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Theme session Report

Future of fisheries-independent surveys - progress in design, technology, estimation, and management

Conveners: Stan Kotwicki (USA), Ingeborg de Boois (Netherlands), Richard O'Driscoll (New Zealand)

Overview

Fisheries-independent surveys (hereafter surveys) are foundational to modern fisheries management, and fisheries and ecosystem research. They are conducted worldwide to study the status of marine populations and ecosystems. The primary role of surveys is to provide consistent time series data for use in stock and ecosystem assessments. However, the consistency of survey time series may be impacted by, for example the: use of new survey technologies; addition of closed areas for conservation (e.g., marine protected areas) or renewable energy production (e.g., wind farms); expansion of stocks into new areas (e.g., changing biogeographic distribution); and addition or removal of survey objectives due to assessment requirements, funding variability, vessel availability, or meteorological conditions. These issues are increasingly common due to rapid changes in marine ecosystems and human activities in and around survey areas.

The contributions to the session more than met expectations. There were 22 oral presentations and 19 poster presentations, covering a wide range of topics: sharing experiences on successful and unsuccessful developments in surveys; use of new techniques and technology; improvements in design that allow for flexibility in effort allocation; evaluation of new survey designs; and efficient survey calibration methods. The quality of the presentations was reflected in the questions afterwards: a wide range of people in the audience (from early career to senior scientists) asked questions. Mostly, the questions were 'beyond' the presentation, so not asking for clarification, but more about consequences, what we can learn from the shared experience, etc.

More than half of the contributions (23) were from the USA. Contributions were also received from 9 other countries, with multiple contributions from the Netherlands (5), Spain (3), Norway (3), and New Zealand (2), as well as single contributions from Canada, Germany, United Kingdom, Chile, and Australia. Half of the session contributions were by women and 40% were by early career researchers. Participation in the session was excellent with over 100 in-person delegates present on both days.

Key Themes

Major survey programs for years concentrated on assuring consistency by enhancing standardization (doing the same thing over and over). However, standardization although still very important, may not always be possible. Changes in ecosystems and in technology are generating a need for survey programs to adapt to the present world through progress in design, estimation, technology, and changes to management approaches. To ensure the value of the time series in the future, surveys may have to change. But this unavoidable change needs to managed to minimize consequences and maximize benefits.

One of the key challenges identified during the session was the growing prevalence of areas closed to traditional survey methods such as trawling due to establishment of marine protected areas (MPAs) and wind farms. An online poll of session participants asked, "Are any of your surveys affected by wind farms and or MPAs?". Twenty-nine of the 42 respondents answered that their surveys were currently impacted by either wind farms or MPAs with 15 impacted by both. This is a current and pressing issue. Lipsky et al. identified four impacts to NOAA (USA) fisheries surveys due to wind development: 1)

Preclusion of sampling platforms from the wind development area due to operational and safety limitations; 2) impacts on statistical designs; 3) alteration of benthic and pelagic habitats, requiring new designs and methods to sample new habitats; and 4) reduced sampling productivity through navigation impacts of wind energy infrastructure on aerial and vessel surveys.

In discussion it was noted that survey designs already exist to cope with excluded areas (e.g., untrawlable ground), but that it is important to continue to monitor such areas. Where trawling and other more traditional surveys methods are excluded, it may be necessary to turn to less preferred (and often less precise) methods of monitoring abundance. It was also noted that in the future it will be important to combine two or more monitoring methods to assess stocks over entire extend of their spatial distribution.

Collaboration with the industry (four presentations from three European countries and example from New Zealand) seems to be a route to extend data collection, and in the same time increase the credibility of the data series amongst fishers. Although fishery-independent surveys can never be fully replaced by industry surveys, for some species close collaboration with the industry in the form of industry surveys, or additional data collection, may lead to increased quality of the stock assessments.

A number of contributions considered the use of alternative, non-destructive survey methods, with a particular focus on optical (camera) surveys. There were examples from the UK, USA, Norway, and New Zealand of successful optical survey methods, including the use of fixed, towed, and in-trawl cameras. A wide range of other technological solutions were also presented including acoustics, longlines, traps, and genetic methods. Using multiple survey methods or technologies together can create synergies, increase the number of species monitored, and reduce estimation uncertainty.

Recommendations

Key attributes to enable ongoing success and relevance of fisheries independent surveys highlighted by this session include:

- Emphasizing value of surveys & time-series data
- Showing that surveys are influential for management
- Obtaining more information from surveys by using multiple platforms and methods
- Improving efficiency of sampling and collecting more data
- Improving survey design and estimation methods to reduce uncertainty in survey data products
- Making results more accessible
- Being opportunistic & adaptable
- Engaging with fishing industry
- Develop methods for use of new technologies to conduct new surveys or to improve existing surveys

Conclusions

In summary, the session presentations and discussions indicated that there is a need for ongoing focus on the future of fishery-independent surveys, in order to ensure that the effect on time series due to necessary changes to surveys is minimized. It is critical that changes to long standing surveys are well thought over and incremental. Changes should focus on optimizing the data collection for integrated ecosystem and stock assessments. The topic of modernizing surveys and adapting surveys to new

conditions is very broad and requires more initiatives on the national and international level. Challenges are common across ICES nations and more work is necessary on the topic of “Future of surveys” in ICES community. Currently more work is planned on this topic during 3rd meeting of the Workshop on Unavoidable Survey Effort Reduction (WKUSER3) in 2025.

Contents

CM 24: The future of establishing groundfish density estimates in untrawlable habitat: paired lowered stereo-camera system and bottom trawl data

Cecilia A. O'Leary[1], Kresimir Williams, Ned Laman, Meaghan Bryan, Ben Williams, Rick Towler

This project works to establish methods for future combined bottom trawl - stereo-camera system survey. Fisheries-independent bottom trawl surveys are a standard practice to sample groundfish and provide abundance data and population information for stock assessment and fisheries management. However, there are often areas in groundfish habitat that cannot be sampled by standard survey bottom trawls because they are comprised of high relief, rocky bottom, and steep terrain. In the Gulf of Alaska survey, which provide data to management and inform quotas for a $2.1 billion value fishery in 2020, these areas of 'untrawlable' habitat constitute up to 18% of the total survey area. Design- and modelbased estimates of abundance from the bottom trawl surveys in these regions are often made without any data from these areas, instead assuming that the density of fish in untrawlable (UT) habitat is the same as in the trawlable (T) habitat. Evidence suggests that abundance and fish species composition in T and UT habitat are different. This difference can cause bottom trawl survey abundance estimates to be biased when trawl catch-derived data is applied to the entire survey area, including UT habitats. In this study, we explore the potential for collecting data from UT habitats using a lowered stereo-camera system (LSC) collected during existing bottom trawl surveys as a method for estimating abundance over UT habitat that can be combined with the T habitat estimates in the future fisheries-independent surveys. This paired drop-camera and bottom trawl data are used to develop a model-based index of abundance for groundfish that combines T and UT habitat-specific information. This work on developing simultaneous collection of two data types on an existing survey will help to provide more accurate and precise indices to GOA stock assessments in the future and improve abundance estimates across T/UT areas, particularly for those species that rely on rocky habitat, tend to be longer-lived with low fecundity, and thus are particularly vulnerable to overfishing and unfavourable environmental conditions

Keywords: Groundfish density, untrawlable habitat, bottom trawl data.

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CM 26: Fishery-independent surveys can benefit from a paired gear approach: a case study from the Southeast Reef Fish Survey

Nathan M. Bacheler, Kyle W. Shertzer, Walter J. Bubley

Fishery-independent survey programs often use sampling gears like trawls, longlines, traps, divers, or underwater video to provide time series data for use in stock and ecosystem assessments. A drawback of using single gears to survey fish populations is that no sampling gear is able to perfectly sample fish communities due to imperfect catchability and gear selectivity, which becomes especially problematic if catchability or selectivity varies over space or time for any reason. Here we describe the pairing of gears in the Southeast Reef Fish Survey (SERFS) to more effectively sample reef fishes along the southeast United States Atlantic coast. Chevron traps have been used by SERFS to survey reef fishes in the region since 1990, but video cameras were added to all traps in 2011 to provide additional data for species not sampled well by traps. As expected, videos provided valuable relative abundance data for a number of important species not surveyed well by traps (e.g., greater amberjack Seriola dumerili, gag Mycteroperca microlepis), but there have been other unexpected benefits of pairing gears. First, detectability and catchability could be estimated for species directly in one gear when captured or observed in the other gear. This information can inform, for example, species distribution models that are used to predict range shifts. Second, it is possible to use repeated site visits of a single gear within a sampling season to estimate presence-absence using occupancy models or abundance using N-mixture models, but these models require the strong assumption of temporal closure between repeated visits. Using paired gears sampling at the same place at the same time eliminates the temporal closure assumption, making it theoretically possible to estimate detection and abundance for fish species directly. We describe various efforts to estimate detection and catchability of trap and video gears and site abundance of reef fish species in the region. The most obvious choice in pairing sampling gears is adding non-extractive sampling gears such as video or environmental DNA to traditional extractive sampling gears, and the benefits of the additional gear can far outweigh the cost.

Keywords: survey, cameras, detection, catchability, sightability

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CM 27: Weakly-supervised classification of acoustic echotraces in a multispecific pelagic environment

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Automatic echo-trace classification models may contribute to increasing the vertical resolution of species allocation and providing complementary information on specific structural and aggregation patterns. Here, we applied a weakly supervised model to deal with habitual multispecific trawl catch information in diverse pelagic ecosystems. Trawl catch proportions were interpreted as the probability of each school to belong to a species and they were used to develop a multiple-output model. Our results indicate that at school-level we can expect an accuracy of 76 % out-of-sample at labeled data. When considering both labeled and unlabeled data the model performance could not be established at the school level but at the haul level by comparing species proportions. Then, the out-of-sample accuracy increased to 80%. Based on the probabilistic output of the model, we developed a metric to measure the confidence of the model for each school assignation. Higher confidence provided higher accuracy, hence showing the validity of the metric. The automatic classification tool developed in this study, are meant to be applied extensively to trawl-acoustic surveys to gain information about the structure and behavior of such aggregations to study temporal shifts in a large 3-D scenario.

Keywords: Machine learning, weak-supervision, poor-labelling, school processing, fisheries acoustics, gradient boosting machine

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CM 44: Developing best practices in advancing new survey technology: lessons from a changing survey landscape in The Netherlands

Steins, N.A.[1], Batsleer, J., De Boois, I.

Fisheries-independent surveys are an important data source for stock and ecosystem assessments. These surveys are often criticized by the fishing industry, whose fishing opportunities are directly linked to such assessments. Such criticism often focuses on the reliability of the surveys and is closely linked to the different ways scientists and fishers know and observe the world. Establishing trust in survey methodology is important in relation to the credibility, support and legitimacy of the science and the management based on it. First, when fishers don't trust the survey, and hence it resulting data, it impacts their trust in the assessments that use survey data. Once the subsequent fisheries advice enters the political arena, questions on the credibility of the advice by stakeholder groups can impact the extent to which scientific advice is taken up by managers. Second, when fishers perceive the survey methodology and its data to be credible, this is likely to lead to increased trust in assessments and advice. Furthermore, trust in methodology and outcomes can become a strong foundation for science-industry collaborations aimed at filling data gaps or addressing scientific capacity issues. With the need for fisheries-independent surveys to adapt to changing ecological, spatial, technological, and budgetary realities, it is important that new survey design and technology also has support from key stakeholders. In The Netherlands, demersal surveys were long regarded with mistrust. We will show how mistrust in fisheries-dependent surveys was actively transitioned towards trust by opening up to criticism. In turn, how this increased industry's perceptions on the credibility of surveys, and subsequently led to novel ways of collaborating in setting up and carrying out fisheries-independent data collection through industry surveys and active industry participation in close kin mark recapture projects. Lessons learnt from the changing survey landscape in The Netherlands are relevant for the development of best practices in advancing new survey techniques that are perceived as credible by stakeholders.

Keywords: Fisheries dependent surveys, credibility, stakeholder engagement, collaborative research, fisher knowledge research

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CM 54: Routine data practices have unintended consequences for mesopelagic fisheries science

Amanda Schadeberg[1], Marloes Kraan, Rolf Groeneveld, Simon Bush

Fisheries scientists are exploring the mesopelagic zone to understand its role in marine ecosystems and as a potential resource. While technology and design affect data quality, we argue that daily social practices of scientists onboard research vessels also shape how the ocean is known and managed. Despite pre-determined plans and protocols for data collection, social observations reveal that values and ambitions for ocean management are also embedded in the practice of data production. While the mesopelagic zone may be a “new frontier”, the routinization of past field campaign practices can inadvertently reproduce single-species management. We show that these scientific practices make the deep ocean into a legible epistemic object and argue that the decisions made during data collection have consequences for the future management of the deep ocean. Efforts to improve fisheries-independent surveys therefore require recognition of social dimensions of at-sea science and re-routinization toward an ecosystem-based approach to marine resource management.

Keywords: data quality, social practices, epistemic object, ecosystem-based fisheries management

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CM 76: Technological advancements in the School for Marine Science and Technology (SMAST) video trawl survey

Nicholas M. Calabrese[1], Kevin D.E. Stokesbury

The SMAST video trawl is a fisheries independent survey that uses cameras in the codend of the net to identify and enumerate groundfish, allowing for tows to be made with the codend open (Stokesbury et al. 2018). Currently lengths and weight from open codend tows are estimated based on length frequencies and length weight relationships from closed codend tows done periodically. Area-swept estimates of biomass are made from these weights assuming 100% efficiency and catchability. The goal of this project is to overcome these obstacles and make the data from this survey more informative to fisheries managers. First, we investigated the accuracy of measurements made from an "off-the-shelf" stereoscopic camera placed in the codend. Preliminary results would indicate these types of cameras are not suitable for measuring moving objects due to their rolling shutter feature. We then designed a passive integrated transponder (PIT) tag detection system that can also be placed in the codend to detect PIT tagged fish. We conducted a mark-recapture experiment on Atlantic cod (*Gadus morhua*) in the Winter of 2022. The population estimate from the experiment was used in conjunction with the catch per unit effort to calculate the catchability and efficiency of the SMAST video trawl survey for cod. The PIT tag detection system proved to be effective in the field, and preliminary analysis on the mark-recapture data has resulted in low (<20%) estimates of efficiency and catchability.

Keywords: Trawl survey, optical survey, stereoscopic cameras, PIT tags, mark recapture, Atlantic cod

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CM 89: FishGlob – towards a collaborative platform integrating scientific bottom-trawl survey data to study and manage species under global change

Aurore Maureaud[1], Juliano Palacios-Abrantes, Zoë Kitchel, Laura Mannocci, Malin L. Pinsky, Alexa Fredston, Esther Beukhof, Daniel L. Forrest, Romain Frelat, Maria L.D. Palomares, Laurene Pecuchet, James T. Thorson, P. Daniël van Denderen, Nancy Shackell, William W.L. Cheung, Bastien Mérigot

Scientific bottom-trawl surveys are ecological observation programs that are conducted along continental shelves and slopes, sampling marine communities associated with the seafloor. These surveys report taxa occurrence, abundance and/or weight in space and time, and greatly contribute to study responses of species and communities to global change. However, combining these data together remains challenging. Within the FishGlob consortium, we enhance the accessibility and visibility of scientific bottom-trawl surveys around the world, and we integrate these data across regions through an international network of experts. We conducted an inventory of survey metadata by looking into publications, existing databases, known contacts, and targeting fishery institutes. We collected metadata for 95 surveys sampling marine fish in each continent and gathering >280,000 samples from the last two decades. We then collected public and private data for 65 surveys to establish an integrated database of fish biodiversity of more than 3,000 fish taxa sampled since 1963. We developed methods for working with these data to conduct cross-system comparisons and overcome disparate survey design and sampling inconsistencies across regions by focusing on two themes: (i) taxonomic integration and homogenization (ii) stability in spatio-temporal survey footprints. More efforts towards combining regional survey data sources and developing common survey designs between regions are critical, as marine populations and species are shifting their spatial range, sometimes across political boundaries. Specifically, efforts in considering neighboring regions into survey design in the future can facilitate survey integration. Open and cooperative data science enabling a common scientific assessment is an important step to enhance the use of big data for research and conservation of species under global change. FishGlob sets the stage for a long-term international collaborative platform bringing together marine data and experts from data science, ecological research, government agencies, and management.

Keywords: bottom-trawl survey, spatio-temporal monitoring, open science, collaboration, data integration, demersal biodiversity

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CM 142: Challenges and solutions for fisheries independent surveys: a New Zealand perspective

Richard L. O'Driscoll[1], Jennifer A. Devine, Emma Jones

Time-series of fisheries independent surveys are used in New Zealand to monitor abundance of commercially important and associated species and to support the quota management system. Some (typically 50–100%) of the cost of surveys is recovered from the fishing industry and there is an ongoing need to justify the value of research. Survey frequency of some key surveys has been reduced from annual to biennial, and other surveys have large gaps in the time-series. This has led to lower precision on abundance estimates, reduced weighting in stock assessment, and decreased ability to estimate annual processes such as recruitment. At the same time, regulatory restrictions such as the introduction of benthic protected areas and trawl exclusion zones, and a desire to move towards less invasive sampling methods, have led to changes in survey area and design and development of alternate survey technologies.

We suggest that to successfully continue time-series of surveys we must: emphasize value of time-series data; show that surveys are influential for management; add value to surveys; derive maximum information; and make results accessible. We provide examples from New Zealand to show how this might be achieved.

Keywords: trawl surveys, fisheries management, quota management system, cost recovery

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CM 143: We're getting a new boat: design of trawl inter-calibration trials

Richard L. O'Driscoll[1], Jennifer A. Devine

New Zealand's inshore fisheries research vessel, the 28-m *Kaharoa*, will be replaced after more than 40 years of service in 2024. A replacement 36-m research vessel is currently being constructed at the Armon shipyard in Vigo, Spain. Simulations were carried out to determine design for trawl inter-calibration experiments, involving paired tows with *Kaharoa* and the replacement vessel. These experiments are scheduled to be carried out in 2024–25. The final experimental design will be influenced by cost and logistical constraints, as well as the desire for statistical rigour.

Keywords: trawl surveys, research vessel, inter-calibration, survey design

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CM 160: Survey time series integration: comparing video observations of snow crab (*Chionoecetes opilio*) in the Barents Sea with demersal trawl and pot data

Georgina Vickery[1], Ann Merete Hjelset, Mikko Heino, Johanna Marcussen, Fabian Zimmermann

Fisheries advice is only as good as the data it is based on. One of the most informative ways of maximising the reliability of stock assessments is increasing consistency and length of the time series data used, as well as ensuring complete spatial coverage of a stock. If data is available, the ability to reliably combine data from surveys using differing gear types reduces the need for specialised surveys for target species. The necessity of a method allowing for reliable comparisons between gears has only heightened with the increasing use of novel surveillance techniques such as video. The use of alternative gear types is of particular relevance for shellfish species such as snow crab, (Chionoecetes opilio) which has poor catchability in standard bottom trawls.

However, despite best efforts to standardise surveys, considerable differences remain in methodologies and hence the interoperability of the collected data. In many areas, including the Barents Sea, this comparability issue is further compounded by adverse weather and changing ice extents, meaning the spatial distribution of survey effort often varies heavily between years.

This paper assesses snow crab abundance and stock composition in the Barents Sea through combining and comparing data from different trawl gear, pot stations and video transects. These data were taken from three survey time series, with differing spatiotemporal extents. Specifically, the Norwegian annual snow crab survey, the Barents Sea ecosystem survey, and the winter demersal fish survey. All data were evaluated and implemented in geostatistical models to estimate gear conversion factors and produce abundance indices integrating multiple gear types and survey time series. To improve the predictive capacity of the modelled distributions, potential relationships between crab occurrence and environmental conditions were tested. These focused on bottom temperature, salinity, ice coverage and sediment grain size.

The successful amalgamation of data from different gear types across three surveys facilitates the understanding of stock dynamics and provides a flexible framework to accommodate future developments in survey methodology and design. The enhanced predictions of stock biomass provide better representations of stock development and uncertainty, reduce the number of abundance indices applied during the stock assessment and contribute to improved management advice for the Norwegian snow crab stock.

This study demonstrates how applying modelling approaches to abundance index estimation can increase the utility of available survey data, ensure time series continuity, and enable the inclusion of new survey methods to improve the assessment of shellfish stocks.

Keywords: time series, gear conversion, catchability, spatial-temporal modelling, survey design

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CM 187: Improved estimates of selectivity for a long-term fishery-independent survey with technological changes

Cole Carrano[1], Steven X. Cadrin

Fishery-independent surveys provide a valuable tool for stock assessment, but changes in technology are inevitable (e.g., decommissioned survey vessels), and advanced technologies can improve multispecies efficiency. For example, the northeast US spring and fall bottom trawl surveys, run by the Northeast Fisheries Science Center, have been conducted annually for over 50 years. Data from spring and fall surveys provides indices of abundance for stock assessments of many fisheries in the region. In 2009, the research vessel the Albatross IV (57 meters and 1130 horsepower) was replaced by the Henry B. Bigelow (64 meters and 3016 horsepower) for the survey. The Bigelow surveys utilize different trawl gear (3-bridle, 4-seam trawl rigged with a rockhopper sweep), than the Albatross (Yankee 36 haddock trawl with cookie sweep), as well as changes to tow duration (20 minutes vs. 30 minutes), speed (3 knots vs. 3.8 knots), and direction relative to bathymetry. A calibration study suggested that the Bigelow is much more efficient at catching many species, especially smaller fish. However, estimates of relative efficiency are uncertain, particularly for small fish, making selectivity estimation difficult and often producing residual patterns in survey age composition for young fish. We used a statistical catch-at-age model to evaluate alternative approaches to compare performance of a single calibrated survey index to separate Albatross and Bigelow time series in applications to several species of New England Groundfish, most recently for a benchmark assessment of American plaice (*Hippoglossoides platessoides*). Model runs with a single calibrated index of plaice had all positive residuals for age-1 in the Bigelow years. Model runs with split series had no residual pattern, while maintaining good fit to fishery-dependent data and retrospective consistency. Splitting the Albatross and Bigelow indices allows estimation of selectivity for each index, improving age composition predictions and model fit. Model runs with separate Albatross and Bigelow series indices have been accepted for plaice and several other species (e.g., summer flounder *Paralichthys dentatus*, Atlantic herring *Clupea harengus*). Preliminary results for other species (Atlantic cod *Gadus morhua*, haddock Melanogrammus aeglefinus, witch flounder *Glyptocephalus cynoglossus*, white hake *Urophycis tenuis*, and pollock *Pollachius virens*) show promising improvements in index fits but variable results for fitting index age composition. Comparisons of estimated calibration factors to relative catchability and selectivity provide broader understanding of how changes in gear technology affect selectivity of similar species.

Keywords: trawl surveys, selectivity, stock indices, calibration

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CM 188: When things turn out different despite good preparations

Nicola S. H. Tien[1], Ingeborg J. de Boois

When a gear change in independent monitoring occurs, it is good to have a proper plan to be able to link the existing timeseries to the new one. In case of unexpected vessel change (for example because the preferred vessel breaks down), it is common practice to either look for a vessel that has contributed to the monitoring before or find a vessel with similar characteristics as the preferred vessel. Monitoring with passive gears in rivers preferably takes place on fixed locations, to limit the effect of river dynamics on the catches. Three different statements that should maintain representative time series.

We will present examples for each of the situations where despite following the best practices, the timeseries were affected. The origins of the unforeseen outcomes were different, and the combination of the examples show that even the 'right effort' may not always lead to a useful result.

Keywords: time series, unexpected results, gear comparison, vessel change, infrastructural changes

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CM 209: Evaluation the efficiency of otolith collection for estimating the age composition of fish

Chin K.[1], K. Bleeker, S. Sakinan, C. Chen, I.J. de Boois

Otoliths (ear stones of fish) are collect to identify the age of fish. Age information is used in fish stock assessment models. When otolith collection takes place during fishery-independent surveys, fish have to be actively killed to extract the otoliths. Therefore, each fish from which otoliths are collected counts as 1 experimental animal in The Netherlands. Although there are common standards for minimum required otolith sample size for ICES coordinated surveys, the origin of such standards is not clear, and the actual number of otoliths required may change depending on the variability in ages within the stock. Otolith collection and processing as well as age reading is time-consuming and costly. To improve the efficiency in allocation of it, is worth to evaluate the current number of otoliths collected in a survey. From literature we know that evaluation of sampling strategies for cod showed that 1 fish per 5 cm length class per haul is sufficient to create an age-length key that can be used in fish stock assessments. We present these 3 methods to optimize the number of otoliths needed for representative age composition and evaluate the advantages and disadvantages of these methods. Ultimately, the objective of this study is to optimize current sampling strategy for otoliths collection in practice.

Keywords: otolith collection, animal welfare, evaluation, age-length key

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CM 219: Addressing interactions between offshore wind energy development and fisheries independent surveys in the United States: Moving from Strategy to Developing a Survey Mitigation Program and Survey Mitigation Plans for NOAA Fisheries in the Northeast U.S. Region

Andy Lipsky, Kathryn Ford, Jon Hare

The National Oceanic and Atmospheric Administration National Marine Fisheries Service (NOAA Fisheries) and the Bureau of Ocean Energy Management (BOEM) share a commitment to develop offshore wind energy in the U.S., while protecting biodiversity and promoting ocean co-use. One of the primary ways marine biodiversity is monitored in the U.S. is through the use of scientific surveys conducted by NOAA Fisheries. Nationally, NOAA Fisheries assesses the status of approximately 450 fishery stocks, 200 marine mammal stocks, and 165 threatened and endangered species. These assessments rely on more than 50 long-term, standardized surveys, many of which have been ongoing for more than 30 years. The overall survey enterprise relies on methods, platforms, and designs unique to each survey, with the goal of providing information to support sustainable management. Owing to the precautionary approach, increased uncertainty in the data originating from these surveys typically results in more restrictive management. As a result, NOAA Fisheries has made extensive efforts to maintain consistency in surveys over time to reduce uncertainty and increase accuracy and precision. Sustaining surveys with consistent sampling designs and methods is an essential feature of their value, allowing understanding of the status and trends of managed species consistently through time. Therefore, we need to consider the impacts of offshore wind development on the survey enterprise. We identify four impacts to NOAA Fisheries surveys due to wind development: 1. Preclusion of NOAA Fisheries sampling platforms from the wind development area due to operational and safety limitations; 2. Impacts on statistical designs; 3. Alteration of benthic and pelagic habitats, and airspace, requiring new designs and methods to sample new habitats; and 4. Reduced sampling productivity through navigation impacts of wind energy infrastructure on aerial and vessel surveys. In December 2022, NOAA Fisheries and BOEM published a federal survey mitigation implementation strategy which lays out a roadmap to determine how to mitigate the impacts of offshore wind energy on NOAA Fisheries surveys. This presentation will provide an overview of the progress and process of implementing the strategy for thirteen scientific surveys that overlap with offshore wind development in the Northeastern U.S. This presentation will also include up-to-date information regarding the status of plans and the methods proposed to evaluate survey impacts, alternative sampling methods and approaches, and how to develop and integrate new survey approaches with existing time series.

Keywords: offshore wind energy, fishery-independent survey, wind survey mitigation program

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CM 233: Survey design and implementation in a rapidly changing environment

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While long-term monitoring studies have always faced logistical challenges, management systems have driven surveys to emphasize the consistency of sampling approaches above all else. However, many ecosystems are undergoing changes of such magnitude (range expansions and shifts, offshore wind development) that resource managers are acknowledging the need to adjust survey designs to those that are flexible enough to be suitable for the present *and* withstand additional, unforeseen future changes. As environments change, so do management priorities, so both the landscape and objective are shifting. Thus, the fundamental question is how to design fishery-independent surveys for flexibility in when, where, and how the marine community can be sampled while appropriately allocating resources to shifting management priorities? We address this question in the eastern Bering Sea and U.S. Arctic, where warming and loss of sea ice are causing distribution shifts that may degrade the capacity of existing surveys to estimate fish and crab abundance. We use new information and analytical tools to evaluate the accuracy, precision and efficiency of existing designs and develop new designs to improve performance in present and expected future conditions. Broadly, we seek to assess the benefits and risks of expanding the survey domain and reallocating observations over space to best sample the entire region, extending from the Chukchi Sea to the eastern Bering Sea continental shelf and slope. Toward this objective, we focus not only on technical advances in survey methods, analysis and design, but also on advancing the breadth of socioeconomic considerations through engagement with Indigenous communities. To inform the design of potential new Arctic surveys, we used simulation from spatiotemporal GLMMs conditioned on historical data from multiple observation methods to optimize stratum boundaries to best sample species of value ecologically, economically, culturally, and for subsistence. Our ongoing work extends this approach to evaluate whether and how environmental observations could be used to inform survey design, including the use of near-term indicators (e.g., temperature, eDNA) to tailor sampling effort allocation to expected conditions during the survey. We present our progress toward the most pressing challenges in marine ecological monitoring: development and refinement of survey design methods that consider multiple objectives and sources of information.

Keywords: survey design, flexible surveys, dynamic surveys, ecosystem surveys, socioeconomic, subsistence, Native Alaskans

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CM 247: Spatiotemporal cross-validation of three survey methods for improved abundance indices of red king crab (*Paralithodes camtschaticus*)

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Sustainable fisheries require input data of sufficient quantity and quality to inform stock assessments and management. However, capacity and resources to collect data are limited, underlining the need for methods that can maximize the utility of available fisheries-independent and -dependent data. The goal is to improve estimates of stock size and uncertainty, even from time series with inconsistent coverage and gear changes. This is of particular concern for the many stocks that are defined as data-limited, especially many shellfish stocks that are often not sufficiently covered by regular scientific surveys due to poor catchability in standard bottom trawls or habitat mismatch. This creates the need for methods that improve the coverage of such species by extracting and integrating information from available data. Additionally, the integration of data from different sources could prevent disjointed and potentially contradicting indices, especially when new survey methods are implemented parallel to existing surveys. Furthermore, combining already available data from surveys using differing gear types represents a cost-effective use of data and reduces the need for specialized surveys for target species. However, ahead of any consolidation of data from different surveys or gear types, information from different gears needs to be compared and, if possible, calibrated against each other.

The red king crab survey in northern Norway provides an experimental setup with nearby stations to assess the catchability of bottom trawl, pots, and video. How well bottom trawls catch king crab is uncertain, and direct observations from video-based surveys and pots comparable to those used in commercial fishing may be more suitable approaches to assess changes in abundance. Interest in less intrusive survey methods has been heightened by concern for habitats that are vulnerable to damage caused by destructive sampling devices such as trawls. Visual surveys have emerged as a promising method for surveying benthic resources. We will present how observed densities and catch compositions of red king crab compare across survey gear, and how information from different gear types can be combined in an integrated estimation of abundance indices. We find common trends across gear types but also highlight challenges linked to substantial spatial variation in a highly structured fjord ecosystem. The results of this case study contribute novel insights into the integration of different data sources and gear types into coherent estimates of abundance indices and their uncertainty to facilitate implementation of new survey methods.

Keywords: stock assessment, data-limited, video, trawl

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CM 273: A comparison of survey design techniques for scallop, Placopecten magellanicus, camera sampling

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Marine invertebrate survey designs can take a wide range of forms, and semi-sedentary species that lie on top of the seafloor can be sampled using optical techniques. A long-standing optical survey of sea scallop (*Placopecten magellanicus*) populations in the northwest Atlantic Ocean has used a systematic sampling design, where stations are evenly spaced. Alternative survey designs such as stratified-random or generalized random tessellation (GRT) sampling may produce more accurate density estimates by using knowledge of scallop distributions and principles of random design, whilst achieving adequate or balanced spatial coverage of the survey area. To address this, extensive simulations were conducted to compare the accuracy and precision of simple random, stratified-random, systematic, and GRT sampling designs across a wide range of years and sea scallop management areas. Real survey data was fit to kriging models to generate fine scale density layers with known average scallop density for each year and area combination, from which simulated survey designs could draw samples. In addition to comparing the performance of the four designs, the formation of strata for the stratified-random design was analyzed. The study examined how the length of time between strata being created and when the sampling takes place affected the performance of the stratified-random technique. Similarly, the number of years of previous data combined to define the strata was also analyzed. Initial results show the systematic design to be as accurate as the other techniques in most situations and more precise, indicating that the current survey design should be continued. These initial results do not consider all simulations. The final results will either support the current systematic sampling design or encourage a transition to alternative sampling designs, and therefore will be highly valuable to the local survey and fishery. These results will also be highly useful to wider fishery-independent surveys, scientists, and managers and could help inform changes or initiations in survey design.

Keywords: survey design, scallops, optical survey, geo-statistics, simulations

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CM 281: Understanding the limitations of static sampling designs to estimate abundance in a rapidly changing ecosystem

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Fishery-independent survey data are critical inputs to stock assessment, ecosystem-based fishery management initiatives, and applied ecological research. However, environmental changes may affect species distributions, and thus spatial availability to surveys, with consequences for consistency and precision of abundance estimates over time. Most surveys retain the same spatial extent and sample allocation among years, regardless of how the ecosystem has changed. Therefore, it is essential to understand the performance of such static sampling designs for monitoring ecosystems under changing environmental conditions and under what conditions they may fail to track trends in relative abundance. We asked whether static sampling designs perform better in limiting uncertainty of abundance estimates in a changing environment when defined with traditional boundaries (e.g., latitude, depth) or when boundaries are defined by typical environmental conditions. To address this question, we simulated observations from a species distribution model conditioned on historical fishery-independent bottom trawl data and observed sea bottom temperature (SBT) in the eastern Bering Sea from 1982 to 2022. This spatiotemporal operating model was projected forward one to five years under a variety of plausible future SBT scenarios. Under each SBT scenario, abundance estimates were compared among several static sampling designs informed by constant or dynamic variables. We then compared these abundance estimates to the true abundance among sampling designs and SBT scenarios to quantify bias in the estimates and their associated uncertainties. This simulation study highlighted that a sampling design informed by SBT can help to produce more precise abundance estimates when species are affected by continuous and rapid climatic changes. The present work will support the design of a flexible sampling framework that may help to increase the efficiency of sampling marine resources under current and future climates to maintain the quality of survey data products for the management of marine populations.

Keywords: spatiotemporal, species distribution model, sea bottom temperature, eastern Bering Sea, survey design

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CM 414: Progress towards an analytical assessment of anglerfish based on an industry-science survey

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The two species of anglerfish, *Lophius piscatorius* and *L. budegassa*, are the subjects of valuable commercial fisheries in the North Atlantic. In northern Europe, they are managed as a single stock occupying a large area from the southern North Sea, around the northern British Isles and out to Rockall. In 2005 an innovative new trawl survey was initiated to provide the evidence needed for catch advice which had, until then, been lacking. The survey, since named the Scottish-Irish Anglerfish and Megrim Industry-Science Survey (SIAMISS), has been carried out annually since (except 2020 due to covid), and its biomass index has been used to provide catch advice using ICES' framework for category 3 stocks. The survey had three main distinguishing features which we describe here.

First, there is the involvement of the fishing industry. The survey's design and its sampling gear were co-created with experienced anglerfish fishermen. Fishing vessels are used to conduct the survey each year, equipped with the same trawl. Scientists on board ensure trawl samples are standardised and measure the necessary biological characteristics of all anglerfish caught.

Second, the survey provides an estimate of absolute abundance based on estimates of trawl gear selectivity. Video observations and an individual based model estimated horizontal herding, which was low, in keeping with anglerfish's behaviour as a sit and wait predator. Footrope escapement was quantified using sub-footrope collection bags, leading to a length-based correction factor to account for small fish escapes. Despite using multiple vessels, the southern North Sea was not covered. Data from the North Sea International Bottom Trawl Survey (NS-IBTS) was used to estimate another correction factor to account for the differences in catchability between the two surveys. Equivalent NS-IBTS data, in the regions not covered by SIAMISS, were then incorporated into a compatible estimate of abundance, increasing survey coverage for the full survey time series.

Finally, a unique age- and survey-based stock assessment model was explored to provide an analytical assessment. The model assumes that the survey produces absolute abundance estimates for fish aged 5 and older (i.e., survey selectivity, q is equal to 1 for ages 5+). Here we present the new SIAMISS time series and preliminary runs of the analytical assessment as an example of progress in estimating absolute abundance from fisheries independent surveys.

Keywords: Anglerfish, trawl survey, stock assessment

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CM 417: Industry contributions to data collection on Northeast Atlantic mackerel: benefits, lessons and challenges

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Atlantic mackerel (*Scomber scombrus*) has a very wide distribution in the Northeast Atlantic Ocean. Monitoring and understanding the development of a stock with such a wide distribution presents an ongoing challenge. Currently mackerel is considered to be a determinate spawner for Spawning Stock Biomass (SSB) estimations using egg production methods, but gonadal investigations suggest mackerel has a more indeterminate spawning strategy. Year-round following of the gonad development of mackerel could provide more insight and evidence for the spawning strategy of the species.

The pelagic fishing industry encounters mackerel in their catches on a regular basis, either as target, or as bycatch species. The 'Year of the Mackerel' project was set-up in 2018 as a collaborative project between fishing industry and Wageningen Marine Research (WMR), to increase the understanding of the development of mackerel gonads over the year, and to see when and where mackerel spawn. The Pelagic Freezer Trawler Association (PFA) collected year-round gonad samples of mackerel which are subsequently analysed by WMR. To date, more than 3000 samples have been collected from 125 fishing trips.

The benefits of this industry-science collaboration is that it is relatively straightforward to collect mackerel gonad samples throughout the year because it can be integrated in the day-to-day work on the vessels. Engaging fishers and scientist in this type of collaboration also creates a better exchange of experiences and understanding. However, to make full use of data collected onboard a commercial trawler, there are still some challenges to overcome. 1) fisheries are relatively unplannable and fishing plans are adaptive based on the catches. Therefore, there is no guarantee that specific samples can be collected. 2) larger amounts of formaldehyde for storing gonads are prohibited onboard. Therefore, new methods had to be developed. 3) different ships have slightly different facilities, making it more difficult to have a consistent working method across ships and crews. 4) there must be availability and willingness of crewmembers to collaborate. 5) the logistical organization and storage of samples. The trawlers can land their fish in different countries, making it harder to collect all the samples in one central location. And finally, 6) as the methods used are different from those used on-board scientific surveys, care must be taken when interpreting and comparing results.

Keywords: industry participation, mackerel, gonad sampling, challenges

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CM 421: Development of comprehensive metadata records for a long-term monitoring program to facilitate data sharing and collaborative research

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Comprehensive and informative metadata records are extremely crucial to understanding and properly using data collected by long-term monitoring programs. The historical Hudson River Biological Monitoring Program (HRBMP) is a long-term survey program covering the Hudson River Estuary (HRE) from Battery Park to Albany, New York, United States and was conducted from 1974 to 2017. The historical HRBMP consists of six core surveys conducted during the survey period. Although these surveys follow statistical principles in their design, such as stratified random sampling, many technical/procedural changes occurred to address issues encountered in the surveys such as logistic limitations and modified survey goals. Major changes in sampling protocol included survey start and end dates, daytime and nighttime sampling, sampling locations, sampling frequency, gear used, and species of interest. Due to possible issues associated with survey design changes, complex data structure, and lack of detailed publicly available information, the research potential of the HRBMP data has not been fully explored. Therefore, having improved information for potential users is critical to the full realization of the HRBMP data research potential. This calls for the development of informative and easy-to-use metadata that is available online and can be accessed by those interested in the historical HRBMP data. We propose an interactive and phased process for developing the HRBMP metadata and data sharing policy. We will start the process with an evaluation of available metadata models to identify a suitable model that is cost-effective and balances the needs of users and complexity of the metadata structure. The selected metadata model should address the following criteria: (1) easy to use and understand by all potential users who may not have experience with large database management; (2) informative of the historical HRBMP data and cost-effective in its development; (3) open and easy to edit/add/supplement with new information; (4) transparent structure; and (5) capacity to provide the necessary spatiotemporal environmental and biological information. The metadata developed in this project will be uploaded online with open access to facilitate historical HRBMP data sharing and collaborative research. Metadata can help potential users better understand the historical HRBMP database, increase the utilization of historical HRBMP data, and promote collaborations with stakeholders and the community to address scientific and management questions critical to the HRE. This framework has the ability to be adapted for other long-term monitoring programs and complex databases and emphasizes stakeholder engagement in the metadata development processes.

Keywords: long-term monitoring, metadata, stakeholder engagement, Hudson River Estuary

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CM 427: Pathways to the modern fisheries-independent surveys of the future

Stan Kotwicki

Fisheries-independent surveys (hereafter surveys) are foundational to modern fisheries management, and fisheries and ecosystem research. They are conducted worldwide to study the status of marine populations and ecosystems. The primary role of surveys is to provide consistent time series data for use in stock and ecosystem assessments. To assure this consistency surveys often concentrate on enhancing standardization. However, standardization is becoming more difficult because of the changes undergoing in survey technologies, regulations, and in environment. For example: new sampling tools are becoming available (e.g., cameras, acoustics, and eDNA); some areas become closed to surveys (e.g., MPAs, trawl exclusion zones, wind farms); fish stocks change their distribution. These developments underscore the need for developing pathways to modernize and adapt surveys to the new circumstances while assuring consistency of survey data products. This is a considerable challenge that can only be addressed with broad range of actions. These actions should include: 1. education of future survey practitioners, stakeholders and public; 2. developing new survey designs that are flexible and less sensitive to changing circumstances; 3. developing methods for incorporation of new technologies to surveys. 4. evaluating new designs and new survey methods; 5. combining multiple surveys, platforms, or technologies; 6. establishing standards for propagation of uncertainty for survey data products; 7. prioritization of objectives in multi-objective surveys; 8. improvement of survey-data products using models, covariates, and other auxiliary information. 9. transitions from destructive or lethal survey methods.

Vision of the future survey should be free of exaggerations and consider both new and traditional survey methods and practices. We envision that future surveys will incorporate multiple platforms and methods, such as: advanced sampling technologies, use of the models is survey design, effort allocation, and data products derivation, and use of artificial intelligence. Surveys will collect more data types and larger volume of data. Surveys will be more responsive to the stakeholders and assessment needs. However, traditional survey methods (trawling, dredging, pots, etc.), although reduced, will continue to be essential for collecting samples for different purposes. Sampling designs and subsampling will still require understanding of state of the art statistical methods. Surveys will continue to cope with difficulties associated with working out at sea, bad weather, equipment breakdowns, etc. Scientists and sailors will continue going out to sea and coming back home.

Keywords: Fisheries-independent survey, vision, survey methods

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CM 438: Mitigating Class-Imbalance in Acoustic Target Classification for Fisheries via Similarity-Based Data Selection

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Acoustic trawl surveys are an important class of fisheries independent surveys. The data are typically manually worked up applying tacit knowledge of the annotator in the process. Machine learning methods, such as deep learning models, have been demonstrated to work well for automating the annotation process, and can provide an important tool for evaluating the time series consistency. However, less than 1% of the acoustic data is attributed to fish schools, which constitutes the foreground class. Consequently, the deep learning models can exhibit bias towards the background class and in extreme cases, even ignore the foreground class completely. This study discusses how to address the challenge of class imbalance in the sampling of training and validation data for deep convolutional neural networks. The proposed strategy seeks to equally sample areas containing all different classes while prioritizing background class that have similar characteristics to the foreground class. The developed under-sampling algorithm is used to select these challenging areas from the background class to detect regions where misclassification is more likely, and we compare the performance with the baseline method. The proposed strategy and results of the under-sampling algorithm can provide a solution to assess acoustic target classification consistency through a time series.

Keywords: marine acoustics, deep learning, class imbalance, data under-sampling, convolutional neural networks

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CM 462: Evaluation of alternative statistical sampling designs for a long-running multispecies bottom trawl survey

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The Northeast Fisheries Science Center has conducted a multispecies bottom trawl survey of the northwest Atlantic continental shelf and upper continental slope since the autumn of 1963. The survey has followed a random, stratified sampling design since its inception and is stratified primarily by depth and latitude. Sampling effort is allocated generally proportional to strata size; however, the current stratification includes several small inshore and offshore strata that alter the proportionality of effort allocation. In recent years, the existing survey design has faced compounding challenges including the creation of habitat protection areas, exclusion of shallow water strata due to vessel limitations, increased fixed gear, and shifting species distributions. Here we evaluate historical sampling and consider alternative stratification and effort allocation options aimed at increasing precision for multiple commercial stocks assessed in the region. Furthermore, alternative statistical sampling designs were evaluated including hybrid sampling designs that combine spatially balanced random and fixed sampling in the vicinity of survey regions that may not be accessible in future years.

Keywords: bottom trawl survey, stratified random sampling, statistical survey design

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CM 477: How might climate change affect indices of abundance? A simulation study starting point

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Many stock assessments in the United States use abundance estimates derived from stratified random bottom trawl data. To accurately represent true abundance, catches of a species must contain a low enough noise level to allow for a discernible pattern and the proportion of the population that is sampled should be consistent over time. These assumptions could be violated given enough noise in the sampling process and/or climate change causing a population to increase its abundance in strata that are not sampled. Using the R package *MixFishSim*, we have developed data-driven spatial models for Yellowtail Flounder, Cod, and Haddock in the western Atlantic Ocean to allow examination of these assumptions through simulation. Movement rates combine species-specific static habitat preferences with temperature tolerances. Habitat preferences were derived from niche models relating bottom trawl catches to environmental covariates. A repeating yearly temperature pattern produces repeating spatial biomass distributions in a given week, while a temperature gradient that increases on average over time results in spatial preferences that evolve throughout a given simulation. We created simulated spatial time series datasets for each species for several temperature scenarios and population trends. Using stratified random sampling on model output we were able to compare abundance estimates derived from the design-based stratified mean to those using a spatio-temporal model-based approach that allows inclusion of environmental covariates (VAST). Our focus was on the ability of contemporary indexing methods to track population trends under shifting spatial preferences.

We found that in general, both index calculation methods are able to produce similar abundance trends to the model output, with model-based estimates providing more consistent year-to-year estimates. The design-based approach tended to provide abundance estimates that were below the true values in our models, while model-based estimates tended to overestimate true abundance. We highlight scenarios where index calculation methods produced misleading estimates as species shifted their spatial densities over time within their assumed stock boundaries. While including environmental covariates can improve model-based estimates, the outcome is sensitive to the multitude of inputs and settings. The impact of shifting spatial densities became magnified when only a portion of a species' spatial distribution was sampled. Counter-intuitively, including covariates can sometimes degrade the estimates in this situation.

Keywords: climate change, VAST, abundance indices, stratified mean, spatial model

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CM 482: Adapting to new technology: using ropeless gear to target American lobster (*Homarus americanus*) in fishery-independent sampling in New England, USA

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Static gear fisheries off the United States east coast target some of the most commercially valuable species, including the American lobster (*Homarus americanus)*. The vertical lines and buoys that fishers use to locate their static gear interact with protected species inhibiting their feeding, movement, and behavior leading to stress and mortality. The north Atlantic right whale (*Eubalaena glacialis)* travels the United States and Canada east coast to feed and spawn, including through areas of static fishing gear, increasing their risk of fishing gear interactions. Less than 350 right whales exist, and they are threatened by climate change, ocean noise, vessel strikes, and gear entanglement. Current regulations to reduce entanglement risks include closed areas and gear modifications, for example ropeless gear technology, which removes vertical lines and buoys. Ropeless gear was tested in an initial study in Buzzards Bay, Massachusetts, USA to trial the gear before use in a fishery-independent survey to monitor American lobster, Jonah crab (*Cancer borealis*), and black sea bass (*Centropristis striata*) abundance and distribution. This initial study allowed the fishers and scientists to become familiar with the gear and to test a variety of ropeless gear types. Catchability was not expected to be impacted as trap specifications did not differ between ropeless and traditional systems. During the experiment, soak time, trap coordinates, environmental factors (temperature, dissolved oxygen, PH, salinity), and catch were recorded. Criteria for a successful ropeless trap system included cost, product availability, and compatibility in study area parameters like depth and bottom type. Gear performance was measured by the ability to locate gear using acoustic receivers, recovery and deployment time of units, and success of gear retrieval. Feedback from fishers supported decision making and survey modifications throughout the process. The applications of ropeless gear technology tested in this fishery-independent survey allows for commercial fishers to gain experience and to consider its use in the commercial fishery. The future of static fishing operations and fisheries independent surveys can coexist with conservation practices through the advent of technology like ropeless gear.

Keywords: ropeless, lobster, north atlantic right whale, fisheries independent survey

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CM 497: Recent advances in the design and technology of an industry-based bottom longline survey in the Gulf of Maine, USA

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The Gulf of Maine is one of the most rapidly-warming ocean regions in the world and contains essential fish habitat for dozens of commercially and ecologically important species. Much of the Gulf of Maine, however, is difficult to survey with traditional mobile-gear technologies due to the prevalence of rocky bottom and fixed fishing gear. In response to this challenge, the National Oceanic and Atmospheric Administration's Northeast Fisheries Science Center (NEFSC) worked with members of the fishing industry to develop the Gulf of Maine Bottom Longline Survey (BLLS). The BLLS is the only long-term fixed-gear survey operated by the NEFSC in the Gulf of Maine and was designed to increase sampling of fish stocks associated with complex habitats that are inaccessible to bottom trawl surveys. Several aspects of the survey design and operations are novel, including stratification by "rough" and "smooth" bottom types using a rugosity index (terrain ruggedness index), partnership with commercial fishers in developing survey protocols, use of electronic monitoring systems to quantify hook disposition, and multi-factor classification of seafloor habitats at each survey station. The design and technology used for the BLLS are of increasing importance as offshore wind energy development precludes mobile-gear surveys and ecosystem-based fisheries management requires enhanced environmental and habitat information.

The BLLS is conducted collaboratively with two small (<18m) commercial fishing vessels operating simultaneously with two scientists on board. The BLLS samples 45 stations between 30m and 290m water depth each spring (April-May) and fall (October-November) in the Gulf of Maine. Data collection at each station includes abundance, biomass, and length measurements for each species, biological sampling for sex, age, maturity, and genetics, tagging of species of interest, bottom temperature, depth, and current direction and velocity measurements, bottom habitat characterization using a drop camera, and hook disposition assessment using electronic monitoring camera systems. A total of 48 unique species have been sampled by the BLLS, including 29 fish species, 10 invertebrate species, and 9 elasmobranch species (4 shark and 5 skate species). Collaboration with industry partners is critical to the operational and scientific success of the BLLS, which provides information to support stock assessments, management actions, habitat studies, life history studies, and survey-comparison analyses. This presentation will highlight the advantages of the survey's unique design and technology, including flexibility to address novel operational and data requirements presented by emerging ocean uses and research questions.

Keywords: survey, bottom longline, cooperative research, habitat, offshore wind, survey design, Gulf of Maine

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CM 539: Assessment of the impacts of changing survey diel protocols in estimating abundance indices

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The location of fish species in the water column varies based on time of day. Therefore, the diel period of sampling is an important factor to consider in fisheries survey design. The Hudson River Biological Monitoring Program (HRBMP) was a long-term monitoring program that had numerous protocol changes throughout its duration, including changes in diel period of sampling. The HRBMP started in 1974 to monitor the impacts of power plants on fishes in the Hudson River Estuary (HRE) in New York, USA. The largest survey component of the HRBMP is the Longitudinal River Ichthyoplankton Survey (LRS), an ichthyoplankton trawl survey conducted from 1974-2017, designed to assess the distribution and abundance of key fish species throughout the HRE. It had inconsistencies in daytime and nighttime sampling and shifting survey objectives with changes in key species. In 1974, striped bass (*Morone saxatilis*) was the only key species, but key species were incorporated into the survey design throughout the survey, altering the sampling protocols, including sampling diel period. Generally, sampling diel period was determined by the presence of post-yolk-sac larvae (PYSL) of the key species, with sampling switching to nighttime sampling after the presence of PYSL was observed. However, changes in key species and inconsistencies in the months of sampling for different diel periods cause questions about the impact of diel period on abundance indices calculated from LRS data. Changes in sampling protocols throughout this long-term monitoring program, including sampling during different diel periods, require the dataset to be carefully evaluated to understand how the changes impact understanding fish population dynamics. This study examines the differences in abundance indices of early life stages of striped bass and white perch (*Morone americanus*) when sampling is conducted during different diel periods. This study aims to meet the following objectives: (1) assess the significance of diel period as a variable in relative abundance; (2) determine if different variables impact relative abundance during the day compared to night and what scale these differences occur on (e.g., species, life stage); (3) determine what would be represented in the data if diel period is ignored. This work will evaluate how different sampling timings may influence estimation of abundance indices, providing insight on possible data calibration to make the data comparable over space and time. This study will also inform other long-term monitoring programs in optimizing data usage under protocol changes.

Keywords: long-term monitoring, diel period, relative abundance, calibration

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CM 547: Evaluating and calibrating historical long-term monitoring data for spatiotemporal consistency

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Long-term monitoring programs provide the opportunity to study how different fish species and fish communities respond to climatically and anthropogenically induced changes in environments, which can lead to improved understanding and management of the dynamics of fish communities and populations of ecological and economic importance. However, long-term monitoring programs can also face challenges with protocol changes that make data interpretation difficult, requiring careful calibration of the data. The Hudson River Biological Monitoring Program (HRBMP) started in 1974 to monitor the impacts of power plants on fishes in the Hudson River Estuary (HRE), the southern 245 river kilometers of the Hudson River in New York, USA. The largest survey component of the HRBMP was the Longitudinal River Ichthyoplankton Survey (LRS) that was developed to monitor the abundance and spatiotemporal distribution of ichthyoplankton in the HRE. Although the LRS sampled river wide from Battery to Albany, NY following a stratified random sampling survey design from 1974 to 2017, many protocol changes were made to the survey over time. The major changes in sampling protocol included survey start and end dates, daytime and nighttime sampling, sampling locations, sampling frequency, and species of interest. However, the impacts of the changes in the sampling protocol on the estimates of spatiotemporal distributions and abundances were not evaluated, potentially complicating the interpretation of biological data collected and spatiotemporal comparisons of abundance and distribution of ichthyoplankton. This has raised questions about LRS data quality and utility, considering the key factors that influence future survey data quality. The overall purpose of this study is to understand the impacts of the changes in the protocols for the LRS. This goal is accomplished through the following objectives: (1) evaluate and identify influential factors to the LRS data, and risks of neglecting their influence; (2) explore appropriate modeling approaches to calibrate the data to reduce the spatiotemporal bias due to survey changes and gaps; (3) compare model-based and design-based abundance indices and identify possible factors for the discrepancies that might have resulted from protocol changes. This study provides insights on possible impacts of not calibrating data for changing sampling protocols and the results can be used to make recommendations on optimizing sampling protocol for the survey.

Keywords: long-term monitoring, calibration, survey design

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CM 564: Quantifying the scientific and economic value of surveys to fisheries management

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Stock assessments are used in fisheries management to help sustain fisheries as a valuable economic resource. Having high quality and consistent data from well-designed fishery-independent surveys is integral to any assessment and our ability to track population changes over time. This need is becoming a higher-priority as species distributions shift with the changing climate. At odds with this requirement are limited funding resources and logistical constraints that may limit the spatial extent of the sampling domain, as well as survey sampling frequency and intensity. Understanding the impact of survey modifications on our assessment results, management advice, and the economic viability of commercial fishing is an essential step to help justify the need for conducting surveys. The goal of this project is to evaluate the scientific and economic benefits of survey data under different survey and climate scenarios using management strategy evaluation (MSE). Identifying the trade-offs among the performance measures when survey modifications are implemented will elucidate the importance of surveys to the full management system and in turn help inform spatial and temporal survey allocation decisions.

Keywords: fishery-independent survey, fishery revenue, spatial operating model, management strategy evaluation

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CM 579: Spatio-temporal variability of sardine Sardina pilchardus population inhabiting the gulf of Cadiz

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European sardine *Sardina pilchardus* is a key species inhabiting the pelagic ecosystem along the Atlantic and Mediterranean coasts. In the gulf of Cadiz, sardine plays an ecologically relevant role by transferring energy from lower to upper trophic levels. However, detailed knowledge regarding its spatiotemporal distribution and high-density areas on a regional scale still needs to be further explored and available as it will allow us to detect climate change impacts on the sardine population. In the present work, we hypothesize that sardine distribution and density off the gulf of Cadiz do not show a negative trend for the time series. To test our hypothesis, we modeled the spatiotemporal distribution of sardines using acoustic data collected from the ECOCADIZ-RECLUTAS autumn survey series (2014-2021). We fitted Bayesian geostatistical models to the time series data to estimate the probability of presence, conditional density, and the effective area covered by the acoustic population for each year studied. We generated prediction maps by applying Bayesian Hierarchical Kriging models. The mean predicted probability of presence of sardine was 0.38 (±0.10), the mean predicted conditional density of 113 (±101) m^2 nm^{-2}, and the mean predicted relative acoustic abundance index was 1 137 875 (±1 016 595) m^2 over the whole time series analyzed. The mean effective area estimated was 3921 (±1007) km^2. We commonly observed areas with a high probability of presence in front of the Guadalquivir river mouth. In contrast, high-density areas were mostly located near the Guadiana river estuary and Cape Santa Maria (Portugal). In 2014 and 2019 sardine population was concentrated in a reduced area, while in 2021 sardine population moved to waters between Cape San Vicente and Cape Santa Maria. Such difference in spatial distribution reflects the inter-annual variability of the sardine population. It may be used to monitor any shift in the population distribution associated with climate change or overfishing.

Keywords: sardine, probability of presence, density, climate change, hydroacoustics, modeling

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CM 580: Cooperative research: Experiences from the integration of a commercial fishing vessel to ensure the continuity of survey indices

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Fisheries-independent survey indices are an important input parameter for stock assessment. A discontinuity in the time series might lead to a larger uncertainty in modelling the stock trajectory. Minor interruptions in space (e.g., areas closed due to conservation or naval operation) or in time (e.g., due to unfavourable weather conditions) might result in smaller areas not being covered by the survey. The failure of an entire survey, e.g., due to a vessel breakdown, can potentially lead to serious consequences for the stock index. This was the case for the sprat index in the Baltic Sea in 2016 which is estimated through a hydroacoustic survey conducted by up to six countries at the same time. The German research vessel could not cover the area allocated due to a vessel breakdown. Fisheries-independent monitoring usually has to be conducted at the same time of the year, therefore, an unforeseen longer-lasting repair led to a cancellation of the entire survey. As the German vessel covers about 50% of the whole survey area, that year's index was recommended not to be used in the stock assessment of sprat and resulted in a data gap for this year, which also means that other nation's survey effort was wasted. To be prepared for similar problems in the future, we discussed possibilities to use Germany's biggest (54 m) Baltic Sea commercial fishery vessel as a research platform replacement when the ship was still under construction in 2019. These discussions led to technical modifications of the vessel to allow e.g., acoustic, hydrography and plankton sampling. In 2021, the research vessel again had a serious technical problem. In order to avoid another gap in the time series, we turned the commercial vessel into a research vessel within few days. Here, we want to discuss the steps necessary to use a commercial fishing vessel for a fisheries-independent survey including vessel prerequisites and intercalibration. We highlight the lessons learnt from this collaboration and present the manifold opportunities which arose subsequently. Next to ensuring the continuity of the time series, a trustful relationship between fisheries and science could be strengthened and mutual understanding established. This further led into setting up a data collection independent of the survey including autonomous hydroacoustic and hydrographic monitoring during their normal fishing operation targeting sprat. This helps us to better understand the sprat ecology such as distribution patterns and might eventually improve fisheries management.

Keywords: fisheries-independent survey, hydroacoustic, commercial vessel, stock index

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CM 623: The evolution of a regional sardine survey into a multi-national, multi-platform ecosystem assessment

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In 2006, NOAA Fisheries' sardine survey began a series of transformations: from the Daily Egg Production Method to the Acoustic-Trawl-Method (ATM); from the area off Central and Southern California in spring, to the area from Vancouver Island, Canada to Baja California Sur, Mexico in summer; from coastal sampling as shallow as 50-m, to only 10-m depth; from trawling at stations to targeted tows; from fixed transects to adaptive sampling; from sampling by one ship, to as many as seven manned and uncrewed platforms; from estimations of the distribution, abundance and demographics of one stock, to those for at least seven stocks of five species. With each of these and many other developments, the additional information improved the original stock assessment as well as those for the other managed or monitored species. The evolving designs and approaches served to both elucidate and reduce estimation uncertainties. This example demonstrates that consistent sampling designs and methods are not always required or even beneficial, because measurement and sampling biases are generally dynamic, and continuous improvements to surveys can reduce uncertainty and enhance the quality and quantity of the information.

Keywords: California Current, oceanographic habitat, forage fish, status and trend, estimation uncertainty

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CM 625: Modeling impacts of survey imprecision on the assessment of fish stocks

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Fisheries-independent surveys are critical data sources for informing fisheries stock assessment; however, uncertainty in survey indices and their variances can lead to errors in assessment outcomes. While uncertainty in survey indices is often incorporated by weighting indices in inverse proportion to their estimated variances, uncertainty in the estimated variances is rarely considered. Uncertainty in survey products can be influenced by a multitude of factors including changes to survey design (e.g., survey intensity) and population dynamics (e.g., increased aggregation or range expansion). To understand the sensitivity of stock assessment outcomes to increased uncertainty in survey data products, we used simulation analyses to evaluate how changes in survey design and population spatial distributions would affect the precision of survey indices, their variances, and how these changes ultimately affect the uncertainty of stock assessment outputs. Understanding how these different sources of survey imprecision propagate through assessments of the population is essential for understanding the risk of management actions and can help inform decisions on how to reallocate limited monitoring resources for populations undergoing shifts in spatial distribution, while minimizing loss of scientific data.

Keywords: survey design, stock assessment, uncertainty

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CM 638: Spatial distribution and biomass of Chilean jack mackerel off south-central Chile based on acoustic records from fishing vessels

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The Chilean jack mackerel (*Trachurus murphyi*), a transboundary species from the South East Pacific, represents one of the most important commercial fisheries in Chile and high seas fisheries. Because of their migratory and patchy behaviour of the Coastal zones off Chile and the High Sea, there are difficulties in quantifying the biomass of this species. Acoustic research surveys made off Chile are normally based on systematic design transects and are not have been continuous over time. In addition, the use of research vessels requires a high cost and time effort to assess the distribution and abundance levels of fish, with a reduced likelihood of extending study areas by incorporating distant fishing grounds. Fishing vessels have been equipped with SIMRAD scientific and fishing echosounders of 38 kHz and 120 kHz (in some cases) since the year 2000 by the fishing industry of south-central Chile. The aim of this study is determinate the spatial distribution, mean density and biomass obtained from acoustic data recorded by 6 vessels of the Chilean jack mackerel (CJM) fishing fleet in their usual fishing operations during 2022 and compare the results with previous years. The abundance calculation was made for 2019, 2020, 2021 and 2022 based on a completely random sampling design through geostatistical method. Acoustic data was collected with eco-integration systems that allow digital recording of the information during the entire trip of the vessels from the harbour to the fishing grounds and back. Also, a comparison was made between results obtained by the CJM annual hydroacoustic evaluation cruise (systematic sampling) in the south-central zone of Chile from 2017 to 2022 and the hydroacoustic evaluation carried out with data recorded by fishing vessels (random sampling) for the same years in the same zone.

Keywords: Chilean jack mackerel, acoustics, fishing vessels

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CM 639: Monitoring juvenile abundance of southern bluefin tuna via a fisheries-independent genetic tagging program

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After having been severely depleted from decades of commercial fishing, southern bluefin tuna (SBT) are now recovering as the result of the Commission for the Conservation of Southern Bluefin Tuna's (CCSBT) science-based rebuilding plan centered on an adopted management procedure (MP). An important component of the MP is having a reliable time series of juvenile abundance estimates. Although catch per unit effort (CPUE) has traditionally been used to provide such information, the relationship between CPUE and abundance is tenuous and subject to many assumptions and biases. As such, the CCSBT recognized the importance of having a fishery-independent method of estimating juvenile abundance. Prior to 2015 the CCSBT funded a scientific aerial survey which provided an index of relative abundance used in the MP. When this program ceased due to a lack of planes and qualified spotters, as well as concerns about changing environmental conditions having shifted the distribution of fish out of the survey area, finding a new cost-effective method for providing fishery-independent information on juvenile abundance became critical, and a genetic tagging program was proposed. A pilot genetic tagging program commenced in 2016 to test the feasibility and logistics of large-scale tissue sample collection and DNA profiling, with tagging in 2016 and resampling in 2017. An absolute abundance estimate with sufficiently high precision was provided to the CCSBT in 2018. Due to the success of the pilot study, the CCSBT endorsed an ongoing genetic tagging program. A time series of juvenile abundance estimates now exists from 2018 to present and forms a key component of the MP (and its associated operating, or "testing", models).

Keywords: genetic mark-recapture, DNA fingerprinting, southern bluefin tuna, management procedure

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CM 641: Re-envisioning west coast pelagic surveys: maintaining critical fisheries-independent time series while integrating survey effort on the U.S. west coast

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NOAA Fisheries' Northwest and Southwest Fisheries Science Centers have been tasked with integrating two fisheries-independent surveys: the Pacific Hake Ecosystem Acoustic-Trawl ('PHEAT') Survey and the Coastal Pelagic Species ('CPS') California Current Ecosystem Survey, by 2025. The biennial PHEAT survey has been conducted jointly with Fisheries and Oceans Canada (DFO) since 2003, with a focus on Pacific hake, euphausiids (a major prey species of Pacific hake), and to a lesser extent pelagic rockfish. The CPS survey is conducted annually and is focused on multiple species including Pacific sardine, Northern anchovy, and Pacific and jack mackerel. Both surveys collect data throughout most of the continental shelf habitat along the U.S. west coast and, because of the transboundary nature of the target species, have strong international partnerships with Canada and Mexico, respectively. Both surveys also use acoustic-trawl methods to estimate biomass for stock assessment models but utilize different approaches to attribute acoustic backscatter to target species. We will provide an overview of this re-envisioning effort, including the overarching goal to maintain aspects of each survey's design integrity to continue to provide fisheries-independent data for sustainable fisheries management. We will also detail important design considerations, including accommodating multiple survey vessels, duplicating data sampling systems, maintaining the continuity of survey effort, and aligning temporal coverage with fish stock distribution. Ultimately, this effort to integrate pelagic surveys may present new opportunities to expand collaborations in support of emerging science, including studies of and applications for environmental DNA to stock assessment, broader oceanographic data collections, and survey methods innovation including machine learning tools for automated acoustic classification of pelagic fish.

Keywords: acoustic trawl survey, pelagic species, fisheries-independent survey

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