pacific Oceans and economically important species. We examined the feeding ecology and trophic position of this species using combined the stomach content and stable isotope analysis (SIA) coupled with stable isotope mixing model analysis. A total of 80 samples (127–300 cm, eye-orbit fork length, EFL) were examined for changes in trophic ecology and level in relation to EFL by using stable isotope analysis of carbon (δ13C) and nitrogen (δ15N). The δ15N values for black marlin ranged from 11.06 to 14.18‰ (mean ±s.d. = 12.69±0.72‰) and the δ13C values ranged from -21.14 to -15.63‰ (mean ±s.d. = −17.25±1.08‰). The δ15N values were positively dependent on EFL (r2 =0.114), whereas δ13C were negatively dependent on EFL (r2 =0.028). Based on stomach content analysis, juvenile black marlin primarily feed upon smaller pelagic fishes (needlefish, flying fish) with lower δ15N values, while adult black marlin consumed larger prey items (moonfish) with higher δ15N values. The trophic position (TP) of each EFL class was correlated, starting from 4.62 TP for size class I (EFL <140 cm) and reaching 5.04 TP for size class VI (EFL > 240 cm). The mean ±s.d.TP was 4.68 ±0.3 for all samples. The results indicate that black marlin occupy a high trophic position highlights their important ecological role as a top predator in the pelagic ecosystems.

Satellite-based indicator of zooplankton distribution for global monitoring of marine living resources

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Meso-zooplankton distribution was derived from Earth Observation after using an extensive calibration dataset of biomass in the North Atlantic. While chlorophyll-a content (CHL) is commonly described as a proxy of phytoplankton biomass, the size of productive fronts, estimated through the horizontal gradient of CHL (gradCHL), were found to be directly connected to meso-zooplankton biomass. Our results suggest that the lifetime of productive fronts often from weeks to months likely meet the requirements of meso-zooplankton development. Furthermore, a coherent interpretation of the productive front lifecycle was performed with respect to CHL levels, meso-zooplankton biomass and predation by higher trophic levels. The proposed product not only describes the daily favorable habitat for feeding but also informs on meso-zooplankton biomass distribution. Since this trophic level is keystone for upper food chains and remains a knowledge gap, the proposed indicator delivers essential information for research and policy. An unforeseen indicator trend of +3.1% per decade from 2003 to 2017 was observed at basin scale under the current effect of climate change, with regional peaks above +20% in relatively poorly productive areas. Such monitoring product is essential to advances in marine food web modeling, fisheries science and the dynamic management of oceans towards sustainability. These results will particularly support the EU Marine Strategy Framework Directive through the characterization of pelagic habitats and the Common Fisheries Policy through the assessment of the environmentally-driven fish productivity and the progressive implementation of a dynamic ecosystem-based approach to fisheries management.

Large-scale distribution of tuna species in a warming ocean

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Despite of the fishery relevance of tunas, a global-scale study addressing historical trends and future climate change impacts for the most commercially valuable species has not been conducted. In this study, we investigate the effect of environment in worldwide distribution and abundance of six tuna species between 1958 and 2004 and estimate the expected changes under the climate change highest carbon dioxide emission scenario. For this purpose, we used a long-term time-series Japanese longline fishery dataset (47 years) and a two-step Generalized Additive Models (GAMs). We also estimated the potential rate of tuna abundance change in countries' Exclusive Economic Zones (EEZs) to assess the future impact for those countries. Our findings revealed that suitable habitat of 68% of tuna stocks shifted poleward and that of albacore and southern bluefin showed the highest habitat decrease in the past. Tuna distribution and abundance changes are expected in the future with higher intensity for the end of the century (2100). Abundance is expected to change in coastal countries' EEZ, mainly increasing in high latitudes and decreasing in tropical areas (except for skipjack and yellowfin). These results allow us to anticipate the potential effects of climate change in tuna populations and start taking the appropriate measures to diminish the impacts.

Characterising little penguin behaviour in relation to bio-physical drivers in a continental shelf region of the south-east Australia hot-spot

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Little penguins (*Eudyptula minor*) are a conspicuous but vulnerable meso-predator in the rapidly changing southeast Australia hotspot region. Populations have been declining across their range at most major colonies in Australia. These declines are hypothesised to be linked with changes in ecosystem dynamics in the foraging grounds of penguins due to climate change induced temperature increases. Within Australian waters, Tasmania occurs at the cool end of their tolerable temperature range. Therefore, the population in the Tasmanian region is of conservation interest as a refuge as climate change continues to affect population size and movements. At the Neck, Bruny Island, the colony of little penguins is the largest in the southeast Tasmanian region. It is also subject to multiple anthropogenic pressures including infrastructure development relating to penguin tourism, feral cat predation and changing foraging conditions.

Their movements in this region have been studied in conjunction with an integrated biophysical study of the continental shelf region where they forage. This site is a region of physical variability as a result of the increasing penetration of the warm, saline East Australian Current into south-east Tasmanian waters during summer. As a result of the increasing dominance of this current, this region is warming at a rate ~3-4 times the global average, and a decrease in the abundance of zooplankton on the shelf has been linked with these changes in physical parameters. Our study aims to determine the links between oceanographic conditions, plankton production and the movement ecology of little penguins using accelerometer tags during the breeding season of 2017/18. The findings of this study are expected to aide in the management of a vulnerable colony and establish baseline information on the foraging habits of this charismatic marine predator in a rapidly changing region.

Cost structure of pelagic fisheries under climate change

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The lack of data on fisheries socio-economic and financial details has negative consequences to understanding patterns of fishing fleets viability under climate change. Both a detailed financial and economic performance was assessed for 10 different fleets of the South Brazil Large Marine Ecosystem, and the key factors affecting profitability were identified. Through an unprecedented set of field survey data, a cost structure comparison between different fleets and ports identified the major factors affecting profit patterns. Besides the total revenue expectation from different pelagic fisheries, profit margins are explained by a typical trend in the cost structure where the ratio between labor and fuel cost is higher in large pelagics. The cost-benefit analysis provides insights into evidences and measures to increase efficiency under climate impacts.

Long in the tooth? Insights into environmental drivers of energy budgets in marine mammals

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Determining the environmental drivers of energy budgets (which underpin population state) is difficult for long-lived marine mammals, due to their cryptic nature and remote habitats. By combining individual chronologies derived from measurements of annual tooth growth in 62 sperm whales sampled from four regions across southern Australia, records of energy budgets spanning 70 years (1935 – 2004) were produced. For the first time for an odontocete (toothed whale) species, here we demonstrate energy budget responses to multiple broad-scale climate drivers across the Australian region. Overall, positive phases of the Southern Oscillation Index and Southern Annular Mode and negative phases of the Indian Ocean Dipole were observed to positively influence tooth growth and in association, the energy budgets of sperm whales. When relationships with individual sampling groups were investigated, variability in the dominant drivers of tooth growth and energy budgets across the groups were observed. Differences in responses are likely associated with spatial variability in foraging patterns and in association environmentally driven variability in the trophodynamics of foraging regions.

Identifying natal origin of Pacific bluefin tuna using otolith oxygen isotopes measured by SIMS

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Pacific bluefin tuna (PBT, *Thunnus orientalis*) is known to spawn seasonally in two distinct regions, one in waters off the Ryukyu Islands (May to June) and one in the Sea of Japan (July to August). Despite efforts to elucidate the spawning mechanism of this species, our understanding of the spawning

ecology of PBT, particularly about the recruitment contribution from each spawning ground remains limited. The purpose of this study is to develop a method to identify natal origin of PBT for various age classes by estimating spawning temperature from oxygen isotopes (δ18O) of otolith core analyzed with secondary ion mass spectrometry (SIMS). This is possible due to different spawning temperatures experienced by PBT in the Ryukyu Islands and the Sea of Japan. We conducted SIMS δ18O analysis on 5 otolith thin sections of adult PBT (>70 kg) from the core to the edge along the growth axis. Each spot was sputtered with 133Cs+ primary ion beam focused to 10μm diameter, which can sputter the area corresponding to the larval period. A number of spots measured ranged from 42 to 78 per sample. The spatial resolution near the core region resulted more than 10 times higher than the conventional method. The result showed the increase of about 1-2‰ in δ18O values (expressed relative to VPDB) around the first annulus (800μm~) in all samples. The first annulus forms when PBT experiences decreasing temperature in autumn through winter, indicating the δ18O increase reflects the actual temperature change experienced by fish. In addition, there was about 0.5‰ difference in δ18O values among the samples in the area deposited within a few months after spawning, suggesting the temperature difference experienced by the Ryukyu Island spawned PBT and the Sea of Japan spawned PBT.

Seasonal and decadal forecast development for a multi-species pelagic longline fishery

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The abundance and distribution and hence availability of highly migratory tuna and billfish species to fisheries are known to be strongly influenced by oceanographic conditions. The five target species of the Australian east coast longline fishery (albacore, bigeye, yellowfin tuna, striped marlin, broadbill swordfish) have a wide distribution outside the Australian EEZ, but the influence of oceanographic factors within the fishery region and the surrounding south-west Pacific region is poorly understood, creating uncertainty in current management arrangements. The waters off the east coast of Australia are also experiencing rapid climate change, with range expansion already observed for many coastal and pelagic fish species. Changes in distribution are also projected for these five species in eastern Australia and the wider Pacific.

Fisheries managers and industry are seeking insight into past, current and potential future oceanographic and environmental impacts upon (i) the spatial and temporal distribution and level of longline catches, catch rates, fishing effort and fish sizes, and (ii) the interactions between focal species in the domestic and international fisheries. In previous work we have developed habitat models and seasonal forecasting approaches for a range of species in Australia, including southern bluefin tuna, using the Bureau of Meteorology's POAMA model, which produces skillful seasonal forecasts of key variables at lead times of up to four months. This new three year project will provide insights into potential long term changes in the longline fishery that may result from climate change, and deliver forecasting capability on seasonal and decadal time scales for the five species targeted in the fishery. We will utilise new high resolution models for seasonal forecasting (ACCESS-S1) and our state- of-the-art decadal forecasting capability. This effort will support decision making by Australian and south-west Pacific managers and fishers, and build capability for operating in a rapidly changing region.

Distribution of larval tunas in the Phoenix Islands Protected Area and estimated spawning sites during multiple phases of an ENSO cycle (2015-2017)

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The Phoenix Islands Protected Area (PIPA) is one of the largest protected areas in the world; it represents 11% of the exclusive economic zone of the Republic of Kiribati, which earns the majority of its GDP by selling tuna fishing licenses to foreign nations. Therefore, closing an area as large as PIPA is costly to Kiribati, and it is important to understand how PIPA contributes to the spawning of tunas. Plankton samples were collected on summer cruises in PIPA in 2015-2017, yielding data on larval tunas from two taxa: skipjack (*Katsuwonus pelamis*) and *Thunnus* spp. Temperature, salinity, and zooplankton abundance across these three years varied markedly due to El Niño conditions in 2015, La Niña conditions in 2016, and more neutral conditions in 2017. Larval tuna distributions varied slightly amongst years, but generally indicate that skipjack larvae are more abundant in the northeast quadrant of PIPA and that Thunnus larvae are present at lower abundance but more evenly distributed in space. Genetic barcoding of Thunnus larvae revealed that both bigeye (Thunnus obesus) and yellowfin (*Thunnus albacares*) tuna larvae are present in PIPA in the summer. Approximately 30 skipjack and 30 Thunnus larvae each from 2015 and 2016 have been aged, providing age-length relationships. Backtracking simulations to determine the likely spawning locations for collected larvae were performed using the Connectivity Modeling System (CMS) with HyCOM velocities and estimated larval ages. Using CMS, most of the larvae collected inside PIPA are estimated to have been spawned within the boundaries, with the pattern of spawning sites and collection hotspots influenced by oceanographic conditions in the 3 years. These simulations indicate that tuna spawning is occurring inside PIPA for all three species under a broad range of environmental conditions.

Impact and adaptation of coastal fisheries under climate change - a case study of set-net fishery in Taiwan

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Direct and indirect impacts of climate change disasters on marine fisheries have increased dramatically in recent years. The influence of climate change cannot be ignored since Taiwan is located in a hot-spot area impacted by climate change. In the future, as climate variability intensifies, the impact of climate change to the overall fisheries will be more far-reaching. When we face an unknown climate disaster, we must have sufficient scientific evidence and foundation to act as reference, to develop suitable adaptive management measures to mitigate disasters and avoid losses caused by climate change. Hence, the purpose of this research project is to investigate comprehensive impact information of climate change and used TaiCCAT's supportive system for decision-making (TSSDA) to analysis climate risk on coast fishery in Taiwan. In the study, we select set net as our target fishery. Set net fishery in Taiwan play important role in their coastal fishery and change of catch is mainly dependent on natural factor. First, we focosed on reviewing the characteristics of natural environment and set net fishery in Taiwan. Simultaneously, we will conduct on-site investigation on fishery manager or inspector of how they confronted with the impact of the climate, as well as different fishery managers or inspectors from diverse regional fishing villages and the local adaptive measurement they have taken. Ultimate, with a risk management analysis of Taiwan's fishery managers and local fishing villages adaptive tactics similarities and differences, together with Taiwan's current department insufficient adaptive measurements or tactics, we need to draft and plan for future feasible adaptive options, thereby reducing, averting and to lighten the influence of future intensification of climate change on the marine environment, society and economy.

Moving from impacts to adaptation in fisheries and conservation of top predators

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Clear evidence of climate impacts on marine species now provides confidence to managers and other decision makers seeking to develop adaptation options for both exploited and non-exploited species. A clear process for developing, testing and then sequencing adaptation options is demonstrated using several case studies from Australia. One case study involves the icon shy albatross – for which conservation managers have implemented a range of interventions to boost breeding success. Disease treatment and nest replacement have both been field tested and resulted in additional chicks fledged. However, we are just beginning to discover how planned intervention may also be antagonistic to natural selection under climate change. A second case study involves preparing marine fisheries management for climate adaptation. Full consideration of the barriers and drivers for adaptation revealed a range of constraints when responding to changes in the distribution, abundance and phenology of target species. Finally, adaptation options for a single fishery confronted with increased uncertainty in species distribution has resulted in the development of habitat forecasts. These examples illustrate the range of non-biological factors that must be understood when planning adaptation responses. Adaptation pathways are an important planning and communication tool that can represent the complexity as well as a way forward under an uncertain future.

Impacts of global warming scenarios on larval and juvenile transport process of Japanese eel (*Anguilla japonica*)

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For Japanese eels (*Anguilla japonica*) distributed in the western Pacific Ocean, the position of the North Equatorial Current (NEC) salinity front, its bifurcation, and the velocity of the NEC and Kuroshio Current (KC) play critical roles in their spawning location, transport processes, recruitment dynamics, and distribution, respectively. Therefore, variations in oceanic environmental conditions might significantly influence larval transport. Previous studies have indicated that the weakening of tropical circulation, the anti-cyclonic change in wind stress curl and the variance of the ratio of precipitation and evaporation as the climate warms. An ocean model Model for Interdisciplinary Research on Climate version 4h (MIROC 4h) simulation under the Intergovernmental Panel on Climate Change (IPCC) A1B climate-warming scenario predicted that the NEC salinity front and bifurcation will move northward, the strong part of the NEC will move southward, and that the KC velocity will increase in the future (2050 to 2099) in comparison with present conditions (1950 to 1999). Therefore, the combination of several mechanisms will affect the transport and recruitment of larvae and juveniles of this species. Particle modelling predicted a 16–32% decline in particles recruited into the KC and a 6–12% increase in those entrained in the Mindanao Current when assuming three swimming speeds (0 Total Length (TL)/sec, 0.69 TL/sec, and 2 TL/sec). Additionally, the drifting time from their spawning area to the KC was extended by approximately 35 days. Furthermore, the distribution of the particles after entering the KC is affected by the differing intensities within the KC.

Perdition and validation for potential fishing grounds of skipjack tuna (*Katsuwonus pelamis*) in the western and central Pacific Ocean

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Skipjack tuna are most abundant commercial tuna species for the Taiwan pelagic purse seine fishery. However, rapid change of marine environment increased the challenge for searching free school fish in the sea. In this study, we aimed to predict the potential fishing grounds of skipjack tuna in the western and central Pacific Ocean. The fishing ground of skipjack tuna was simulated by habitat suitability index (HSI) based on fishing logbook data and satellite data. The selected environmental factors included sea surface temperature front, sea surface height, and salinity. The results indicated that, during El Niño events in 1997 and 2015, the fishing grounds were widely distributed in the areas from Solomon Islands to Kiribati, whereas the hotspots of fishing grounds appeared in vicinity of the Tuvalu during La Niña event in 1998 and 2016. We compared potential fishing grounds with fishery logbook, the rate of optimum harvesting which were defined as more than 25 tons per net is about 67% in the potential fishing grounds.

Long-term trends in distribution and abundance of small cetaceans estimated in relation to oceanographic and topographic variables in the waters off the Pacific coast of Japan

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In the western North Pacific, the Kuroshio Current flows from south to east along the Pacific coast off Japan, and its variability plays an important role for marine ecosystem in that area. Thus, taking environmental variability into account to stock assessment is important for animals inhabiting these waters. Using datasets from line-transect sighting surveys between 1985 and 2015, the authors recently published abundance estimates of the six species of delphinids, rough-toothed, common bottlenose, pantropical spotted, Risso's dolphins, and short-finned pilot, and melon-headed whales. These estimates were obtained from standard design-based line transect approach. Spatially and temporally explicit information on their distribution and abundance are still not obtained, and thus relationship with environmental variability is not clarified. In addition, in spite of long study periods, comparable estimates were provided only for three years, because the survey block configurations differed among years and a number of unsurveyed areas left in some years. The present study analyzed datasets from 1985, 1986, 1987, 1992, 1993, 1997, 2006, 2007, 2014, and 2015 using generalized additive model (GAM)-based habitat models to estimate spatial distributions and time-series abundance for the six species of delphinids. Temperature (0, 100, and 200 m deep), topography (depth, slope and distance to four main islands of Japan), and year were considered as potential explanatory variables. The estimated habitat maps showed species' specific distributional patterns. The habitats and abundances tended to increase from 1980s to recent years for most species. Unlike in standard line-transect approach, even if lack consistency in survey designs, the present approach can reasonably extrapolate abundance within the survey area based on the relationship with environmental variables, and would be useful to estimate trend and status of the population.

Quantitative evaluation of ecosystem services supporting the growth of Japanese chum salmon

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Chum salmon (*Oncorhynchus keta*) are distributed widely in the subarctic Northern Pacific and play an essential role in the North Pacific ecosystem and provide important ecosystem services: provisioning, cultural, and supporting services. The chum salmon can be divided into several groups and the stock of the Japanese group is maintained by artificial release. The chum salmon released in Japan migrate to the Okhotsk Sea, western subarctic North Pacific, the Bering Sea and the Gulf of Alaska and return to their home rivers in the summer of their fourth/fifth year. The annual catch of Japanese chum salmon is ~70 billion yen in sales, which can be regarded as the monetary value of provisioning services of Japanese chum salmon. In this study we attempt to estimate the background services that support the growth and survival of Japanese chum salmon using a bioenergetics model coupled with a 3D lower trophic ecosystem model (3D-NEMURO). It is estimated that Japanese chum salmon consume ~5 million ton of zooplankton in total per year. Assuming that the value of zooplankton is equivalent to the krill traded in the metropolitan central wholesale market, Japan, for example, the monetary value of consumed zooplankton is estimated to be ~2 trillion yen per year. This result suggests that the harvest of chum salmon equivalent to ~70 billion yen is supported by the background service (shadow cost) of ~2 trillion yen.

Spawning biology of the black sea bream *Acanthopagrus schlegelii* in Hiroshima Bay, revealed from spatiotemporal distribution of pelagic eggs

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Hiroshima Bay is one of the largest fishing areas for black sea bream *Acanthopagrus schlegelii* in Japan. Recently, the landing of this species in the bay has been gradually decreasing. Therefore, frameworks for reproductive biology of the species are essential. To get the basic knowledge of spawning biology, we surveyed about their spawning duration, ground and time of the black sea bream in Hiroshima Bay.

We collected pelagic eggs using submersible pomp and NORPAC net from late-April to late-July for 4 years in the bay (2015-2018). The number of survey stations for spawning duration, ground and time were 2, 14, and 1, respectively. Simultaneously with the spawning duration survey, we collected matured adults for measurement of gonadosomatic index (GSI). For estimation of spawning time, field-caught eggs were categorized into 9 developmental stages (A: 1-cell, B: 2-cell, C: 4-cell, D: 8-cell, E: 16-32-cell, F: Morula, G: Blastula, H: Embryo formed and I: Yellow chromatophores appeared). Species identification for black sea bream eggs used the monoclonal antibody method.

Black sea bream eggs appeared in late-April and then settled down in early-July. The peaks of egg density in the bay with the highest adult GSI were marked at early-May to mid-May. Based on the horizontal egg distribution, egg density in the outer bay was much higher than that of the inner bay. The significant lower egg density at the inner most of the bay area suggested that adults avoid the low salinity area for spawning grounds. On the contrary, high egg density recorded near the oyster farming area suggested that black sea bream utilized abundant oyster rafts as main spawning grounds. The majority of the 1-cell stage eggs that appeared around sunset supported semi-nocturnal spawning behavior of black sea bream.

Comparative evaluation of ecosystem characteristics and fishery impacts based on Ecopath foodweb models

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Japan has built its fisheries management upon single-species stock assessment, whereas carrying on traditional dietary culture of utilizing a large variety of marine organisms from seagrass, invertebrates to top predator species. Recently, many coastal communities in Japan suffer from the shrinkage of local fisheries and seafood culture. In order to ensure the sustainability of marine ecosystems, biological resources, and local economy and society, we need to understand the characteristics of regional ecosystems and the impacts of fisheries thereon. However, it is difficult to judge the "desirable" state of an ecosystem and the optimum yields from it under the current information-limited situation. In this study, we adopted a comparative approach and constructed Ecopath models for three Japanese regions to assess the ecosystem characteristics and the fishery impacts through the comparison with other Ecopath models published for various periods and regions of the world. Whereas Ecopath originated from a network analysis tool, network indices are not always suitable for multi-model comparison since the network properties differ depending on the model construction (e.g. the degree of aggregating functional groups). We therefore compared total biomass, production and fishery removal obtained from the flow analysis, and partitioned the biomass and flow into trophic levels to describe the food web structure and fisheries impacts in a comparable manner. The results showed that Japanese fisheries in the three regions utilized wider range of trophic levels starting from TL2. Fisheries impacts evaluated as the footprints on primary production (PPR; Pauly 1998) and the loss of foods for higher predators (L-index; Libralato 2006) were generally at moderate levels compared to those in other regions of the world. The Seto Inland sea model indicated that the fisheries there utilized a wide range of trophic levels but posed relatively large total impacts.

Feeding habits of the larval Pacific Bluefin tuna Thunnus orientalis in the two nursery grounds

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Pacific Bluefin tuna (PBT), *Thunnus orientalis*, spawn in the waters around the Nansei Islands (northwestern edge of the Philippine Sea) and the Japan Sea. To evaluate feeding habits of PBT larvae is important because faster growth larvae can only survive. The diet compositions and amounts of larval PBT (body length, BL: 2.7–7.6 mm) in the Japan Sea (2011–2017, n = 314) and the Nansei area (2016 and 2017, n = 99) were observed using morphologic and metagenetic methods. The main prey items were different between the areas: they were copepods in the Nansei area and Podonidae in the Japan Sea. In the Japan Sea, the diet composition was different by BL: the small larvae (<4 mm) fed on nauplius of copepod, shift to Podonidae during middle size larvae (4–6 mm), and the diet compositions during large size larvae (>6 mm) had a wide variety. The piscivorous habit, which is the key to the rapid growth, was only observed from a 7.5-mm larva collected in the Nansei area in 2017. The diet amounts based on the morphologic observation were not different between the areas. The circadian rhythm of prey amounts was observed: the amounts of prey increased daytime and decreased rapidly two hours after sunset, these facts indicate that larvae can capture the prey only daytime. The diet amounts have a positive correlation with BL and water temperature, and not with the densities of prey in the water. The stomach contents of larvae were empty when seawater temperature was below 25.4°C, and this threshold of temperature for capturing the prey was according to the optimal temperature of their habitat. These facts indicate that habitat of PBT larvae is controlled by water temperature throughout their feeding habits.

Influence of oceanographic variability on catch rate of yellowfin tuna (*Thunnus albacares*) cohorts in the Indian Ocean

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The yellowfin tuna (*Thunnus albacares*) is one of the important commercial species for longline fisheries in the Indian Ocean. In this study, we collected the records of catch rates and length measurement data of longline fisheries to investigate the association between the environmental variations and distributions for each cohort of yellowfin tuna by using empirical orthogonal function and generalized additive models. These functional associations can be used to evaluate the effects of climatic variability on the spatial pattern of the feeding grounds and spawning grounds. The results showed the distributions of juvenile (0~1 yrs) were affected by the varied of mixed layer depth and chlorophyll-a concentration, and concentrated in the northwestern Indian Ocean in the first and second quarters and moved to southwestern parts in third quarter. The change of mixed layer depth caused by Dipole Mode Index were affected the distributions of the major fishing cohort (2~3 yrs) in the first and fourth quarters in the western and central Indian Ocean. The 2~3 yrs cohorts were moved from northwestern to central Indian Ocean in the third quarters and leaved the lower sea surface temperature around the sea of Somalia. The distributions of older cohort (>4 yrs) showed the seasonal variations and mainly influenced by the varied of mixed layer depth and chlorophyll-a concentration. The results suggested that climatic oscillations were affect the suitable environments of yellowfin tuna spawning ground on Madagascar and the Bay of Bengal and feeding ground on western and central Indian Ocean.

Detection of potential habitat hotspots of albacore tuna (*Thunnus alalunga*) in the South Indian Ocean using the satellite and longline fishery data

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Albacore tuna (*Thunnus alalunga*) is one of the important commercial species of the longline fishery in the southern Indian Ocean (SIO). The satellite-based oceanographic data with the longline catch data during 2009 to 2015, were used to evaluate the effects of oceanographic conditions on the hotspot habitat for Albacore tuna in the SIO using the maximum entropy models (MaxEnt). The higher nominal CPUE (>10 inds./1000 hooks) of Albacore tuna was mainly distributed in the waters of 25 to 40°S during the period of April to September. The spatial habitat patterns were explained predominantly by sea surface temperature (17–19°C) in wintertime. Hotspot habitat formations were also possibly related to the Sea surface salinity (35.6-36.0) and chlorophyll concentration (0.12-0.24 mg/m3).

Marine environmental effects on the spatio-temporal distribution of swordfish (*Xiphias gladius*) in the Indian Ocean

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Swordfish (*Xiphias gladius*) is an important apex predator in marine ecosystems caught in commercial tuna longline fisheries and recreational fisheries. The spatial and temporal distributions of swordfish may be impacted by certain marine environment factors in the Indian Ocean, leading to possible shifts in the distribution of the fishing ground. In this study, we collected fishery data from the Taiwanese distant-water tuna longline fleet for swordfish and satellite based remote sensed oceanographic variables for 2009-2016, to investigate potential impacts of environment variability on the fishing condition of swordfish. Empirical models were developed based on generalized additive models (GAMs) and habitat suitability index (HSI), and were used to analyze the feasibility for forecast of fishing condition of swordfish. Impacts of different resolution on predicted distribution at monthly 5° and weekly 1° spatial grids were also examined in this study. All the marine environmental factors considered in the habitat models were statistically significant ($p<0.05$). Result shown that sea surface temperature (SST) and chlorophyll-a (CHL) had most affect on Indian Swordfish. GAMs were thus considered as an appropriate approach to develop habitat models for swordfish in the Indian Ocean. Most of the Swordfish were found distribute mostly in the trophic area. Results of this study could provide useful scientific information for fisheries management, if needed, to potentially reduce the swordfish bycatch in tuna longline and purse seine fisheries.

Diel vertical movements of bigeye tuna (*Thunnus obesus*) off eastern Taiwan

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The complex relationships between diving behavior and population dynamics at various spatial and temporal scales are major research focuses in fisheries ecology. To learn about the movement patterns of bigeye tuna (*Thunnus obesus*) and interaction with longline fisheries in eastern Taiwan, a pop-up satellite archival tag (PSAT) was deployed on a ~45 kg bigeye tuna. Though the PSAT prematurely popped-up, the tag was recovered by researcher and provided in aggregate data from 47 days-at-liberty. Typical of the diel diving patterns displayed by many pelagic apex predators, the tagged tuna dove deeper during daytime than at nighttime with pronounced crepuscular transitions. During daytime (0 – 1,036 m, 4.2 - 26 °C) the tuna spent the majority of its time above 400 m (307.3 ± 95.3 m SD) at temperatures from 12 - 24°C (16.03 ± 2.9°C). At nighttime (0 – 873 m, 6.5 - 25°C), residency was largely confined to the surface mixed-layer to ~150m (56.9 ± 45.3 m; 23-25°C, 23.7 ± 0.9°C). Across the entire time series, daytime and nighttime depth distributions appeared to be limited by a 12°C and 2 °C change relative to sea surface temperature (ΔSST), respectively. Bigeye tuna follow the diel vertical movements of prey organisms comprising the deep sound scattering layer to exploit them effectively as a resource.

Spatial distributions and catch rates variability of Bigeye tuna (*Thunnus obesus*) cohorts related to oceanographic and climatic indices in the Pacific Ocean

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The bigeye tuna (*Thunnus obesus*, BET) is one of the important commercial species for longline fisheries in Pacific Ocean. In this study, we collected the long-term (2002-2012) records of bigeye tuna catch rates, length data of longline fisheries and divided into immature and mature group. The generalized additive models (GAMs) were used to investigate the relationships between environmental variables and catch rates for evaluating the fishing condition of the immature group and mature group of BET. The model selection processes showed the cumulative deviances explained by selected GAMs were 32.9% and 38.1% in immature group and mature group respectively. The result showed the catch rates were significantly correlated with the temporal (year and month), spatial (longitude and latitude), environmental variables of sea surface temperature (SST), chlorophyll-a concentration (CHL) , mixed layer depth (MLD), sea surface height (SSH) and climate index (Pacific Decadal Oscillation and North Pacific Gyre Oscillation). A similar pattern of immature and mature group revealed positive correlations for the catch rates and SST in the range 26-28℃, 0.1-0.2mg/m3 of CHL, 0.4-0.5 m of SSH, and 60-100 m of MLD. However, the MLD explained the greatest amount of deviance for the immature group, but the greatest amount of deviance was CHL for the mature group. As a result, we speculating that the movement patterns of tunas are under the control of the environmental conditions, because the time and areas strata favorable for spawning and for feeding are limited and variable in time and space.

Long-term variability of piscivorous fish in exploited China Seas under climate change with implication for fisheries management

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Due to persistent fishing expansion in the past six decades, fisheries resources in China Seas have been over-exploited and targeted fish tend to be smaller in size and younger in age. Marine piscivorous fish constituted a large portion of Chinese fisheries catch, however, their long-term variability has rarely been investigated in spite of intensive fishing pressures and climate change. In this study, we attempt to identify their responses to climate change and to provide scientific basis for fisheries management and sustainable exploitation of these resources. Eight taxa from pelagic to demersal and from cold-water to warm-water species were selected to represent piscivorous fish assemblage in China Seas. Total catch of these piscivorous fish in China Seas increased during the early 1990s and then remained at a relatively stable level around 1.2 million tons after 1997, showing a similar trend with their prey species (e.g., sardine, anchovy). Principal component analysis (PCA) showed evident interannual-decadal variabilities in the catches of these fish with step changes in PC1 around 1990/91 and in PC2 around 1960/61 and 1996/97. Different trends occurred among individual taxa with sharks, rays and lizardfishes manifesting downward trends while Pacific cod, eels and hairtail displaying increasing trends. Common dolphinfish and Japanese-Spanish mackerel increased largely in the 1990s and declined slightly during the 2000s. Significant correlations between piscivorous fish catch and the catch of their prey species, PC1, and SST suggested that decadal variations in piscivorous fish responded well to climate change and also associated largely with the dynamics of their prey species. In addition, significant changes were identified in their life history traits such as reduced average catch sizes and truncated age compositions, strongly indicating the effect of fishing. We therefore advocate precautionary fishery practices under climate change.

Investigating drivers of spatial patterns and decadal shifts in marine food webs: results from global meta-analyses of nitrogen and carbon isotopes in tunas

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Marine ecologists still lack a thorough understanding of the drivers, scales, and mechanisms affecting the trophic structure of marine ecosystems, limiting our ability to project future impacts of fishing and climate change. To better understand spatial patterns and broad-scale drivers of oceanic food web dynamics, the CLIOTOP Marine Predator Isotope Task Team compiled tuna stable carbon and nitrogen isotope datasets from ecosystems around the world and used novel statistical approaches. Regional variabilities in baseline δ13C and δ15N values were accounted for using a global ocean biogeochemistry model. Meta-analyses of these datasets revealed that while tuna share similar functional trophic roles, deeper-foraging tuna had higher trophic positions globally. Spatially, food-chain length was longer in the western and central Pacific Ocean, where tunas appear to occupy the broadest trophic niches. Results from general additive mixed models demonstrated that predator trophodynamics are driven by a complex set of environmental parameters. The δ15N values and trophic positions of tuna declined under reduced oxygen conditions suggesting that habitat compression due to increasing hypoxia will impact the overall trophic structure of marine food webs and the corresponding feeding behaviour of marine predators. Tuna δ13C values increased with sea surface temperature, suggesting that ocean warming will further impact marine food web dynamics and foraging habitats of tuna. Time-series analyses indicated the δ13C values of tuna have declined globally over a 15-year period (2000-2015) which reflects increases in fossil fuel-derived carbon and potential wide-spread changes in phytoplankton communities or physiology. Results from our meta-analyses substantiate the occurrence of major and fairly recent alterations in the ocean carbon and nitrogen cycles and in the structure and function of oceanic ecosystems around the world.

Developing alternative conservation measures for bigeye tuna in the eastern Pacific Ocean: a dynamic ocean management approach

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The tropical tuna purse-seine fishery in the eastern Pacific Ocean is one of the biggest in the world, with recent annual catches exceeding 600,000 tons. Although management measures to maintain exploitation rates at sustainable levels are in place, some populations may have started to experience notable declines. This is the case for bigeye tuna (Thunnuns obesus), for which the last assessment showed considerable uncertainty with respect to stock status. To meet management objectives, the Inter-American Tropical Tuna Commission has implemented a 2018-2020 conservation plan, which includes a 72-day fishery closure, as well as an additional 30-day closure of an area known as the "corralito". These measures are vessel class-specific but the relationship between capacity and fishing mortality is unclear. Moreover, most of the bigeye catch is produced by the fishery on floating-objects which targets skipjack tuna (Katsuwonus pelamis). Thus, alternative and adaptive management measures that decrease bigeye catches while minimizing the impact on skipjack catches need to be developed. Toward this end, we modelled the relationship between bigeye catch and environmental characteristics to understand the species spatio-temporal distribution and hotspot dynamics. We used Boosted Regression Trees to describe relationships between the presence of bigeye tuna and a set of abiotic and biotic variables, including conventional environmental information (e.g. SST, CHL), as well as novel parameters, such as Lagrangian coherent structures, sub-surface ocean characteristics and eddy and front indicators. We explored the utility of these habitat models to provide decision-makers and resource-users with near real-time descriptive maps highlighting areas of high probability of bigeye catches. We discuss the application of our approach for forecasting on a seasonal timescale and how our outputs can assist end-users in the development of effective catch-based conservation measures.

Horizontal and vertical movement of greater amberjack around Taiwan

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The greater amberjack (*Seriola dumerili*) is found in warm waters around the world, such as the East China Sea, and is an important species in fisheries and aquaculture. Recently, water temperature in the East China Sea has risen rapidly (1.2°C/decade), which may affect the migration, activities, and spawning area of S. dumerili. In order to predict the impact of global warming on S. dumerili, it is necessary to understand natural habitat and movement of this species. Thus, we aim to determine the ambient temperature, fundamental swimming behavior, and migration of S. dumerili.

We attached two types of data-loggers to 24 individual *S. dumerili* (TDR-Mk9, Wildlife Computers Inc./MiniPAT, Wildlife Computers Inc.) and released them at Chenggong, Taiwan in November 2016 and 2017. We recovered 12 individuals and obtained the ambient temperature and swimming depth from each fish. We calculated ambient temperature with a 95% confidence interval for individuals using a cumulative distribution function.

The 95% confidence interval lower limit value was 17.4–19.2°C and the upper limit value was 22.8–25.0°C. The greater amberjack migrated widely around Taiwan. One individual migrated between 21.58 and 24.87°N, between 118.58 and 123.13°E, based on data recorded over 82.7 days. In the eastern Taiwan, there are mainly three water masses, the Kuroshio surface water, Kuroshio tropical water, and Kuroshio intermediate water, which move up and down in response to bathymetry. We suggest that S. dumerili may select their swimming depth to feed on prey inhabiting a specific water mass.

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Distribution shift of albacore tuna (*Thunnnus alalunga*) associated with environmental changes in the Pacific Ocean

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Albacore tuna *Thunnus alalunga* is one of the most important commercial fish species caught worldwide. Since the catch of albacore tuna has approximately doubled in the past 60 years in the Pacific, clarifying the interannual variability of their distribution is essential for fisheries resource management of highly migratory species. This study aims to elucidate the spatio-temporal variation of albacore distribution, particularly focusing on relationships between albacore distribution and environmental changes by applying empirical orthogonal function (EOF) analysis based on Japanese longline fishery data. According to EOF1, the distribution shifted from east to west of the north Pacific in the 1990s. Time series of the score showed a significant correlation with catch fluctuation of the prey species such as Japanese sardine Sardinops melanostictus and Japanese anchovy Engraulis japonicus. The catch of sardine sharply decreased, and the catch of anchovy began to increase in the north Pacific in the 1990s. This great species alternation is generally termed as the regime shift. Due to the drastic resource decline, the distribution of sardine shrunk from the central and western Pacific to a limited area off Japan. On the other hand, the result of EOF2 showed a relationship between the distribution and El Niño–Southern Oscillation (ENSO) events. The score showed two peaks in 1982–1983 and 1997, which were both consistent with years when a strong El Niño occurred. As shown in a previous study, albacore distribution probably has concentrated in an area where water temperature has increased due to El Niño events.

Is the SST a driving force on the annual variability of Northeastern Atlantic albacore (*Thunnus alalunga*) catches ?

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North Atlantic albacore (*Thunnus alalunga*, Bonn 1788) is a highly migratory species, that performs annually displacement to the feeding Northeastern Atlantic areas on the spring-summer seasons. This trophic migration was the origin of the development of a surface fishery that targets juveniles and adult albacore in the region. Mostly the Spanish troll and baitboat fleets in the offshore Atlantic waters and Bay of Biscay exploit this resource.

Annual trend of nominal catches taken by these fleets were investigated. Spanish volume of catch represents 50 % of total TAC (28.000 t) for North Atlantic albacore stock. Catch from 1990 to 2016 were examined to detect negative or positive anomalies from the average temporal trend. The yearly anomalies were explored based on the ± 1 st.dev. The selected year were study based on a temporal monthly window with inclusion of CPUEs collected by trip from the troll fleet from July to September.

The mean nominal CPUEs and the mean SST values obtained from EU Copernicus website were averaged by 1ºx1º degree square were analysed.

The analytical approach uses the spatial correlation Moran´s I test for the observed CPUEs and SST distribution maps.

The aim of this study is to test the hypothesis of SST distribution effects on the spatial variability of the catch rates observed for the troll fleet. Explores the existence of plausible correlation to explain the variable spatial pattern and variability of catch observed in the anomalous years of 2002, 2005 and 2016 selected for this study.

The environmental niche of the global high seas pelagic longline fleet

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International interest in the sustainable use of high seas biodiversity has grown in recent years. There is an opportunity for new technologies to enable improvements in management of these areas beyond national jurisdiction. Here we explore the spatial ecology and drivers of the global distribution of the high seas longline fishing fleet by using boosted regression trees (BRTs) to create predictive models of the distribution of fishing effort from newly available automatic identification system (AIS) data. Our results show how fishing effort can be predicted using biophysical and physiographic variables, many related to the expected distribution of the species targeted by longliners. We also find that the longline fleet has seasonal environmental preferences (e.g. increased importance of cooler surface waters during boreal summer) and may only be using 38-64% of the available environmentally suitable fishing habitat. Possible explanations include misclassification of fishing effort, incomplete AIS coverage or how potential range contractions of pelagic species may have reduced the abundance of fishing habitats in the open-ocean.

Acoustic characterization of micronekton vertical distribution related to the environment around New Caledonia (south-west Pacific)

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Micronekton is one of the most ecologically important components of mesopelagic ecosystems, mainly as an intermediate trophic link for top predators. However, regional distribution patterns and dynamics of micronekton in the water column need further investigation. Acoustics, specifically echogram analyses, are efficient methods to explore these dynamics. Usual approaches involve averaging echogram values by horizontal layers or calculating metrics and analyzing them temporally. Here we propose an innovative approach where vertical acoustic profiles are treated as the sample unit. We thus address more efficiently vertical distribution variability. Spatial and temporal variability of micronekton vertical distribution is evaluated from EK60 data from six research surveys around New Caledonia (26°S-18°S and 120°W-130°W). This 2011-2017 dataset constitutes a sample of 77,100 vertical profiles across 84 days. Combining various statistical methods, data are sorted into 18 homogeneous vertical profiles groups. These are secondarily linked to environmental variables: physical environment (e.g. distance from coast); satellite-derived surface oceanographic data (e.g. SST); and, vertical oceanographic profiles (e.g. oxygen). Statistical analyses emphasise diel vertical migration is the main factor driving acoustic profile shape variations. The method describes clear patterns and discriminates some spatiotemporal variation. Temperature and oxygen profiles appear to be the most influential structuring variables at night, whereas salinity and light are the most influential during day and transition-time. Acoustic profile groups are linked to water mass, changing with seasons. Winds and 20°C isotherm depth influence vertical distribution in waters close to the coast, whereas SST and bottom depth are most influential far from the coast. Tagging data demonstrates that predators feed in different depth ranges (e.g. seabirds 0-30m and bigeye tuna 0-400m). As our method allows prediction of spatial-temporal vertical profile, it can be integrated with feeding depth of predators to better understand trophic interactions and the role of micronekton.

The effect of environment on the use of animal tagging data

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Large-scale mark-recapture tagging experiments generally assume that tagged individuals provide a representative subset of some underlying population. Via recaptures and returns of this tagged subset, properties of the population can then be inferred, including its size, and rates of mortality, growth, and connectivity. Such analyses may form critical components of stock assessments, and inform management decisions for hard-to-observe oceanic species. However, there are many processes that cause a tagged group of animals to not mix with untagged animals in a region, to the degree that they are no longer representative of that population. These processes include low tag dispersion, emigration of tagged individuals, and tag deployment in high areas of fishing mortality.

Using a recently development individual-based simulation model for ocean animals (Ikamoana), we show how such tagging experiments may be affected by environmentally-driven movement behaviours. By simulating the movement of both fish released from a single tagging location, and the untagged fish from the same cohort across the region, we demonstrate the bias that may occur in rates of recapture. Using Pacific skipjack tuna (*Katsuwonus pelamis*) as an example species, we demonstrate that the spatially non-uniform nature of fishing effort can result in simulated, tagged fish experiencing greater depletion due to fishing than the untagged cohort in the same region. These levels of depletion can be up to 80 times that of untagged fish, under certain tagging and environmental scenarios. Such bias may be minimised by incorporating the current knowledge of environmentally-driven behaviour of both fish and fishers into tagging experiment design.

Our results highlight the importance of examining assumptions when using mark-recapture tagging data. We discuss our simulation methodology in the context of improving tagging and other monitoring programmes, as well as analysis of the data that they provide.

Demographic structure, natal origins and feeding grounds of adult Pacific Bluefin tuna (*Thunnus orientalis*) landing in Taiwan

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Pacific bluefin tuna (*Thunnus orientalis*, PBF) is a long-live fish and the population is heavily exploited at different life stage. Biological and fishery data as a foundation for fishery management of the PBF have been collected and analyzed in order to restore the population. Annual tuna age compositions were estimated by applying year-specific age-length key to the length frequencies of the catch in the northwestern Pacific spawning grounds in 2015-2016. Ages of the spawners showed a bimodal distribution progressing each year to larger age with younger (6-13 years) and older fish (15-28 years) consisted of >70% and <30% of the catches, respectively. The ratios of otolith δ18O and muscle δ15N were analyzed to infer the natal original and feeding grounds of the PBF, respectively. Most individuals landed in Taiwan were hatched in the northwest Pacific Ocean (> 80%) with fewer individuals hatched in the Sea of Japan (<20%), suggesting greater contribution of Pacific spawning to the population. Most PBF analyzed (> 90%) had δ15N values < 15.2‰, indicating their feeding grounds in the western Pacific Ocean while few fish had δ15N values > 15.2‰, suggesting a recent migration from eastern Pacific Ocean to the spawning grounds. These results indicated that the demographic structure of the PBF spawning in the subtropical to tropical Pacific Ocean have stronger link to the population feeding in the western Pacific Ocean. We expect that higher abundance of young adult PBF will recruit to the spawning grounds in the northwestern Pacific Ocean in 5-6 years if the current fishery management to largely reduce the fishing mortality of PBF < 30 kg is carried out.

Bottom-up drivers of sand lance distribution on Stellwagen Bank and the northeast US shelf.

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Sand lance are an important forage fish throughout the sub-polar regions of the Atlantic and Pacific Oceans. On the northeast US shelf, northern sand lance (Ammodytes dubius) are critical prey for numerous top predators, including humpback whales, bluefin tuna, and numerous sea bird species. However, the distribution, abundance, and feeding of northern sand lance has been understudied owing to a lack of a directed fishery for the species. This work aims to understand what drives the extreme spatio-temporal variability in the distribution of adult sand lance and their quality as a prey source through habitat modeling, stomach content analysis, and lipid content analysis. Presence/absence generalized additive models using in situ CTD casts coupled with adult sand lance collections on Stellwagen Bank indicate that sand lance are most often caught in shallow depths (<40 m), moderate bottom temperatures (6-12^(o)C), and moderate salinities (32-32.5). Stomach content analysis suggests that sand lance feed from February through September, after which they appear to cease feeding prior to spawning in November. Diet varies seasonally, with Calanus finmarchicus present during the spring. Total lipid content (whole fish) exhibits significant intra-annual variability, peaking in May—likely a result of spring consumption of Calanus finmarchicus. Total lipid content subsequently decreases in late summer through early winter during the spawning period. Decreased likelihood of sand lance presence at warm temperatures is consistent with the suggested thermal limits of this species and may affect their distribution in the rapidly warming northeast US shelf ecosystem. Sand lance exhibit intra-bank habitat preferences and temporal variability in lipid content, which may in turn affect the patchiness of predators observed on the banks of the northeast US shelf. Further analyses of sand lance distribution throughout the region will determine if these patterns are consistent on broader spatial scales and over several decades.

Comparison and integration of different ecosystem models for appropriate use of model characteristics

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A number of ecosystem modelling frameworks have been used in recent years. These ecosystem models have been developed against background of specific objectives (e.g. planning fishery management strategy or understanding food-web interaction) and different focus on ecosystem dynamics (e.g. effects of climate change and fishing). Therefore, each model has specific characteristics and particular limitations in modelling. In any given objective, it is important to select appropriate model frameworks with considering model limitation, modelling costs and obtainable outputs based on available data. In the present study, we have developed three different ecosystem models, Atlantis, Gadget and Ecopath with Ecosim (EwE) for a same ecosystem. Characteristics and limitations of each model were evaluated in the modelling steps including data requirement before model-run, during running, usefulness of model outputs and validity of model outputs. Among the three models, Atlantis required many kinds of data before model-run and took longer running time than the other two models, while EwE required less data than the other two models. Gadget must have some observational data before run in order to fit the model to the data, but this statistical optimization procedure for estimating unknown parameters was most useful characteristics of Gadget. The results suggested an alternative approach that incorporates three models and their functions, which also improves the validity of the models. Guidelines for appropriate model selection and use for ecosystem based fisherie management under specific objective and available input data will be introduced in our talk.

Potential impacts of climate variability on the *Eleutheronema rhadinum* habitat in the coastal waters of Taiwan

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Fourfinger threadfin is one of the important commercial species in the coastal fisheries of Taiwan. This aims to understand for fishing activity of sampling gillnet fishery and community structure of fishery resources in coastal waters off Taiwan. In this study, we collected logbook of sampling gillnet vessel, environmental data (i.e. Sea Surface Temperature, chlorophyll-a concentration, bathymetry and current velocity). We also investigated spatial distribution of hot spot for species that regularly released in recent years, and analyzed annual variation on community structure of fishery resources for species. Through ArcMap software, spatial distribution of fourfinger threadfin showed widespread in the coastal waters of western Taiwan in each season. Both climate change and human factors cause decreases in marine resources, thus affecting the livelihoods of stakeholders (Teng et al., 2016). The most optimal habitat (HSI >0.6) was found in areas with satellite-derived temperatures within the range of 19.6–25.8°C, current velocity of 0.2-0.42 m s-1, bathymetry of 36-43 m, and 0.812-3.216 of Chl-a concentrations. Therefore, it is necessary and urgent to explore and identify the fourfinger threadfin potential habitat hotspots in the coastal waters of Taiwan. Through the habitat model, we provide the scientific assessment to set the effective management strategy and may provide the references for the further study on fingerling released for our government or fishery management organization.

How do ectothermic fishes use different temperature conditions?

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Body temperature is very influential drivers of physiology and activity of animals, however, the body temperature in ectothermic fishes has been explained only by ambient water temperature, because their body temperature was assumed to be equivalent to water temperature. The ocean has a large temperature variation in a vertical direction, and fishes can experience different temperatures by their vertical movement ranging several hundred meters. In fact, previous studies have reported that some ectothermic fishes use vertical temperature gradient for thermoregulation by vertical excursions. It is important to know how body temperature of fish is affected by the different temperature condition. Thus, we focused on the change of body temperature during vertical movements. In order to observe the response of body temperature during vertical movements, we recorded body temperature, ambient water temperature and swimming depth of sailfish (Istiophorus platypterus) and amberjack (*Seriola dumerili*) under natural conditions. We attached data-loggers into a total of 28 fish (3 sailfish and 25 amberjack) and released them off the southeastern coast of Taiwan. The temperature data of each species was fitted by heat-budget models to estimate heat-transfer coefficients. We used the estimated heat-transfer coefficients and swimming behavior to determine how fish utilize ambient water temperature. As a result, the tagged fishes showed a species-specific mode of vertical excursions. Sailfish mostly stayed beneath the sea surface, whereas, amberjack stayed under thermocline and sometimes entered into thermocline. Amberjack swam wider and cooler water temperature range than sailfish. When 2 species were exposed to cooler water in depth, their body temperature decreased, but the speed of temperature change was different between species. Body temperature of sailfish dropped faster than that of similar sized amberjack. Our result suggests that knowing the thermal constraints of ectothermic fishes is important to consider the selection of vertical distributions.

Application of time series analysis to detect the effect of multi-scale climate indices on global yellowfin tuna population

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The biophysical effects of large-scale environment and climatic indices play a critical role in controlling tuna distribution and abundance. In this study, we collected Taiwanese longline fishery data to investigate the yellowfin tuna distributions and fluctuation of catch rate based on global scales the period of 1980-2010 by using advanced time series analysis, including the state-space approach to remove seasonality, wavelet analysis to investigate transient relationship and multiple regression to revealed significant climate indices from each area. Cross-wavelet coherence of the standardized CPUE in western and eastern Pacific Ocean were found to have a periodicity of 2~3 year and 2~6 year with Atlantic Ocean and Indian Ocean, repectively. Results of multiple regression revealed the Atlantic Multi-decadal Oscillation(AMO), Pacific Decadal Oscillation(PDO) and the North Pacific Gyre Oscillation(NPGO) were significantly influenced the standardized CPUE and gravity of fishing grounds of global yellowfin tuna. In additional, longitudinal gravity of fishing grounds revealed significantly correlated with the Dipole Mode Index (DMI) and Ocean Nino Index (ONI) in Indian Ocean and Pacific Ocean. The results suggested the long-term decadal climate indices such as AMO, PDO and NPGO will affect the population abundances, however, interrannual variability (e.g., DMI and ONI) only lead to the spatial variations of fishing grounds.

Changes in demersal marine ecosystem structure off northeastern Japan before and after the Great East Japan Earthquake revealed by Ecopath modeling

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Japan experienced the most disastrous earthquake and tsunami in northeastern Japan in March 2011. This disaster led to the accident of the Fukushima Dai-ichi Nuclear Power Plant made the situation more serious and caused a great calamity for the people and industries on the Pacific coast of the Tohoku region of Japan. As a result, the fisheries in the Tohoku region were forced to shut down due to reasons such as the loss of commercial vessels, the destruction of processing plants of fish products, the deterioration of fishing grounds, and the diffusion of radioactive substances. The Tohoku region is one of the most productive fishing grounds in the world, therefore the changes and recovery of the marine ecosystems in this region is a great concern for a lot of people. It was reported on the basis of the bottom fish biomass surveys in this region conducted by FRA that there were increasing (eg., Pacific cod, lanternfishes) or decreasing (eg., demersal sharks) demersal fish stocks compared to the condition before the disaster. It is expected that the structure of the ecosystem in this region also changed through the shifts of habitats and species interaction. In this study, we constructed two Ecopath models for the demersal marine ecosystem before and after the disaster in the southern district of Tohoku region based on fisheries resources survey data and commercial fisheries catch statistics. We compared the food web structure and function of the two Ecopath models using outputs of the network analysis tools and examined the changes in the impacts of commercial fisheries on the ecosystems. These results help not only to understand the changes in the structure of the ecosystem caused by the disaster, but also to detect the potential impacts of the bottom fisheries on the damaged ecosystem.

A rapid ontogenetic shift in the diet of juvenile yellowfin tuna from southwestern waters off Taiwan

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Yellowfin tuna *Thunnus albacares* is one of the major fish species caught around subsurface fish aggregation devices (FADs) in the waters southwest of Taiwan. However, how it interacts with other organisms around FADs is poorly known. In this study, the foraging behavior of juvenile yellowfin tuna, 1,477 specimens (28–108.0 cm FL), collected from nearshore FADs around Taiwan was studied using stable isotope and stomach contents analyses. The analysis of stomach contents indicated that juvenile Yellowfin Tuna with FL < 50 cm mainly feed on larval purpleback flying squid Sthenoteuthis oualaniensis, larval shrimps, and zooplanktonic organisms such as amphipods. Yellowfin Tuna with FL of ~ 50 cm switch their diet to teleost fishes such as Japanese Barracudina Lestrolepis japonica, Skinnycheek Lanternfish Benthosema pterotum, and fishes in the families Exocoetidae and Scombridae. Stable isotope analysis indicated that the δ15N values ranged between 6.2% and 12.6%, and the estimated trophic position varied from 3.18 ± 0.24 for tuna with FL < 30 cm, while it reached 4.59 ± 0.50 for those with FL > 50 cm and 4.75 ± 0.06 for those with FL > 90 cm. Based on the distinct diet shift of the juvenile Yellowfin Tuna, demonstrated by both stomach contents and stable isotope analyses, this study concluded that the tuna shift their diet at approximately 50 cm FL.

Comparative study of skipjack tuna (*Katsuwonus pelamis*) fishery stocks from South Atlantic and Western Indian Oceans

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The skipjack tuna, *Katsuwonus pelamis*, inhabits tropical and subtropical oceans the world over, and contributes substantially to total tuna catches. Both fishing pressure and anthropic influences affect skipjack populations, impacting on economic returns and investment. The present study compares spatial time-series of catch and catch-per-unit effort (CPUE) of pole-and-line fishing of skipjack tuna from Brazil, South Africa and the Maldives. Both regional and comparative (inter-regional) analysis were conducted for the period 1970-2014 through CPUE standardization, spatial mapping and correlation tests. CPUEs from Brazil and Maldives' skipjack fisheries showed a significant positive correlation between the period 1982-1993. Interestingly, from 2004 to 2011, South African skipjack catches correlated positively with Brazilian's, and negatively, with Maldivian's. Mostly South African fishery displayed seasonal variations attributed to ENSO events. This study reflects an effort to articulate an inter-regional appraisal of skipjack pole-and-line fisheries, focusing on globally strategic developing and emerging economies. Evidence of common patterns influencing these fisheries should encourage international South-South cooperative management of the resource.

Spatial variability in responses to environmental conditions in long-finned pilot whales

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Investigating past responses to variations in the marine environment can provide insights into how future changes may affect species. Using long-finned pilot whales (Globicephala melas) stranded in New Zealand and Tasmania, Australia as a case study, we investigated relationships between tooth growth chronologies (as a proxy for annual energy budgets) and inter-annual variations in broad-scale climate indices (Southern Oscillation Index: SOI, Indian Ocean Dipole: IOD, and the Southern Annular Mode: SAM) and spatially explicit, seasonally averaged environmental variables (sea surface temperature: SST, and zonal wind speed). Tooth chronologies from pilot whales that stranded in Australia had a positive relationship with the SOI (greater tooth growth associated with higher SOI values) and a negative relationship with the IOD (greater tooth growth associated with negative IOD values). Those from New Zealand also had a positive relationship with the SOI, but with a one year lag. Positive SOI and negative IOD conditions are associated with increased storm activity across the southern Australian/New Zealand region. The resulting changes in regional SST, currents and frontal activity will influence the distribution of prey resources. Spatial correlations between the Australian chronology and SST revealed spatial consistencies in areas of higher tooth growth across seasons. In contrast, pilot whales utilising New Zealand waters demonstrated greater spatial variability in relationships. These results suggest differences in movement patterns between the two regional groups, with those pilot whales from Australia using regions with reliable prey resources in the subtropical and subantarctic fronts south of Tasmania. Those from waters around New Zealand may move more dynamically between regions of seasonally enhanced productivity and high prey biomass across more eastern waters in the New Zealand region.

Temperature-dependent vertical distribution of larval Pacific bluefin tuna, *Thunnus orientalis*, in the spawn fields

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The Japan Sea and the waters around the Nansei area (northwestern Philippine Sea) are the nursery grounds of larval Pacific Bluefin tuna (PBT), *Thunnus orientalis*. The Japan Sea is cooler, more productive and heterogeneous than the Nansei area, and thus comparison studies on the larval vertical distributions between these two areas present an opportunity to gain an in-depth understanding of the controlling factor of habitats of PBT larvae. Though the vertical habitat of PBT larvae in the Nansei area was reported, have not been known in the Japan Sea. Thus, to compare the vertical distributions of larval PBT between two areas, observations were conducted using a 1-m2 Tucker trawl and a 3.14-m2 ring net between 0 and 30 m depth during the spawning seasons of 2016 and 2017. Most of the larvae in the Japan Sea (756 of 938 individuals) were collected at the surface using the ring net, while the number collected at the surface in the Nansei area (152 of 420 individuals) was the same as that collected at 10 and 20 m depths (109 and 96 individuals, respectively) using the Tucker trawl. The presence probability of larval PBT showed the same trend as the numbers of larvae, and it was best explained by only temperature based on a general additive model: probability was low in cooler water irrespective of the areas, and salinity, chlorophyll a concentration, mixed layer depth and diel rhythm were not selected as the explanatory variables. These results suggested that larval PBT prefers the warm-water condition, and the suitable vertical habitat in the Japan Sea is shallower and narrower than the Nansei area. Thus, the global warming helps larval PBT increasing their habitat not only horizontally but also vertically in the Japan Sea.

Interannual-decadal variability in the abundance of large predatory fish in the Japan Sea during 1964-2010 in relation to climate regime shifts

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Long-term variabilities in the catches of large predatory fish (including 18 pelagic and demersal taxa) in the Tsushima Warm Current (TWC) region of the Japan Sea were examined to identify the responses of these taxa to climate regime shifts. Total catch of these large predatory fish decreased during the 1970s and 1980s but has increased since the 1990s with large differential variability in individual species. Pelagic fish such as yellowtail and tunas decreased during the 1980s but increased during the 1990s, while demersal species such as Pacific cod showed opposite variation pattern. A principal component analysis (PCA) for these 18 taxa suggested decadal variation patterns with step changes occurring around the mid-1970s, the late-1980s and the early 1990s in the first two principal components (PC1 and PC2). The PC1, accounting for 51% of the total variance, corresponded well with the winter water temperature in the Japan Sea. The PC2, which accounted for 16% of the total variance, showed a correspondence with both the summer water temperature and total catch of zooplanktivores. Spatialized trawl and set-net fisheries data indicated that distributions also changed with climate regime shifts: yellowtail increased in the northern region, while cod and sharks decreased in the southern region during the warm regime, and vice versa. We discussed the reasons for different responses of these predatory taxa to climate regime shifts both in terms of their abundance and their spatial distribution. In addition, we provided advice for fisheries management of large predatory fish in the Japan Sea in the context of climate change. These results revealed that the variabilities in the large predatory taxa were mainly associated with the climate regime shift in the late 1980s as indicated in the winter temperature with less prominent impacts from the summer water temperature and prey conditions.

Age estimates for fourfinger threadfin in coastal waters off western Taiwan based on length frequency analysis

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Fourfinger threadfin (*Eleutheronema rhadinum*) is an economically important species in coastal waters off western Taiwan, as shown in the catch of fourfinger threadfin with an increasing trend since 2012. However, research and literature related to life history and biological parameters for fourfinger threadfin is limited, except for fishery biology studies, external morphological analysis and geographic distributions. Port sampling for fourfinger threadfin length data was conducted by month during 2016 and 2017, where 12,673 individuals were measured in total. Results show that the major fishing season for fourfinger threadfin starts from the late October until December or next January. The largest fish of 98 cm fork length was sampled in the southwestern waters off Taiwan, followed by 85 and 81 cm fish in length in the northwestern and northern waters. The largest size available from waters off central Taiwan was only for 61 cm fork length, while the smallest size of 8 cm was sampled in same area. Results from preliminary length frequency analysis show that fourfinger threadfin can grow to more than 30 cm FL in one year, as investigated by the spatial and temporal patterns and the shifts in length composition by months. This study provides estimates of life history parameters such as growth and mortality, which are basic scientific data for future stock assessments.

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