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Theme session Report

Managing fisheries bycatch of threatened species

Conveners: Eric Gilman (USA), Milani Chaloupka (Australia), Petri Suuronen (Finland)

Introduction

There is growing concern over the conservation status of marine megafauna that are exposed to incidental bycatch in marine fisheries. Fisheries can have large impacts on co-occurring bycatch species, particularly those with low reproductive potential due to long generation lengths, low fecundity and other life history traits that make them especially vulnerable to anthropogenic mortality. In addition to population-level effects from reduced abundance, bycatch removals can cause cascading effects through trophic food web links in some ecosystems. Bycatch can also cause reduced population fitness through fisheries-induced evolution. Bycatch results in costs to fisheries' commercial viability including from regulatory measures, requirements of market-based mechanisms and reduced fishing efficiency. Bycatch can also create risks to food, nutrition, and livelihood security.

Session Scope

The theme Session on Managing Fisheries Bycatch of Threatened Species session began with a keynote presentation by Amanda Hamilton of Tri Marine, one of the world's largest tuna companies. Amanda outlined the seafood industry perspective on the importance of information, management, and outcomes of fisheries bycatch of threatened species. Over the past two decades major seafood buyers have transitioned from a having a narrow focus on price and quality to a broad consideration of meeting third party ecological sustainability measures and crew labour standards —as well as complying with national and regional management body conservation and management measures that includes a growing suite of measures related to bycatch monitoring and management.

Theme Session C comprised 32 oral presentations and 16 posters that covered the following five broad areas:

- *Monitoring fisheries bycatch*, including developments in artificial intelligence and machine learning.
- *Risk assessment frameworks for data limited settings*, including case studies of fisheries-specific assessments of effects of fisheries on the bycatch of at-risk species, the estimated conservation status of populations of threatened species, and the employment of novel approaches such as a quantitative ecological risk assessment method that estimates instantaneous fishing mortality to compare to reference points of yield-per-recruit models, the use of data derived from smartphone apps and reconstructing historical effort data.
- *Bycatch management frameworks*, including tools for real-time fleet communication of bycatch, dynamic area-based management tools, criteria for evaluating alternative bycatch management strategies, approaches for assessing harvest control rules, and progress by a regional fisheries management organization – the General Fisheries Commission for the Mediterranean – in managing bycatch.
- *Predicting bycatch fishing mortality rates*, including the benefits of meta-analytic synthesis approaches to estimating components of bycatch fishing mortality, estimates of at-vessel and post-release mortality rates of at-risk species, handling and release methods to increase post-release survival, assessing the effects of fishing gear components (longline hook and bait type)

on species-specific fishing mortality rates, and assessing seabird bycatch risk using a probabilistic time geographic approach.

- *Bycatch mitigation methods*, including seabird, dolphin, elasmobranch and crab bycatch mitigation options for gillnet and trammel net fisheries; findings on acoustic reflector pearls in mitigating porpoise bycatch in gillnets; approaches to mitigate depredation and bycatch of the grey seal in Baltic Sea fisheries; bycatch mitigation deterrents for cetaceans in a sardine purse seine fishery; and the use of stereo cameras, artificial intelligence and an innovative gate to support real-time management of trawl bycatch and discards.

Session Outcomes and Conclusions

During the final section of the session, the participants identified and discussed the following key points raised during the session:

- Bycatch of at-risk species is a problem in marine capture fisheries in all regions, creating ecological and socioeconomic costs.
- There are numerous effective bycatch management measures that are also commercially viable – some applicable across gear types such as area-based management tools and real-time fleet communication, some gear and taxonomic group-species, such as acoustic pingers on gillnets and tori lines on longline and trawl fishing vessels.
- The innovation of new, promising gear technology bycatch solutions is ongoing, and especially effective through cooperative research with fishers.
- Deficits in fisheries management frameworks, including in monitoring, control, surveillance, and enforcement, pose substantial obstacles to robust bycatch management in some fisheries.
- Technological advances hold substantial promise to address monitoring deficits – including electronic monitoring, machine learning and smartphone application.
- Knowledge exchange such as through the ICES ASC promises to foster improvements in fisheries bycatch research and evidence-informed policy.

Contents

CM 15: Criteria for evaluating alternative management strategies for fisheries bycatch of threatened species

Eric Gilman, Milani Chaloupka, Petri Suuronen

Fisheries targeting highly productive species can have profound impacts on co-occurring species also susceptible to capture that have long generation lengths, low fecundity and other life history traits that make them vulnerable to anthropogenic mortality. There has been increasing concern over the sustainability of bycatch mortality of marine megafauna given their vulnerability to exploitation, ecosystem-level cascading effects from declines in abundance and reduced population fitness from fisheries-induced evolution. There has also been increasing attention to risks from bycatch to food, nutrition and livelihood security. The presentation identifies key criteria for the development of evidence-informed, integrated bycatch management strategies. We introduce the following criteria that can be applied to determine which alternative bycatch management measures best meet fishery-specific ecological and socioeconomic objectives:

- **Tier in a sequential bycatch mitigation hierarchy**: Interventions that avoid capture are considered before those that minimize catch risk. These are then followed by remediation interventions that reduce fishing mortality and sublethal impacts. Finally, either direct, compensatory banking or in lieu fee-based offsets of residual impacts that were not possible to avoid, minimize and remediate can be implemented as a last resort.
- **Relative strength of evidence:** Policy decisions should be guided by the relative degree of risk of error and bias and strength of evidence of the efficacy of alternative management interventions
- **Contribution to achieving objectives on population effects**: Bycatch mitigation methods can be assessed based on how they contribute to meeting objectives for mitigating catch and mortality rates of individual populations and stocks of threatened bycatch species.
- **Costs to commercial viability:** Some bycatch management measures may cause costs to economic viability, practicality and fisher safety.
- **Tradeoffs from multispecies conflicts**: Some measures can benefit one threatened bycatch species but exacerbate the catch or mortality risk of others. Bycatch management strategy evaluation can account for these conflicts so that tradeoffs are planned and acceptable.
- **Likelihood of compliance**: The probability that a prescribed bycatch management measure will be implemented, determined by the fishery-specific enabling environment. This accounts for whether fishers are expected to voluntarily employ the method based on costs to commercial viability and whether it constitutes a major change from conventional practice. The criterion also accounts for whether efficacy is affected by crew behavior, and whether the method is suitable given the capacity of the management system to conduct robust compliance monitoring.

Policy guided by these criteria promises to achieve ecological and socioeconomic objectives of bycatch management strategies.

Keywords: bycatch, fishing mortality, selectivity, sequential mitigation hierarchy

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CM 19: One study is not enough — Bayesian meta-synthesis of ocean-specific shark bycatch mortality rates

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A single study can never provide definitive insights into a conservation problem or a fisheries policy intervention. A synthesis of knowledge from many studies is essential to support evidence-informed fisheries bycatch mitigation policies. In accord with this principle, we conducted a meta-synthesis of summary estimates of shark bycatch mortality in pelagic longline fisheries. Sharks are one of the most species-diverse marine taxa that include apex and meso-predators essential for ocean ecosystem maintenance. Shark bycatch in pelagic longline fisheries and consequent direct (at-vessel) or indirect (delayed) mortality is a global conservation and fisheries management concern. We used Bayesian multilevel phylogenetic meta-regression models (clade-specific GAMMs with binomial likelihood) with informative predictors to aggregate a large dataset on summarized shark at-vessel mortality (AVM) rates for two major clades: the Carcharhiniformes with relatively high extant species diversity and the Lamniformes with low extant diversity. We accounted for clade-specific species-level variance by including a phylogenetic correlation matrix as a group-level effect derived from a comprehensive phylogenetic tree based on 1192 Chondrichthyan species. We derived robust estimates of AVM rates for 13 shark species that co-occur in both the Atlantic and Pacific Oceans with sufficient sample size to support ocean-specific comparison. We found that shark AVM rates were generally higher in the Atlantic Ocean compared to the Pacific, which we surmised is most likely a function of ocean-specific differences in pelagic longline fishing practices rather than intrinsic ecological or geographic risk factors. The Pacific blue shark (posterior predicted marginal mean = 0.09, 95% highest posterior density interval or HDI: 0.02-0.21) and the Atlantic tiger shark (0.06, 95% HDI: 0.01-0.17) had the lowest AVM rates, the Atlantic oceanic whitetip shark ca 0.27 (95% HDI: 0.08-0.51), the Atlantic bigeye thresher sharks ca 0.52 (95% HDI: 0.29-0.75), while the silky (0.58, 95% HDI: 0.29-0.83), scalloped hammerhead (0.54, 95% HDI: 0.23-0.79) and smooth hammerhead sharks (0.61, 95% HDI: 0.29-0.86) in the Atlantic had the highest predicted marginal mean AVM rates. Importantly, Carcharhiniformes such as hammerheads had the highest predicted AVM rates but species in this clade overall have a lower extinction risk relative to the Lamniformes such as the bigeye thresher. Robust phylogenetically-adjusted ocean-specific shark AVM rates are important for supporting evidence-informed bycatch policy for regional fisheries management authorities that could focus on ocean-specific hazard mitigation measures such as gear technologies to reduce catchability, improved handling-and-release practices and global bans on shark finning and trade.

Keywords: bycatch, shark mortality, phylogenetic regression, Bayesian inference, hazard mitigation

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CM 61: Modernizing historic fishery effort distribution data to advise risk reduction for the North Atlantic right whale

N. Willse[1], K. Staples, E. Summers, Y. Chen

The rapid decline in the population of North Atlantic right whales has forced development of entanglement risk reduction measures for the American lobster fishery and accelerated the transition away from traditional fixed gear fishing gear to ropeless methodologies. In the Gulf of Maine, these conservation efforts are stymied by a lack of fishing effort distribution and fixed gear spatial density data. Accurately describing the distribution and density of fishing effort is necessary for ropeless implementation plans to have any cost/benefit perspective. Collecting these data from fishers in real time is difficult due to the divisive nature of entanglement risk management and poor time series of fishery spatial behavior data. We explore historic data sources for ways to describe fishing effort distribution and trap density in the American lobster fishery. We suggest ways to develop these data to make them more representative of modern fishery behavior, while providing novel data to advise entanglement reduction efforts. These data can be used to advise management measures on the feasibility of ropeless technologies based on seasonal patterns in trap density, providing a gradient of ropeless implementation potential across spatial and temporal scales. Overlap of areas with high right whale occupancy and high ropeless practicability represent high value implementation sites. We outline this methodology for research use that is highly politicized and when broad scale stakeholder engagement yields poor returns. Linking fishing effort distribution with spatial abundance of lobster across the Gulf of Maine categorizes how well this pursuit fishery follows changing abundance trends. Successful linkage of the pursuit effort and abundance relationship allows estimation of effort distribution under climate change-forced population distribution shifts, and future bycatch risk to endangered whale species. This approach has applications for fixed gear fisheries across the northern Atlantic as these endangered cetaceans continue to shift distribution northward to pursue Calanus copepods.

Keywords: plastic, pollution, ecosystem service, economy, environment, sustainability

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CM 70: Post-release survival of mobulid rays in purse seine fisheries

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Manta and devil rays (collectively mobulids) are endangered and in decline in many regions of the world. Extremely low reproductive rates make mobulids sensitive to fisheries pressure and other anthropogenic impacts. Targeted fisheries for these species have been significantly restricted over the past decade, but incidental capture in both small-scale and industrial fisheries remains a significant threat. An estimated 13,000 mobulids are captured in tuna purse seine fisheries each year. In the majority of RFMO-managed fisheries, mobulid retention is now prohibited and individuals must be released. However, requirements for low-impact handling practices have only recently been implemented in RFMOs, and their efficacy is unknown. Only one study exists on mobulid post release survivorship, which estimated a survival rate of 43% for *Mobula mobular* in New Zealand, suggesting survivorship for mobulids overall may be relatively low. In the Eastern Tropical Pacific, post-release survivorship of mobulids in the Inter-American Tropical Tuna Commission (IATTC) jurisdiction was formerly assumed to be 0% due to poor handling practices such as lifting and release using gaffs and cables. A 2015 conservation measure implemented by IATTC prohibits these poor handling practices and encourages that mobulids be released quickly using alternative, improved practices. Further, a recent study of *M. mobular* suggests that improving post-release survivorship would be the most effective way of reducing the impacts of tuna purse seine fisheries on the eastern Pacific population. We report on a cooperative satellite tagging effort between researchers, management agencies, fishery observers, and fishing crews to study the post-release survival rates of mobulid rays in the ETP. Since 2018, we have deployed 51 satellite tags on four species of mobulids: *M. mobular, M. thurstoni, M. tarapacana,* and *M. birostris*. We find significant differences in survivorship among species, with very high survivorship in *M. mobular*, very low in *M. thurstoni*, and close to 50% in *M. tarapacana* and *M. birostris*. We report on the estimated effects of operational characteristics, environmental conditions, and handling and release procedures on survival probability. We discuss ongoing efforts by scientists and fishing crews to develop improved handling methods and reduce bycatch impacts on mobulids.

Keywords: Bycatch mitigation, manta and devil rays, industrial fisheries, satellite tagging

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CM 93: The potential of artificial intelligence to manage and reduce bycatch

Jose A. Fernandes-Salvador[1], Jon Ruiz, Igor Granado, Xabier Lekunberri, Izaro Goienetxea, Naiara Rodríguez-Ezpeleta, Iñaki Quincoces

Vessel digitalization and genomics, supported with big data integration and artificial intelligence, have shown potential to assist fisheries management. It has generated interest by the authorities as supported by a recent request on the application of artificial intelligence to fisheries by the European Parliament's Committee on Fisheries. These technologies are particularly relevant in reducing and managing bycatch, an activity that often relies on the integration of massive highly uncertain and noisy datasets of heterogeneous nature. For example, digital imaging coupled with artificial intelligence can assist cost-effective processing and classification of catches for monitoring bycaught species and their size. Big data integration coupled with artificial intelligence can contribute to reduce bycatch through improving operational species distribution fit-for-purpose forecasting, which often relies on the integration of massive datasets of noisy, highly uncertain, and heterogeneous nature. Genomic monitoring, including in situ analyses, can provide information about bycaught and potential bycatch species respectively, while also assisting species distribution modelling. Here, we present the potential avenues of vessels digitalization, big data integration and artificial intelligence, using recent developments tested under real environment conditions in tuna fisheries as example. In a first example, we show that the use of electronic monitoring using cost-effective low-resolution cameras installed on fishing vessels without additional reconditioning produced comparable with the results of port human sampling for landing estimates. In a second example, we show that the digitalization of fishing vessels and the use of probabilistic distribution models results in generation of environmental data. This data is key to reduce the risk of fishing bycatch species while aiming to mitigate and adapt to climate change. Finally, perspectives for future work are also given.

Keywords: vessels digitalization, big data integration and artificial intelligence

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CM 98: Finding our way through the forest: using machine learning to improve catch estimation

Jason Gasper[1], Jennifer Cahalan[2]

Federal fisheries off Alaska are managed based on near-real time estimates of catch generated using a combination of data from the North Pacific Observer Program, which deploys observers into the fisheries to sample catch, and industry reported information. For some species, catch is carefully monitored against limits that are set based on biological constraints and quota allocations, while other species are limited to control discard amounts. However, fisheries encounter a variety of species that have differing catch characteristics that are fishery specific such as time of year, locations fished, depth fished, size of vessel, and species targeted. Post-stratification is a widely used method for controlling the precision of catch estimates within a population. Strategic use of post-stratification may increase the precision of estimates when compared to designs without post-stratification. However, choosing fishery characteristics to define post-strata may be elusive due to the high dimensionality of fishery data and complexity of creating post-strata that are optimized for multiple species. We propose a novel application of random forest classification to explore multivariate post-stratification designs. These designs were evaluated by selecting the best performing trees from the ensemble using design-based estimation metrics and ex-sample skill testing. Results showed that the decision trees could identify fisheries using a combination of covariates that were not considered in previous estimation designs. This method allowed us to identify post-strata designs that are fishery-specific and thus improve the precision of the species estimates of discard used for management. Overall, these methods provide an innovative application of machine learning paired with design-based methods to define post-strata in complex estimation situations where fishery management is impacted by high variance estimates.

Keywords: random forests, machine learning, Alaska, catch estimation

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CM 104: Assessing selectivity and bycatch of endangered, threatened and protected species in the trolling and pole-and-line artisanal tuna fisheries

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Fisheries bycatch is one of the main recognised reasons for the loss of marine megafauna and consequently, several international conservation agreements require member states to monitor bycatch and minimize the impact of fisheries on non-target species. Particularly, the International Commission for the Conservation of Atlantic Tunas (ICCAT) encourage the collection and provision of information on bycatch with endangered, threatened and protected species (ETPs) in all fisheries in the ICCAT area, especially in data gap areas. The Spanish artisanal tuna fishing (troll and pole-and-line fisheries) implemented an onboard observer monitoring programme in 2016 to assess ETPs bycatch in the NE Atlantic, a hotspot area for ETP migration and wintering. Specifically, we (1) assessed fishing selectivity by analysing catch and discard composition, (2) identified main bycaught ETP species and (3) evaluated the mortality of bycaught ETPs. Tuna fisheries were very selective with more than 99% of the total catches corresponding to the target species and discards being minimal. The overall ETPs bycatch showed that animal captures were very unusual, but with occasionally high number of animals involved. 18 ETP species (3 marine mammals and 15 seabirds including shearwaters, storm-petrels, gulls, terns and gannets) were recorded during fishing operations. Only 3 seabird species were captured in the artisanal tuna fishery: the great shearwater *Ardenna gravis* (in trolling), the northern gannet *Morus bassanus* (in pole-and-line) and the northern fulmar *Fulmarus glacialis*. The species with the highest percentage of interaction (66.1%) was the great shearwater (39 individuals) that were mainly released alive (92.3%). The spatial location of the interaction matched the habitat preferences of the main interacting species: great shearwaters in oceanic waters and norther gannets in shelf-slope areas. Our results provide basic knowledge to advance in the assessment of ETPs bycatch, while contribute to reduce the knowledge gap detected in the ICCAT fishing grounds in the Northeast Atlantic Ocean.

Keywords: fisheries discards, fisheries bycatch, protected species, migratory seabirds, fishing selectivity, artisanal tuna fisheries

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CM 139: Spatial overlap of threatened groundfish with commercial fisheries highlights conservation priority areas in Eastern Canada

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Unintentional bycatch of threatened or vulnerable species is an urgent conservation concern, undermining the sustainability of otherwise healthy fisheries. To address such concerns, policy incentives to mitigate bycatch of at-risk species have become increasingly prominent. Bycatch risk however is challenging to quantify and mitigate, partially due to limited observer coverage. Novel analytical tools can help to develop a more thorough understanding of the spatiotemporal relationships among species-at-risk, their environment, and commercial fisheries. Here, we utilized fishery-independent surveys to quantify the spatial overlap between target and bycatch species to estimate bycatch risk and identify conservation priority hotspots on the Scotian Shelf off Eastern Canada. We utilized a novel generalized-linear-mixed-model framework incorporating spatiotemporal random effects to predict density patterns for three threatened groundfish species commonly caught in the commercial groundfish trawl fishery (Atlantic cod *Gadus morhua*, American plaice *Hippoglossoides platessoides*, and White hake *Urophycis tenuis*), as well as two species more targeted by these fisheries on the Scotian Shelf (Haddock *Melanogrammus aeglefinus* and Pollock *Pollachius virens*). Spatiotemporal estimates of relative density for at-risk groundfish between the years 2011-2020 were modelled using fisheries-independent research trawl survey data, then overlaid with that of commercially targeted species to identify hotspots of species co-occurrence. Additionally, density estimates for at-risk groundfish between the years 1983-1992, a period of higher stock abundance, were modelled to identify historically important habitats. Historically dense areas for all at-risk groundfish species were identified widely throughout the Scotian Shelf, while current spatial patterns were found to be more restricted around core habitats, most notably George's Bank, the Jordan Basin, and the Laurentian Channel. Areas of high co-occurrence between at-risk species and commercial targets were found to be concentrated across the western region of the Scotian Shelf, most notably on Emerald, George's, and Brown's Banks, suggesting an increased risk of bycatch in these areas. We propose that this method represents a powerful analytical tool to help improve our understanding of bycatch risk for any heavily depleted, threatened, or endangered fish species using widely available fisheries survey data.

Keywords: bycatch, species-at-risk, spatiotemporal models, data-limited species, ecosystem-based management

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CM 147: Cooperative development and adoption of bycatch release devices for vulnerable elasmobranch species with the Spanish tropical tuna purse seine fleet

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During the last five years scientists, fishers and stakeholders from the Spanish tropical tuna purse seine fleet have been collaborating in the development and testing of novel bycatch release devices (BRDs) to increase post-release survival of accidentally caught sharks and mobulid rays. Despite being a modern industrial fleet with high-tech fishing equipment, most on-deck release methods up till now were being executed manually in a rudimentary manner. Adult elasmobranchs are difficult to release from deck due to their large size and dangerousness, leading to crew safety concerns which at times resulted in safer but poorer release methods such as the use of hooks or nooses to manipulate animals. Through consultation with fishers, alternative release equipment is being developed to address these problems. The battery of new release tools include shark release velcros, shark ropes, mobulid sorting grids, shark handlers, bycatch release ramps and hoppers with ramps. These tools have been conceived to minimize bycatch handling that results in lower risk for crew and reduce release times and stress for the animals. Numerous trials have been conducted in the Pacific, Atlantic and Indian Oceans to test prototypes under real fishing conditions with the help of fishing companies. These tests are very useful to gain knowledge on the validity of the equipment designs and improve subsequent prototypes. Because all vessels have different deck configurations, some of the larger BRDs like ramps or hoppers require fine tuning their design to better accommodate them to the spaces available to not interfere with regular fishing operations (e.g., sac formation and brailing on deck). It is recommended that in the future newly constructed vessels consider the disposition of BDRs during initial design planning stages to fully integrate them into the fishing operation. None of these BDRs are yet mandatory, however, the Spanish fleet through this cooperative process is increasingly adopting them voluntarily. Regular workshops have been conducted with skippers, crew, ship-owners, and other stakeholders of the fleet to disseminate results and gain acceptance. These novel BDRs are redefining best release practices in tuna purse seine fisheries and provide a foundation for management bodies like tuna regional fisheries management organizations (tRMFOs) to update their bycatch release conservation measure standards.

Keywords: bycatch release devices, elasmobranchs, collaborative research, tuna purse seiners, bycatch mitigation

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CM 154: The effects of data class and assessment frequency on Management Procedure performance: the case of NE Porbeagle

Nathan G. Taylor[1], Mauricio Ortiz[2], Ai Kimoto[1], Rui Coelho[3]

Like operational control points in harvest control rules, we show that assessment frequency can be a key control variable in Management Procedure Performance. But the pattern in the effect of assessment frequency on Management Procedure performance depends on the class of data being used in the Management Procedure. As an illustrative example, we condition Operating Models on catch and CPUE time series of the northeast stock using life history and other parameters from the 2020 ICCAT assessment for the western porbeagle stock. The effect of assessment frequency on performance depends on the performance metric and data that are input to the Management Procedure so that for example increasing assessment frequency does not necessarily result in improvements in Management Procedure performance. Accordingly, assessment frequency should be considered as a control variable just like the others in the evaluation of any Management Procedure.

Keywords: simulation, stock assessment, depleted stocks, shark fisheries, tuna fisheries, population dynamics, bycatch, fishery sciences, fishing effort

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CM 168: No reduction in bycatch rates of seabirds observed in bottom set gillnets equipped with LED lights

Gudjon Mar Sigurdsson

Seabird bycatch in gillnets is a worldwide problem with few if any available mitigation tools. LED lights attached to the gillnets have been suggested as a potential solution, and a study in Peru showed promising results where bycatch was reduced by adding LED lights to bottom set gillnets. In this study the potential seabird bycatch reduction of LED lights was tested in a set gillnet fishery for Atlantic cod (*Gadus morhua*) in Iceland. In a paired trial, nets with and without LEDs were fished off a commercial gillnetter in western Iceland. The LED equipped net sets caught significantly more seabirds while a slight but statistically insignificant reduction in fish catches was also observed. Attraction of some of the species of seabirds towards the lights was also observed. Caution should be taken when implementing the use of LEDs on gillnets or trawls as while they might reduce bycatch of some taxa, it is possible that some species or groups of birds are attracted to the lights.

Keywords: Seabird-fishery interactions, Seabird bycatch, bycatch mitigation, gillnets, LED

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CM 170: How Shark Management Performance is Affected by Bycatch Indices: the effects of non-linear relationships between bycatch per unit effort and abundance on the CITES listed NE Porbeagle Sharks

Nathan G. Taylor[1], Mauricio Ortiz[1], Ai Kimoto[1], Rui Coelho[2], Enric Cortés[3], Rodrigo Forselledo[4]

One potential problem with applying any Management Procedure that requires an index of abundance for sharks is that they are often bycatch so that there are concerns about the index not being representative of the abundance non-target species. Using the example of the northeast Atlantic porbeagle shark stock, we run a set of simulations across a range of non-linear relationships between CPUE and abundance from hyperstable to hyperdeplete. We test a set of MPs that have previously demonstrated to meet minimum satisficing standards of having a least a 50% change that the stock is above the CITES Appendix 2 threshold of 20% SSB0, at least a 50% chance that the stock is above the level that supports maximum sustained yield, and at least a 50% of chance that fishing mortality is below the fishing mortality that produces maximum sustained yield. We show that for model-free MPs, the effect of hyper stability on MP performance is minimal. For the model-based MPs, performance is adequate provided that there is not excessive hyperstability or excessive hyperdepletion. A key research recommendation for any potential index-based Management Procedure is to determine if there is evidence for hyperstability of hyperdepletion, and to see if such effects can be removed through the standardization process.

Keywords: Simulation, Stock Assessment, Depleted stocks, Shark fisheries, Tuna fisheries, Population dynamics, Bycatch, Fishery sciences, Fishing effort

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CM 212: Potentialities of incentive-based approaches to reduce marine mammal bycatch

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Relative to top-down regulation, incentive-based bycatch reduction measures – such as bycatch levies, penalty-and-reward systems, cap-and-trade approaches, real-time incentives, market measures – provide vessels with greater flexibility to design solutions to reduce bycatch in creative and cost-effective ways. They can allow vessels to respond flexibly to changing market, environmental, technological and resource conditions. They also allow vessels to use decentralized and private information that is not available to the management authority.

Based on the discussions around case studies presented at a workshop held in Brest in March 2023, we review a variety of incentive-based approaches to reduce bycatch and explore the potential applicability of these approaches to address marine mammal bycatch. The scope of this review includes governance dimensions related to implementation of these approaches, concerns for political and legal feasibility, equity, information sharing, as well as compliance. We discuss the lessons learned from cases where these have been implemented and identify important operational aspects, barriers, and opportunities for their potential applicability to limit marine mammal bycatch in other contexts.

Keywords: incentive-based management, bycatch, marine mammal conservation, fisheries management

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CM 216: Can pearls protect porpoises? Application of acoustic reflectors in gillnets to reduce bycatch of harbour porpoises and other odontocetes while keeping fish catches high

Hannah S.[1], Thomas N.[1], Sara B.[1], Uwe L.[1], Daniel S.[1]

The incidental catch in fishing gear, especially in gillnets, is one of the main threats to marine mammals around the world, including harbour porpoises (*Phocoena phocoena*). Consequently, there is an urgent need for the mitigation of bycatch to protect marine mammals while maintaining fisheries. This study develops and tests fishing techniques that reduce the bycatch of porpoises in gillnets but ensure profitable catches of targeted fish species. As porpoises use echolocation for orientation, one way to achieve this might be to increase the acoustic detectability of gillnets by attaching small acrylic glass spheres to a gillnet as those pearls were found to have a strong echo. Therefore, the netting becomes acoustically "more visible" and the animals should recognize the so-called "*PearlNet*" as an impenetrable object. In addition to the bycatch reduction capabilities for harbour porpoises, a sufficient catch efficiency for target species is essential for a wide use in fisheries. To investigate the *PearlNet*'s effects on fish catches, catches of target fish species in the *PearlNet* were compared to catches of a conventional gillnet. Our study found no significant differences in the catch efficiency. The positive results of these trials show that in case bycatches of harbour porpoise can be reduced significantly, the *PearlNet* could be a fair compromise between fisheries interests and marine conservation goals not only in the Baltic Sea but also worldwide. Investigating the bycatch reduction of harbour porpoises by using the *PearlNet* compared to a standard gillnet in a large-scale experiment as well as an automatized production of *PearlNets* for providing large amounts of them will be the next steps.

Keywords: porpoises, gillnets, bycatch reduction

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CM 229: Advanced, spatially based and real-time, software solutions for fisheries management

Amos Barkai

Unintentional bycatch, in addition to be very harmful to the marine ecosystem, may also place significant financial implications when “chock” species, i.e., bycatch species, are overfished resulting in the fishing season of permitted species being prematurely terminated. The Northeast US scallop fleet decided to address this issue by introducing a real-time electronic bycatch monitoring and reporting system to their fishery. In collaboration with OLSPS, an international company involved in fisheries resource analysis, data collection and fisheries management, the Olrac Bycatch avoidance solution was developed. The main objective of this system was to have the fishers report their bycatch catch per unit effort (CPUE), mainly of the primary “chock” species (yellowtail flounder), and scallop catch in a real-time electronic format to a central database. This data is then anonymised and made available to the entire fleet to alert the fishers to areas of high CPUE for bycatch species. This allows fishers to make informed decisions regarding where to fish to avoid or reduce the occurrence of yellowtail flounder bycatch, which could possibly result in the premature closure of the access area.

The result was an end-to-end bycatch avoidance software tool based on the widely used Olrac commercial fishing eLog system. The Olrac bycatch avoidance utility includes two components: a) an on-board, GIS-based, vessel unit which was used to record and report bycatch CPUE and send them to the shore; and b) a web-based shore unit which is used to aggregate reported CPUE data and convert these CPUE data to a fleet level assembled spatial density map. These aggregated CPUE maps were then sent back automatically to the fleet fishing vessels at sea. This allows fishers to view bycatch CPUE density maps while still at sea and use them to avoid areas of high bycatch. The Olrac bycatch avoidance solution was tested successfully on-board 15 scallop vessels and is now waiting for a go-ahead for a full, fleet-wide, commercial deployment.

Keywords: sustainable fisheries, Olrac, electronic logbook, bycatch density maps

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CM 234: Vulnerability of skates bycaught in the demersal longline fishery in the French exclusive economic zones of Kerguelen and Crozet (Southern Ocean)

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Bycatch is a major threat to many marine megafauna species. While little is known about skate ecology, they are often bycaught in demersal fisheries. Knowledge of their biology and ecology are thus crucial to assess the status of the populations. In addition, it is necessary to understand the interaction with the fishery (intensity, frequency and magnitude) to develop effective fisheries management and bycatch mitigation measures. Since 1996, longline fishery occurs in the French subantarctic waters off Kerguelen and Crozet Islands. This fishery targeting Patagonian toothfish (*Dissostichus eleginoides*), captures three large deep-sea skates: *Bathyraja eatonii*, *Bathyraja irrasa* and *Amblyraja taaf.* The aim of the project was (i) to evaluate the resilience of these species investigating diverse biological characteristics (growth and reproductive biology) and (ii) to determine their susceptibility to fishery using parameters that describe the interaction, such as spatial overlap and post-release mortality. Overall, understanding these two components will allow us to determine skate vulnerability to fishing and to give inputs to fishery managers and industry to adapt mitigation measures and practices onboard to ensure effective conservation.

Keywords: bycatch, elasmobranchs, deep-sea skates, Southern Ocean, demersal longlining, *Bathyraja* sp.

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CM 235: A probabilistic time geographic approach to quantifying bycatch risk of seabirds

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Accounting for uncertainty is essential for precautionary approaches to managing risk of seabird bycatch in fisheries. However, there is no existing mechanism to explicitly quantify the uncertainty of individual birds encountering (co-occurring within 30 km) and attending (within 5 km) individual fishing vessels. Here we draw from the field of time geography to develop a method to measure seabird-vessel interactions probabilistically. The approach involves creating voxel-based probabilistic space-time prisms (PSTPs) to model the movements of individual birds and vessels, with trajectory data derived from bird-borne GPS devices and vessel Automatic Identification Systems (AIS). We intersected these PSTPs to quantify the probability of interaction between bird-vessel pairs over time and space. We demonstrate the approach with a case study of Toroa (Antipodean Albatross; *Diomedea antipodensis antipodensis*) interactions with pelagic longline vessels in part of the South Pacific high seas over five days in July 2019. We found 15 vessels within 150 km and three hours of two individual birds, yet interaction occurred with only two of those vessels. We visualised the probability of encounter and attendance over time and space and determined that these interactions lasted several hours each. The time geographic approach adds to existing tools to quantify seabird bycatch risk by providing an explicit measure of uncertainty of seabird-vessel interaction. When scaled up, the method could strengthen the evidence base for enforcement of existing bycatch mitigation requirements and advocacy for improved strategies. We provide a flexible methodological pathway and R scripts, the application of which would allow managers to estimate bycatch risk for multiple marine species, even those with lower-resolution positional datasets.

Keywords: seabird, fisheries, bycatch, time geography

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CM 258: Catch and bycatch in the tangle net fishery for spiny lobster (*Palinurus elephas*) off the south west coast of Ireland

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The commercial fishery for spiny lobster (*Palinurus elephas*) occurs off the southwest coast of Ireland. Although historically, prior to the 1970s, the main fishing gear used in the fishery was top entrance 'French Barrell' traps, spiny lobster are now targeted with large mesh tangle nets. These nets are efficient at capture of spiny lobster but have poor selectivity.

The species composition of the catch and by-catch was surveyed over a 6-year period from 2017-2022. Between 2-10 vessels provided data depending on year. A total of 2634 nmiles of tangle nets were surveyed across 15 vessels. The catch composition of the fishery included 4 species of teleost, 13 species of elasmobranchs, grey seal and 4 species of crustaceans. There was no cetacean by-catch.

Spider crab, spiny lobster and brown crab were the numerically dominant species in the catch. Other commercial species such as lobster, pollack, monkfish, turbot and saithe were caught regularly in low numbers. Captures of grey seal increased over the study period with a total of 396 individuals caught. Endangered and critically endangered species, including flapper skate, blue or common skate, angel shark and white skate, were caught in low numbers. In addition, and in order of abundance, spurdog, thornback ray, dogfish, spotted ray, blonde ray, painted ray, sting ray, undulate ray and cuckoo ray were recorded.

The spatial and temporal distribution and abundance patterns of these species were examined. The results confirm their presence in the Tralee Bay area and the importance of that area as a refuge for these endangered species. The by-catch of critically endangered species poses a high risk to the continued presence of these species in Irish waters and indeed in European waters given that the area is known to hold the last European remnant populations of species such as angel shark and white skate.

Grey seal by-catch was related to the distance between fishing events and the nearest seal colony haul out site. Sixty % of seals were caught within 10km of the haul out site. The high by-catch of grey seal is a significant risk to the seal colony. It is unlikely that it can sustain this level of by-catch mortality without inward migration from other colonies.

Keywords: spiny lobster, tangle net, bycatch, elasmobranchs

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CM 260: Reducing seabird bycatch from gillnets in the Baltic Sea: a toolbox approach

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Over three billion people's livelihoods depend on marine and coastal resources, and the market value of these resources and related blue industries is estimated at US$3 trillion yearly, equivalent to around 5 % of the global gross domestic product (GDP). Plastics make up around 80% of the total waste discarded in the ocean, and each year, over 13 million metric tons of plastic enter the marine environment threatening biodiversity and affecting ecosystem services upon which the economy of coastal countries depends. In this sense, we investigate how plastic waste influences the provided ecosystem service by coastal and marine environments using the Millennium Ecosystem Assessment conceptual framework (known as Ma conceptual framework). The analysis provides us with basic data and information about the impact of plastic on marine ecosystem services and highlights the need to consider managing our plastic waste mainly because each ecosystem service feed into another.

Keywords: seabirds, marine ducks, gillnets, bycatch, mitigation methods

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CM 280: Bio-inspired acoustic beacons to limit fishery by-catch of common dolphins *Delphinus delphis*

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Fishery by-catch is the main direct threat to marine mammals globally. Acoustic repellent pingers have been developed to reduce dolphin by-catch. However, mixed results regarding their efficiency have been reported worldwide on different species and fishery. Within the DOLPHINFREE project "Dolphins free from fishery by-catch", we develop prototypes of a new generation, bio-inspired, acoustic beacon. They emit returning echoes of echolocation clicks of a common dolphin *Delphinus delphis* from a fishing net to help dolphins in detecting its presence. Ultimately, the objective is to reduce their by-catch in the Bay of Biscay, France. In addition, a passive acoustic listening system to identify dolphin presence, allowing beacon emission only when detected, has been developed by the LICADO project and benefits the bio-inspired beacon. Furthermore, prototypes of energetic modules are developed to increase beacon autonomy and to facilitate fishermen handling. Several energy options have been studied and assessed (i.e., piezo-, tribo-, hydro-, solar electricity), among which induction has finally been identified as the most suitable possibility for easy beacon recharge. Behavioral responses of common dolphins in response to beacon emission have been assessed by experiments at sea during summers 2020 and 2021. The results highlighted that the device led dolphins to echolocate and communicate more (x2.46 in mean echolocation clicks and x3.38 in mean whistle duration, respectively), thus would favor net detection, and calmly left the source emission's area. Tests made during 1043 fishing operations (FOs) of professional gill netters, to assess the practicality and to provide preliminary data on the efficiency of the new device, have been performed with observers onboard during 228 days at sea in 2021 and 2022. Preliminary results being encouraging, complementary tests of bio-inspired acoustic beacons during FOs of professional gill netters, including more boats and number of FOs, are planned to assess statistically its efficiency in reducing common dolphin by-catch.

Keywords: bio-acoustics, etho-acoustic, cetaceans, echolocation, bio-inspiration, sound processing, Bay of Biscay

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CM 284: BEAM me up! Developing a Bycatch Evaluation and Assessment Matrix to support bycatch advice for sensitive species

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The 2022 ICES Working Group on Bycatch of Protected, Endangered and Threatened Species (WGBYC) developed a standardized and repeatable framework called the Bycatch Evaluation and Assessment Matrix (BEAM) to support the ICES advice process on the impact of commercial fisheries on Protected, Endangered and Threatened Species (PETS). The estimation of bycatch rates from sampling programs is essential to understanding the impact of fisheries on those species. Total mortality estimates rely on accurate estimates of total fishing effort, and reliable data on PETS bycatch events from representative monitoring of fishing fleets. Where bycatch of a given population of PETS or sensitive species occur in multiple fisheries, data need to be integrated in the final bycatch estimation. These multiple estimation processes come with varying degrees of precision and accuracy and the challenge is to know when those are considered sufficiently acceptable to support bycatch advice. To assess monitoring data quality, the BEAM is underpinned by a fleet simulation model, SCOTI, in which bycatch observations were modelled with varying types and levels of monitoring bias. Due to the diverse nature of fishing practices, these simulations help to highlight métiers where levels of sampling bias may preclude the production of robust bycatch estimates and can guide minimum requirements for monitoring sampling designs to meet acceptable levels of bias and uncertainty. We estimated variability in bycatch per unit effort (BPUE) estimates within fishery and between country and years to assess whether this variance may be deemed large. The results of simulations indicated that large variability may present conditions with high risk that BPUE estimates could be biased if factors affecting this variability are not considered in the estimation process. The BEAM is also informed by criteria on data availability such as: total fishing effort, population abundance estimates and existing bycatch removal thresholds. A traffic light approach is used to facilitate the interpretation and application of the BEAM results. Here we demonstrate the value of the BEAM in two real mixed fisheries scenarios: bycatch of loggerhead turtles in the Adriatic Sea and grey seals in the Celtic Seas. These real-world scenarios show that a simulation-based assessment of monitoring data quality can help inform bycatch advice and highlight changes in sampling designs to improve the reliability of bycatch assessments. The BEAM offers an adaptive assessment that evaluates the availability and quality of inputs to inform advice on the impacts of fisheries bycatch to PETS.

Keywords: sensitive species, bycatch estimation, advice provision

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CM 286: Multifaceted effects of hook and bait types on target/non-target species for pelagic longline fisheries and consideration for bycatch management

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The pelagic longline fishery, in an effort to reduce bycatch of sea turtles, have developed and deployed fisheries bycatch mitigation techniques such as replacing J/tuna hooks and squid bait with circle hooks and whole fish bait. However, little emphasis has been placed on the side effects of bycatch mitigation measures on endangered species other than target bycatch species. Several previous studies of the side effects have been marred by lack of control for the covariates. Here, based on long-term data obtained from research cruises by a pelagic longline vessel, we examined the effects of using circle hooks and whole fish bait to replace squid bait on the fishing mortality of target and non-target fishes, and also bycatch species. A quantitative evaluation analysis of our results, based on a Bayesian approach, showed the use of circle hooks to increase mouth hooking in target and bycatch species, and their size to be proportional to the magnitude of the effect. Although deploying circle hooks increased catch per unit effort (CPUE) and fishing mortality per unit effort (MPUE), changing the bait species from squid to fish clearly had a far greater impact on shark mortality than the use of circle hooks. Because the impact of the introduction of bycatch mitigation measures on species other than the focused bycatch species is non-negligible, a quantitative assessment of bycatch mitigation-related fishing mortality is critical before introducing such measures.

Keywords: circle hook, finfish bait, fisheries management, pelagic longline fishery, sea turtle, sharks

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CM 290: Projecting the future distribution of target and bycatch species in the California Current System

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Marine biodiversity is experiencing unprecedented challenges due to anthropogenic climate change. Highly migratory species are some of the most responsive to climate stressors, as they can rapidly alter their distributions to avoid unfavorable conditions. The California Current System is one of the world's most productive systems and provides important habitat and foraging grounds for many highly migratory species, including target and bycatch species. However, it is unclear how these species will utilize this system in the future as climate change alters the physical and biological environment. Here, we project daily habitat suitability from 1980-2100 for one target (swordfish) and two bycatch species (California sea lion and leatherback turtle) in the California Current System using an ensemble of three high-resolution (~10 km) downscaled ocean projections under a high emissions scenario, the Representative Concentration Pathway 8.5 (RCP8.5). We calculated future niche overlap between target and bycatch species and changes in the direction and distance of distributional shifts and core habitat area for each species. Some of the species are expected to shift more than 100 km northwest from their current center of gravity while others shift less than 100 km or constrain their habitat toward the coast. California sea lion was projected to lose habitat area (~66%) by the end of the century, while swordfish and leatherback turtles would gain habitat (~50%) in response to climate change. Because shifting species distributions can create mismatches between existing management areas and conservation goals and result in unanticipated impacts and significant socio-economic consequences, our species projections provide a valuable resource for proactive management of protected and fished species under climate change.

Keywords: climate change, species distribution model, highly migratory species, global climate model, California current system, downscaled ocean projections, habitat suitability index, center of gravity

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CM 294: Mitigating harmful interactions between the Baltic grey seal and fisheries

Petri Suuronen

Grey seal populations in many regions of the northern Atlantic and the Baltic Sea are exhibiting strong recoveries from past depletions. These recoveries represent a remarkable conservation success, but also have created a serious problem for the fisheries sector. The unintended consequences on fisheries have created complex issues for resource managers to solve. In the northern Baltic Sea, mitigation technologies have been intensively developed to support the fishing sector and to reduce the entanglement of seals in fishing gear. This presentation assesses benefits and implementation costs of seal-proof gear modifications and alternative fishing practices as well as technological instruments such as acoustic deterrent devices (ADDs) that may help in mitigating the conflict and reducing the entanglement. It is essential to understand that while preventing seals from taking food from fishing gear, seals are also being protected. It is a win-win situation.

Keywords: seal-fishery conflict, catch losses, entanglement, solutions

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CM 303: Additional weight to mitigate seabird bycatch in the Mediterranean: A pilot study in small-scale demersal longliners

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As top predators, seabirds are key elements of marine ecosystems, and at the same time represent one of the most threatened groups of birds. Highly oceanic species, such as petrels and shearwaters, are characterised by particularly long life-span and low productivity, which make them extremely vulnerable to anthropogenic pressures causing adult mortality. Among these pressures, fisheries bycatch is regarded as the primary source of adult mortality at sea. Previous studies roughly estimated about 5000 shearwater deaths caused by Mediterranean Spanish small-scale demersal longliners annually, including the Critically Endangered Balearic shearwater, which breeds exclusively in the Balearic Islands. To avoid these undesired catches, several mitigation measures have been recommended by ACAP. Among them, the addition of weights in lines to increase sinking speed have been suggested as a feasible measure for industrial bottom longliners. However, little research has been performed regarding small-scale fleets. Following preliminary trials, we tested a configuration with 2 kg of weight every 25 hooks, and compared it with "standard" configurations, which use smaller and more spaced weights. The trials (n=9) were conducted in a 6.7 m length bottom longliner in Ibiza (Balearic Islands, Spain). Speed to reach 5 and 10 m depth, as well as the corresponding access window (horizontal distance travelled by the line when reaching 5 and 10 m depth) where measured by means of *Time Depth Recorder* devices attached to the lines. There was an increase in sinking rate of experimental relative to control lines (without weights), mostly in the first 5 m depth (45.8%; Welch Two Sample t-test, $p = 0.0024$), and less pronounced when considering 10 m depth (35.7%, not-significant; $p = 0.13$). Similarly, the 5 and 10 m-access windows average were reduced from 81.8 ± 8.3 m to 63.7 ± 19.9 m (Welch Two Sample t-test, $p = 0.0052$) and from 160.0 ± 35.0 to 134.7 ± 46.9 m (Welch Two Sample t-test, $p = 0.2765$), respectively. Furthermore, 5 events of bycatch were recorded during operations with control lines, while no bycatch occurred when using the experimental configuration. On the other hand, several drawbacks were observed by the collaborator fishermen. For instance, likely difficulties in releasing a bird if hooked in the weighted line and the risk of gear loss in rocky bottoms. Thus, despite these promising results, more research is needed to overcome these inconveniences.

Keywords: seabirds, bycatch, mitigation, shearwater, longliners

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CM 304: Simulations for Characterising Optimal moniToring Implementations to inform the BEAM monitoring advice framework

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Precise and accurate bycatch rates (BPUE) of sensitive species are needed to inform bycatch advice. Traditional approaches to estimate precision and accuracy, based on repeated sampling, are difficult to implement in real world fisheries. Many factors, related to either species and fishing practices, affect BPUE and are rarely identified exhaustively. Estimates of BPUE may be biased when monitoring data violate the assumptions of the sampling design, for example when observer coverage does not capture unknown variation in bycatch rates. At the same time, the magnitude of bias may in some cases be acceptable because it falls within the margin of errors of operational bycatch management. We therefore need to understand what sampling designs can result in BPUE estimates whose accuracy and precision fall within acceptable ranges for given fisheries. Here we developed a simulation platform, SCOTI, to investigate how fishing characteristics, reporting, and monitoring design interact to influence bias and precision of BPUE estimates. First, a representative virtual fishing fleet and its associated bycatches during a year are created to obtain a simulated 'true' BPUE. On this virtual fishing year, we then apply different monitoring sampling strategies to assess to what extent the estimated BPUE from monitoring differs from the 'real' BPUE. SCOTI is a flexible tool with possibilities to investigate the influence of (a) fishing properties (e.g., gear types, fishing intensity, fleet heterogeneity and fleet size), (b) monitoring designs (total effort as well as allocation of effort among vessels and hauls), (c) bycatch detection probability and (d) incomplete fishing effort reporting. We report on the effect of varying BPUE within a fishery of a particular gear type (e.g., métier 4) between different fishing characteristics (e.g., métier 6) but designing sampling without considering these high-resolution fishing characteristics. We show that minimum required monitoring intensity, as well as vessel coverage, depend on the difference in BPUE between the fishing characteristics unrecognised in monitoring. This guidance can be used in semi-quantitative instances when BPUE variance is not precisely known but its order of magnitude can be qualitatively appraised. SCOTI was initially developed as part of the ICES WGBYC BEAM and is made publicly available, as a beta version, so users worldwide can use it and build on the platform to account for additional factors affecting BPUE estimates.

Keywords: sensitive species, bycatch rate, BPUE, bycatch monitoring, simulations

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CM 314: Accidental bycatch of birds and seals in passive commercial fishing gear of Estonian coastal fishery

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Managing fisheries bycatch of threatened species is seldomly studied together with fishing effort data. This study was conducted to describe bycatch of seals and birds from passive commercial fishing gear (fykes and gillnets) in Estonian coastal areas of the Baltic Sea during 2020 and 2021. Coastal fishermen registered bycatch data 2021 and at the same time official data on fishing effort was analysed to calculate catch per unit effort of bycatch and to estimate bycaught individuals over all coastal fishery. Altogether 248 bycatch cases were registered. Bycatch of four mammal (grey seal, ringed seal, Eurasian beaver and Eurasian otter) and 15 bird species were registered. Grey seal was the most abundant mammal species registered (52 registered, estimate of 110±22 individuals caught in coastal waters in 2021). Two ringed seals caught allowed for estimated bycatch of this species to 20 (±10) individuals in Estonian coastal areas in 2021. Other mammals were registered as single individuals. From 59 bycatch cases of mammals 52 individuals were caught with fykes and 7 with gillnets. In case of birds, the most abundant species caught in passive fishing gear was great cormorant (65 registered in study, estimate of 286±48 individuals caught in 2021). From 139 bycatch cases of birds 68 were caught in fykes and 71 in gillnets. In comparison to previous analogous studies from Estonian coastal fishery, this study demonstrated considerably lower bycatch estimates for seals than suggested before (260-2157). This could result from methodological differences, but management effects may be also likely. Current study also indicates that the abundance of bird species in the area is positively associated with bycatch estimate of the species. This is illustrated by replacement of long tailed duck as the most numerous bird caught in fishing gear during 2000-s with great cormorant in current study. Current study also revealed that 16.6% of birds that were caught in passive gear were released alive.

Keywords: bycatch, catch per unit effort, waterbirds, passive gear

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CM 318: Long-term study evaluating factors affecting bycatch of harbour porpoise (*Phocoena phocoena*) and harbour seal (*Phoca vitulina*), including pinger effectiveness, in Swedish gillnet fisheries

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Incidental bycatch in gillnet fisheries is considered one of the main threats to harbor porpoise populations worldwide. Such bycatch is depending on several factors, including biotic factors such as porpoise distribution and behaviour, as well as factors related to the characteristics of the fisheries.

One porpoise bycatch mitigation method proven to be effective in gillnet fisheries are acoustic deterrent devices (pingers). In an ICES' advice from 2020, pingers were recommended to be used in the Baltic to reduce the bycatch of the endangered Baltic harbour porpoise. However, type of pinger was not specified, most likely due to the fact that pingers available on the market have not been tested in fishing trials or were audible to seals. In the Baltic, the large and increasing grey seal *(Halichoerus grypus)* population is causing a serious conflict with the coastal fisheries, due to economic losses. Pingers audible to seals may lead to the "dinner bell" effect, i.e., seals associating the pinger sounds with easily accessible food, leading to increased depredation and seal bycatch.

In this study we evaluate several factors, including two types of pingers which have not been tested in a long-term fishery trial before, potentially affecting the bycatch of harbour porpoises and harbour seals in Swedish gillnet fisheries. Fishery trials were carried out in collaboration with 14 fishermen, operating along the Swedish west coast from 2018 until 2023. The fishing boats were equipped with camera systems documenting the fishing operation. The fishermen operated the onboard systems along with filling out protocols with information such as net mesh size, height, and length and soak time. Data from 960 fishing days, 2550 net links emptied was evaluated. A Generalized Additive Model was used to analyze the bycatch of porpoises and seals in relation to environmental and fisheries variables. The results show that pingers significantly reduced harbour porpoise bycatch, one pinger type being more effective than the other. Mesh size, effort (soak time * net length), year and number of bycaught harbour seals also significantly affected porpoise bycatch. Seal bycatch on the other hand was not affected by pinger use. Seal bycatch was affected by net mesh size and height, effort, and number of bycaught porpoises. These results give us a quantitative understanding of the variables involved in porpoise and seal bycatch, which can help inform management on how to mitigate bycatch in the gillnet fisheries, and on what fisheries needs to be targeted.

Keywords: bycatch of protected species, pinger, harbour porpoise, harbour seal, mitigation measure, long-term fishery trial, gillnet fishery

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CM 327: The impact of commercial fisheries on tope shark (*Galeorhinus galeus*) in the northeast Atlantic

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As higher trophic level predators, species such as tope shark (*Galeorhinus galeus*) are essential for maintaining healthy marine ecosystems. Therefore, quantifying fishery impacts is needed to ascertain the level of threat, population status, and to gauge the efficacy of current management measures. In UK legislation, tope cannot be targeted. There is a prohibition on the landing of tope in Scotland and a prohibition of landing longline-caught tope elsewhere. Within the British waters of England and Wales the quantity of tope bycatch that can be landed by other gears is limited to 45 kg per day. To assess the impact of fisheries on tope in British waters of the northeast Atlantic, and the efficacy of current management practices (and regulatory discards), data from the Cefas Observer Programme as well as landings data from the Marine Management Organisation have been analysed. Findings highlight those métiers in which tope is most vulnerable, and the associated discard/retention patterns. Overall trends show a reduction in retained individuals over time (aligning with increasingly strict legislation) but distinct differences in bycatch levels across gears and locations around the British Isles. These differences can be further broken down by season, length class, and sex of individuals. From the distribution and interactions shown in these data, the next steps are to estimate total discards (and estimated dead discards) for each métier and overall population-level impacts.

Keywords: tope shark, fisheries, bycatch, discard, northeast Atlantic

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CM 340: That's all we Know: Inferring the status of threatened deep-water shark *Dalatias licha* based on an integrated assessment

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The kitefin shark *Dalatias licha* (Bonnaterre, 1788) is a widely distributed deep-water species, living at depths around 200 m and classified as near threatened by the International Union for Conservation of Nature's (IUCN). Historically, the kitefin shark has been caught as both target and by-catch in benthic trawl, bottom longline, and gillnet fisheries in the Atlantic and Mediterranean Sea. The highest catches were recorded by Portugal and had the Azores archipelago as the main origin, with Azorean catches representing about 80% of the total landings in biomass between 1988 and 2002. The economic interest in the kitefin shark in the Azores started in the early 1970s for food consumption and the squalene content of its liver oil. Despite being closed in the late 90s, fisheries targeting the under-assessed deep-sea kitefin shark *Dalatias licha* are being reconsidered in the Azores archipelago. In this study, we conducted demographic analyses based on age-structured life tables to assess basic population parameters and vulnerability to hypothetical harvest rates, as well as an exploration of fishery-dependent (historical commercial catches) and fishery-independent (scientific surveys) data with surplus production model in continuous time to reconstruct stock trajectories and to estimates fisheries management reference points. Demographic parameters for the kitefin shark are typical of low-productivity species that exhibit slow growth and late maturation, and population growth rates without fishing pressure is of only about 5% per generation. Surplus production models showed that commercial fisheries exceeded maximum fishing mortality rates (F_{MSY}) in all exploitation periods and caused median biomass to be lower than its lower limit (B_{MSY}), which translates to overfishing scenarios for considerable time periods. The model described increasing biomass trends and points to a potential recovery after a period of 20 years. Finally, the combined results showed that this species is very highly sensitive to overfishing, requires a long time-period to recover the biomass to sustainable levels and should not be exploited by commercial fishery.

Keywords: Elasmobranch fisheries, deep-water sharks, demographic analysis, stock assessment, threatened species

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CM 344: Statistical analysis of the cetacean bycatch monitoring programme on board the Spanish set gillnet and bottom pair trawl fleets in the Bay of Biscay

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The first year of data, from October 2020 to September 2021, of the Spanish cetacean bycatch observer programme was analyzed to explore the following issues: a) representativeness of the sampling frame; b) estimation of bycatch per unit of effort (BPUE); and c) sampling coverage. Regarding the first issue, the probabilistic sampling design of the Spanish cetacean bycatch monitoring programme, with record of refusals, has allowed to address bias analysis, find the source of bias and correct it in the parameter estimation. Secondly, in relation to the estimation of nominal BPUE, several aspects have been decisive: to use an estimation process disaggregated by domains configured by the combination of fishing gear (métier) and fishing area (ICES Division), given the different bycatch rates between fleets and fishing grounds; as well as recording the direct scientific observation, which is essential in the pair trawl fleet when it is monitored by a single observer located in a single boat. Finally, in relation to the coverage rates necessary to achieve statistical robustness with rare events such as the bycatch of marine mammals, our results point to levels around 30% sampling coverage, depending on the métier and its bycatch rate. The results obtained allow to conclude that the current Spanish European DCF at-sea sampling programme (which include the sampling of by-catch of non-target protected species) and the Spanish cetacean bycatch monitoring programme provide similar results of cetacean bycatch for some of the ICES Divisions and métiers monitored. On the other hand, achieving the high levels of sampling coverage necessary for the proper estimation of the bycatch of rare events, which represents an economic and logistical challenge, it is necessary to explore the combination of monitoring based on scientific observers at sea with other alternative methodologies, such as the use of electronic monitoring, improvement of recording of bycatch in official control logbooks, etc.

Keywords: Cetacean, bycatch, at-sea sampling, monitoring programme

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CM 351: Are fishers' views of bycatch likely to influence their uptake of appropriate mitigation actions to avoid it?

Julia Calderwood

The bycatch of threatened species represents a serious threat to the delicate balance of our oceans, having far reaching impacts on food web structures, habitat stability and marine ecosystem health. While fishers affirm that they do not like having to discard anything if it is already dead, as they recognize it represents a lost resource, it is hypothesized they do not view all components of unwanted catch in equal measures, and this may influence subsequent efforts to avoid and reduce bycatch. To explore this hypothesis observer data from the Irish demersal fleet was examined to determine the proportion of bycatch by species across fisheries and regions. The difference between target species and non-target species that were caught and later discarded were identified to help better examine the different components of bycatch in the context of examining fishers' opinions towards these.

A mixed method approach was then adopted to compare the quantitative data on bycatch in the fleet with the recollections of industry stakeholders regarding the key bycatch species they recalled in catches. Interviews and surveys were conducted with two groups of fisheries stakeholders, i) skippers of fishing vessels, ii) fisheries observers. Both groups were asked about their main recollections on the key landed and discarded species from their experiences of working at sea. The inclusion of these two groups allows for consideration of how those who have an economic interest in fishing operations may recall catches differently from those who are working independently of fishing vessels. Key differences between the quantitative and qualitative datasets were identified to determine which bycaught species were or were not mentioned by fisheries stakeholders. This allows us to consider how these views may impact upon the uptake of bycatch avoidance tools and techniques. Next stages of this research include returning to stakeholders to discuss the results and ensure they have been correctly interpreted. This work contributes to the understanding of the social and economic factors that may influence how fishers view and regard bycaught species and allows us to consider how best to mitigate against such catches. The inclusion of fishers' knowledge in this study is essential to account for different stakeholder perspectives and to build collaborative relationships to develop bycatch mitigation solutions that are widely acceptable, feasible and effective.

Keywords: discards**,** bycatch**,** selectivity, fishers' knowledge

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CM 357: Spatio-temporal relative risk of bycatch for four protected cetacean species commonly found in the Irish EEZ

Luke Batts[1], Dave Reid, Patricia Breen

Ireland's waters are thought to be one of the most important habitats for cetacean species in Europe. In this analysis we investigate the relative risk of bycatch of four protected species commonly found in Irish waters: harbour porpoise (*Phocoena phocoena*), common bottlenose dolphin (*Tursiops truncatus*), common minke whale (*Balaenoptera acutorostrata*), and the short-beaked common dolphin (an ecotype of the common dolphin *Delphinus delphis*). Modelled abundance distributions for both winter and summer seasons were obtained from the relatively recent ObSERVE aerial survey report and used to conduct a Productivity Susceptibility Analysis (PSA) for a range of fishing gears. Previous PSAs for the region have focussed on less species, specific gears, or have not included a spatial/and or seasonal aspect. This study aimed to conduct a comprehensive PSA for these four species. Results highlight the spatial and seasonal variability of relative risk of bycatch, reflecting previous findings for common dolphin and harbour porpoise, as well providing useful additional information for minke whale and bottlenose dolphin in the region.

Keywords: bycatch, cetaceans, risk, PSA

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CM 358: Common dolphin bycatch in bottom trawling: the role of the catch composition

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In the Bay of Biscay, the common dolphin *Delphinus delphis* has been subjected to high rates of bycatch since 1990. In recent years, bycatch has increased up to unsustainable levels, turning the conservation status of the species in the European Marine Atlantic into unfavorable/inadequate. Bycatch rates of common dolphin in the Bay of Biscay vary throughout the year, being especially high during winter. During this season, both Spanish and French trawlers and netters (gillnets and trammel nets) have been identified as potential main contributors to these rates. Recent studies have modelled common dolphin bycatch by using operational variables (e.g., haul duration) or oceanographic variables (e.g., temperature). In this study, we focus on the data collected by the Observer program on the Basque bottom trawling fleet to investigate the role that fishery catch (target and accessory species) play in the probability of occurring bycatch and in the number of individuals caught. Since the analysis of bycatch, as a rare event, is characterized by a high percentage of zeros and a high variability, we have modelled bycatch data using two-stage models, also called “hurdle models”. Although more data would be needed to get more robust estimates, our preliminary results suggest that the bycatch of common dolphin is related to the catch of small pelagic fishes (e.g., anchovy). These species form part of the diet of the common dolphin and would also explain the lower bycatch rates in summer, when the species is supposed to feed on mesopelagic species located in offshore waters.

Keywords: protected species, trophic relationships, incidental catch, trawling

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CM 360: Exploring potential dynamic time-area closures to reduce silky shark bycatch in the European tropical tuna purse seine fishery operating in the Eastern Atlantic Ocean

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Effective fisheries management has been instrumental in improving stock status for commercial target species of tunas and billfishes globally, as well as reducing risk for non-target species. Yet extinction risks in oceanic sharks being incidentally caught in these same fisheries remain increasing. Reducing the incidental catch ("bycatch") of shark and ray species remains a priority in tuna Regional Fisheries Management Organizations (tRFMOs). Most of the management measures in place have focused on minimizing the mortality of the incidental catch and not actually avoiding the interactions of fisheries with vulnerable shark and ray species in space and time. Spatial measures such as dynamic or fixed time-area fishery closures could complement existing measures to reduce the interactions between bycatch species and fisheries, while preserving, or even increasing, target species catch. In this process, one first step is to identify the areas of potential interest to apply spatial management measures by understanding where and when target and bycatch species co-occur. Silky shark (*Carcharhinus falciformis*) is the main shark bycatch species in the tuna purse seine fishery targeting tropical tunas - skipjack (*Katsuwonus pelamis*), yellowfin (*Thunnus albacares*), and bigeye tunas (*Thunnus obesus*) in the tropical Atlantic Ocean. The main objective of this study is to identify areas and periods of time with persistent high silky shark bycatch rates and low target tropical tuna catch rates in the tropical Atlantic Ocean to test their potential to apply dynamic time-area fishery closures. For this, we will use the European Union (French and Spanish) tropical tuna purse seine fishery observer data collected between 2010-2022. The ultimate goal of our analysis is to provide managers with effective spatio-temporal management options so they can evaluate trade-offs between protecting silky sharks by reducing their bycatch in tropical tuna fisheries and ensuring economically viable target fisheries without foregoing catches of target species.

Keywords: bycatch species, silky shark, tropical tuna purse seine fishery, dynamic time-area closures, eastern Atlantic Ocean

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CM 361: Deterrent devices reduce bycatch of cetaceans in the Portuguese sardine purse seine fishery

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Bycatch of common dolphins (*Delphinus delphis*) is known to occur in the Portuguese Sardine Purse Seine Fishery (SPSF) and could be a significant contributor to the mortality of the species in Portuguese waters. From 2020 to 2021, a pilot trial using an acoustic deterrent device called the DDD (Dolphin Deterrent Devices, manufactured by STM Industrial Electronics, Italy), was undertaken in the SPSF operating off the south coast (Algarve) of the Portuguese mainland to evaluate the devices effectiveness at reducing cetacean bycatch. Data collection was carried out by onboard observers and vessel crew observers. The data were analyzed to compare bycatch rates (Bycatch per Unit Effort - BPUE) between fishing operations (hauls) with and without acoustic alarms. 38 common dolphins were caught in 228 hauls not using the alarm, 9 of which were registered dead and the remaining released alive, while no bycatch was observed in 233 hauls using the alarm. Bycatch rates were 0.056 and 0, for the control and acoustic device treatments, respectively. Modelling and statistical tests on the data using two-stage "Zero Adjusted Poisson" regression models, indicated that the differences between hauls with and without alarms in both the proportion of hauls with bycatch, and the mean number of specimens per bycatch positive haul are statistically significant ($p < 0.05$). The proportion of hauls with bycatch is reduced with alarms by 100%, with a 95% confidence interval of 100% - 98.5 %. These results are extremely promising and indicate that this model of acoustic deterrent provides an important tool for use in the SPSF, and potentially in other similar fisheries, to reduce bycatch and help the fishery meet the ecological criteria demanded in sustainability certification processes.

Keywords: acoustic deterrent devices, bycatch, common dolphins, *Delphinus delphis*, DDDs, Portuguese Sardine Purse Seine Fishery

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CM 374: One to rule them all…: Using multispecies fish pots to reduce the bycatch of marine mammals and seabirds

Sara Berzosa[1], Hannah Schartmann[1], Thomas Noack[1], Uwe Lichtenstein[1], Daniel Stepputtis[1]

Gillnets are common gear worldwide, being a small-scale fishery with local importance in the Baltic Sea. While gillnets have benefits in comparison with active fishing gear, a major challenge is the bycatch of marine megafauna, such as marine mammals and seabirds, which frequently entangle and drawn in gillnets. Modification of existing gear is one approach but, as the modification of gillnets might have their limitations – especially in relation to seabird bycatch, alternative fishing gear should be further investigated and developed to tackle this issue. One promising alternative to gillnets is the use of fish pots which have little bycatch risk for marine mammals and seabirds. Pots are environmentally friendly fuel-efficient fishing gear with a low impact on the sea bottom. They can be operated from small boats and be designed to be seal proof. Moreover, pots have the advantage of keeping the catch alive until it is collected, allowing to return the unwanted fish alive to the sea, and improving the quality of catches. For the last decades, pot designs have been mainly focused on the catch of one species, such as cod in the North Atlantic.

This focus on single species does not use the full potential of pots to support economically sustainable small-scale fisheries. Therefore, the present study investigates different entrance designs and retention devices for fish pots, also targeting flatfish species. The behaviour and interactions with the fishing gear were evaluated by observing entry and exit rates of two flatfish species (plaice (*Pleuronectes platessa*) and turbot (*Scophthalmus maximus)*). Systematic experiments were conducted in an enclosed net pen using an infrared (IR) lamp and camera system to avoid influencing the behaviour of the flatfish during the night. The results will improve the gear design and development of pots for multiple species fisheries - not only in the Baltic Sea, but also in other areas.

Keywords: fish traps, alternative gear, flatfish, bycatch reduction

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CM 377: Exploitation and conservation status of Rajiformes species in the Western Mediterranean

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Fisheries management requires the best scientific knowledge on the exploitation and conservation status of stocks. This is challenging for by-catch species, for which assessment data is more limited than for target ones. That is the case of chondrichthyan species, particularly vulnerable to fishing impacts due to their life history strategy. In the present study we use an integrative approach, including innovative assessment methods and genetic diversity analysis, to assess the exploitation and conservation status of six skate species in the Balearic Islands (western Mediterranean).

Among them, *Raja clavata* is the most important species in terms of abundance and the unique with a time series of landings long enough (from 1964) to be used in production models. Thus, these data, along with information from bottom trawl surveys (since 2004) are used to apply CMSY++ and Bayesian state-space Schaefer production models to assess its exploitation status. For the rest of the species, the exploitation status is analysed with a novel production model, based on time series of abundance data from surveys (AMSY).

The conservation status for all the analysed species is assessed by comparing the mitochondrial Cytochrome C Oxidase subunit I gene (COI) nucleotide diversity in the Balearic Islands populations against the COI genetic diversity benchmarks estimated for Elasmobranchii and Rajiformes species from sequences available in BOLDSystem. To do so, a small piece of pelvic fin from the specimens caught during the surveys was collected. The tissue is processed in the laboratory to extract DNA, amplify COI sequence through Polymerase Chain Reaction and for sequencing. Sequences are analysed to estimate nucleotide diversity of Balearic Islands populations of the studied species.

Results show that exploitation and conservation status can present different patterns for the same species. That is the case of *R. clavata*, which showed that the stock is currently overexploited, even though its exploitation status is stable or even has improved during the last decades. We can conclude that evaluating both exploitation and conservation status of these species combining assessment methods and genetic diversity analysis can be a useful approach to better understand their population dynamics and to improve the current fisheries monitoring program.

Keywords: assessment, by-catch, skate, production models, genetic diversity, Balearic Islands, Mediterranean

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CM 380: Mobile electronic monitoring for fisheries management and research: HafsAuga mobileEM

Lachlan Fetterplace[1], Emilia Benavente Norrman, Kristin Öhman, Filip Bohlin, Lisa Sörman, Per Johannesson, Andreas Lind, Katja Ringdahl, Sara Königson

Electronic monitoring (EM) using cameras has become a valuable tool to document fisheries catch and bycatch. However, implementing EM in small-scale fisheries is challenging and has been hindered by numerous factors, including high costs, technical expertise required for installation, and lack of power supply on small vessels. In addition, as most EM systems on the market are difficult to move between vessels, they do not effectively enable random data collection, which may be required to get reliable estimates of bycatch across a fleet. Those more basic EM systems available, designed for use in small scale fisheries, are still image based, have low frame rates and are not capable of recording in high enough video quality to identify species with high precision or to capture sufficient data for use in machine learning development.

To meet the requirements needed to randomly monitor the Swedish small-scale fishery and to enable data to be used further for machine learning applications, we created the HafsAuga MobileEM - a low-cost mobile multi-camera, GPS, and remote data offload system for recording fisheries catch, bycatch, and effort data. The system records high-quality video at up to 60 fps and comes as a small unit (~2kg) that can be deployed for first use in less than 30 minutes. Designed to be simple to operate and install, it is also easily configurable and modifiable, has a very small space requirement, and allows users to connect to a vessel's 12v power or to an internal battery to record high-quality video footage continuously for over a week on a single charge. This system is ideal for use in small-scale fisheries, and fisheries where fleets need to be randomly sampled by management or researchers.

Here, we describe the HafsAuga MobileEM system in detail and its performance in the small-scale Swedish fishery, where it has been in use since 2020. Fifteen vessels have had systems mounted on them along the Swedish west and east coast, and up to 750 fishing days have been recorded. Since 2022, the systems have been implemented as the main monitoring method in the EU Data Collection Framework (DCF) for monitoring the bycatch of protected species.

Keywords: Electronic monitoring, bycatch, PETS, mobile monitoring, porpoise, small-scale

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CM 413: Smartrawl: a vision for sustainable fishing and an end to trawl bycatch

Paul G. Fernandes

Bycatch and discards are some of the main threats to ocean biodiversity loss and fisheries sustainability. According to recent estimates, around half of global annual discards (4.2 million tonnes) were from bottom trawls. In Europe, the practice is banned through the Landings Obligation, but there is no effective means of preventing it, nor policing it effectively, so it continues unabated.

This presentation describes Smartrawl, a technological solution to the problem. The system consists of a stereo camera, a computer, and an innovative gate. These components are inserted into the trawl extension, a narrow channel of the trawl just before the cod-end. The stereo camera captures images of passing objects at 2 Hz. The computer, employing artificial intelligence algorithms, will then detect, size, and identify them. Based on user-selected preferences of species and size, the computer then sends a message to the gate to either close, thus catching the animal, or open, releasing it back into the water. The gate is unique in being driven by water flowing through the trawl to rotate between open and closed states. It is, therefore, free from cables, large battery packs, and any requirement for monitoring and control. Instead, the system is pre-programmed to only catch what a fisher wants, and to release all other animals back into the sea unharmed.

Crucial to the system is understanding how quickly animals pass the camera, which dictates how quickly the gate needs to respond. Camera trials in the North Sea, generating >200,000 images, were analysed to determine passage rates. These ranged from 1 fish every 0.5 s to more typical rates of one fish every several seconds. Faster rates were associated with patches of small fish, which would be released in the cod end due to mesh size selectivity. The gate was, nonetheless, designed with a response time of 0.5 seconds.

The system is still in development, but most of the components have been built and tested. Provisional AI algorithms have been developed, which, by virtue of being run on the local, small PC, can take a second or two to run using current technology. The algorithms also need large numbers (several thousand per species) of high-quality images to be trained, and we also report how image quality has been improved. The presentation highlights the ongoing developments to improve and integrate the components and plans for further trials to test the system in the field.

Keywords: Bycatch, discards, trawl, selectivity, Artificial Intelligence, AI, image analysis, biodiversity, landings obligation, sustainable fishing

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CM 420: Monitoring bycatches of mammals and birds in small-scale Swedish gillnet fisheries

Katja Ringdahl[1], Anna S. M. Persson, Sara Königson, Sofia Nyberg, Filip Bohlin, Kristin Öhman

The Swedish gillnet fishery is heterogeneous, covering multiple target species and gillnet types. Bycatches of mammals and birds are monitored through a combination of observers and electronic monitoring. The reason for this is to get as good coverage in the sampling as possible, expressed as sampled trips as well as sampled vessels. Majority of the vessels in the fishery are smaller than 10 meters, which creates challenges. It is physically difficult to fit observers onboard some vessels and the power supply is sometimes limited and therefore cannot support camera systems.

The overall challenge then becomes getting a sufficient representative sampling of the fishery: covering as many vessels as possible and including the heterogeneity of the fishery. In the Swedish monitoring program we have adapted camera systems so they can use external power sources, where needed. The systems can also, with help of own staff, be moved between vessels. This means that there are few limitations regarding the features of the vessels, or the amount of available systems when including new vessels in the monitoring. In 2022 there were 17 vessels involved in the electronic monitoring with 363 trips covered. For the observer monitoring, we approach all vessels with an activity level of minimum 25 trips a year and follow up on non-responses in order to improve the coverage in the sampling. In 2022 50 fishing trips were covered by observers. Thus, with a combined effort of observer and electronic monitoring, we were able to cover approximately 5% of the total trips within the total survey area. However, the coverage did vary between different parts of the survey area. It was higher in the area where a previous pilot study on electronic monitoring had been carried out, indicating that it takes time to build of trust.

Sweden is in a favorable situation as vessels not obliged to carry logbook need to report on effort, position, catches and gear types used on a monthly basis. This mean that we on a broad basis know which vessels that fish were. This allowed us to use a risk-based approach in the design of the monitoring program by grouping vessels into strata based on their geographical fishing pattern. The idea is to, in a controlled way, allocate more sampling effort to vessels fishing in areas were the risk of bycatch of the most sensitive species, the Baltic harbour porpoise (*Phocoena phocoena*), is highest.

Keywords: bycatch, observer monitoring, electronic monitoring, small-scale fisheries, risk-based approach

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CM 426: Towards automated bycatch detection in Electronic Monitoring data: a case study on small-scale fisheries and porpoises bycatch in gillnets

Erik Svensson, Lachlan Fetterplace, Sara Königson, Katja Ringdahl

Electronic Monitoring (EM) using cameras is believed to play a major role in future monitoring programs, especially when monitoring bycatch of protected species (PETS). One species subjected to bycatch which has had particular focus recent years, is the harbour porpoise. To estimate bycatch of harbour porpoises, the most cost effective, reliable and realistic way of carrying out this monitoring is through EM.

For footage acquired on board fishing vessels, terabytes of video data is generated and thereafter analyzed. The current practice of manually screening footage does not scale well in terms of cost, time, and perhaps also in reporting quality. In order to make this work more effective, streamlined and automated, there is a need to use techniques and tools from the field of computer vision, such as modern Machine Learning (ML) techniques, that is, deep neural networks. Based on EM data collected in Swedish west coast gillnet fisheries, from 2018 until 2023, we share our experience and exclusive results detecting porpoise bycatch using supervised ML techniques.

Automated bycatch detection is challenging. Building a supervised ML detection model requires training the model on labeled data. Porpoise bycatch events are rare and thus the detection of porpoise bycatch could be regarded as a problem of anomaly detection or a one-class classification problem with little data. In this study we evaluate the possibility of using Convolutional Neural Networks based object detection to identify bycatch of porpoises in the footage. This includes assessing if available data is sufficient in order to build a detection model that has acceptable levels of precision and recall. In addition, we describe the process needed when deploying ML machinery on EM footage, outlining the data processing pipeline going from the footage to labeled images, and resolving issues with regard to General Data Protection Regulation by anonymizing the data. In order to increase performance of the detection model other images from external sources, not only bycatch images, were collected and added to the training data set. We also demonstrate how data augmentation could improve model performance.

This is the first study that show it is possible to use ML to detect bycatch of porpoise in EM data on gillnet fisheries. To speed up development, train the model on new scenarios and increase model accuracy, institutes carrying out monitoring programs should join forces and collaboratively develop ML. This is needed if we want to implement ML in future EM programs.

Keywords: Machine Learning, bycatch, gillnet fishery, object detection, harbour porpoise

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CM 443: Building a comprehensive pipeline to estimate bycatch among fleets: a case study in the Bay of Biscay common dolphins (*Delphinus delphis*)

Mathieu Brevet, Laurent Dubroca, Matthieu Authier

Accidental bycatch is a major cause of marine megafauna decline worldwide. However, obtaining precise estimates of bycatch rates often turns out to be difficult due to scarce data, sometimes being non-randomly acquired and, therefore, partly unrepresentative of reality. We aim here to tackle such an issue by building a comprehensive framework that, from standardized data on fishing vessels' activity and bycatch on a specific species, classifies vessels into functional fleets (depending on their fishing techniques and strategy), computes their fishing effort and estimate their bycatch probability along each year in a robust way. We relied on the phenomenological Bayesian framework developed by Authier et al. (2021), specifically designed to estimate bycatch from potentially non-representative data accurately. In the case of common dolphins' bycatch, this method will be applied to the French fishery operating in the Bay of Biscay to model how the different fleets vary in their probability of bycatching dolphins during the last decade.

Keywords: bycatch, fleet, fishing effort, Bay of Biscay, common dolphin

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CM 489: Initiatives to investigate and improve bycatch data from cetacean strandings

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Cetacean strandings can provide key information to assess and understand bycatch mortality and its potential impact on populations (as for common dolphins in the Bay of Biscay) but the extent to which this is currently feasible varies widely across Europe.

Several initiatives are presently underway to improve and standardize bycatch diagnosis from carcasses, streamline reporting of strandings data, and establish a common database. The ICES Working Group on Bycatch routinely gathers available information (currently far from comprehensive) on annual stranding records by member states, including information on evidence of bycatch, which feeds into the ICES advisory process on bycatch of Protected, Endangered and Threatened Species (PETS).

In 2021, ICES Working Group on Marine Mammal Ecology initiated a questionnaire survey of European strandings networks to gather information on their organization, resources, protocols for data and sample collection, and bycatch diagnosis, in cetaceans and other PETS. ACCOBAMS completed a similar initiative in 2022 and we are presently consulting West African strandings networks about the information they collect on PETS bycatch. The utility of strandings to quantify bycatch is being investigated in several projects in Spain. The IWC has current bycatch and strandings initiatives, and ASCOBANS and ACCOBAMS have developed protocols for cetacean necropsy and bycatch diagnosis. In April 2023, two relevant workshops are planned, the ECS/ASCOBANS workshop on “Scoping the development of a European marine strandings database” and the ACCOBAMS-ASCOBANS workshop on “Current cetacean bycatch issues in European waters”,

This presentation will briefly describe the various ongoing initiatives and their results to date. Based on the WGMME questionnaire survey, cetacean bycatch is an important cause of death for harbour porpoises, pelagic delphinids and baleen whales. Several regions reported upward trends in bycatch mortality in these groups and in seals. Bycatch was associated with a wide variety of gear (e.g. static, towed and floating gears, traps, pots, and pole and line). Highlighted needs include better coordination of data collection, standardised pathological investigations and consistent reporting nationally and internationally. Reported strengths and weaknesses of the networks, as well as identified assessment and data gaps, provide useful information to enhance the potential of these networks to contribute to bycatch assessment.

Finally, we consider how the utility of information arising from strandings could be maximised, including the application of drift models and life tables, placing bycatch in the context of population health status, and the need for good quantification of survey effort by stranding networks.

Keywords: strandings, bycatch, questionnaire survey, protocols, SWOT

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CM 508: Bycatch of anadromous clupeid fish at sea in the North and Western Iberian Peninsula region: insights into stock mixing at sea and conservation implications

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The anadromous clupeid allis shad, *Alosa alosa* (Linnaeus, 1758), and twaite shad, *Alosa fallax* (Lacépède, 1803), collectively called European shads, are diadromous fish migrating between their reproduction areas in rivers and marine feeding grounds. Both species are in decline due to cumulative impacts of human activities across their life cycle. Anthropogenic impacts in continental waters are far more documented than the sources of anthropogenic mortality in the marine environment, including bycatch. Shads are in particular risk of bycatch because of their school-forming behaviour, especially before the onset of spawning migration, and their use of coastal habitats where fishing fleets are operating. Recent work suggested that shad populations are mixing at sea, therefore, by-catch may potentially affect whole shad populations. Previous studies showed that the otolith core composition for a combination of ^{87}Sr:^{86}Sr isotopic ratio, Sr:Ca and Ba:Ca successfully assigned the natal origin of individuals in *A. alosa* and *A. fallax*. The main objectives of the present study were to document bycatch distribution along the marine habitats in the North and Western Iberian Peninsula (Northeast Atlantic) and determine how bycatch of both species is qualitatively partitioned among continental populations using an otolith microchemistry approach. A total of 135 adult individuals from both species (100 *A. alosa* and 35 *A. fallax*) were collected along the North and Western Iberian Peninsula, from Figueira da Foz (mouth of the Mondego River, Portugal) to the Ártabro Gulf (North-West Galician coast, Spain), between December and March 2017 to 2021. In general, more fish were found from the larger populations and were also found everywhere from a dispersal perspective. Natal allocation results will be discussed in terms of potential management and conservation implications.

Keywords: bycatch, threatened species, *Alosa alosa*, *Alosa fallax*, otolith microchemistry, natal origin, machine learning

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CM 517: Using species-specific gear modifications to reduce discards in trammel net fisheries

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Small-scale fisheries (SSF) employ static gears such as hanging nets, which are considered to interact with marine ecosystems in more benign manner than towed gears. Despite this, trammel nets, one of the most commonly used fishing gear in the Mediterranean SSF, produce high volumes of discards that can account for 25% or more of the captured biomass. Discarded organisms can include endangered or threatened species like elasmobranchs, as well as non-commercial invertebrates that damage fishing gear or delay disentanglement. We tested various gear modifications in two important métiers of Greek fisheries that rely on trammel nets. The first métier targets the common cuttlefish *Sepia officinalis* (cuttle-net) at shallower depths (5-10m) between February and May and suffers from high capture rates of the spider crab *Maja crispata*, which creates numerous difficulties for the fishing process. The second métier targets the common sole, *Solea solea* (sole-net), at greater depths (35-40m) between May and October, and displays high bycatch rates of elasmobranchs, mainly the marbled electric ray *Torpedo marmorata*. The gear modifications included (a) the use of a guarding net fitted to the footrope, (b) an increased hanging ratio, (c) increased net tension by adjusting the number of floats and lead-line weight, and (d) a reduction in the mesh size of the outer panels. The modified gear had varying degrees of success in the two métiers. The use of a guarding net was the most successful modification for the cuttle-net because it reduced the catch of spider crabs by 78% while having no effect on the catch of cuttlefish (-6%) or teleosts (+13%). In terms of the sole-net, the most effective modification was the use of smaller mesh in the outer panel, which managed to reduce captured biomass of elasmobranchs by 40% without affecting the catch of the target species, namely the common sole and the mantis shrimp *Squilla mantis*. Both types of modifications are relatively simple and inexpensive to apply, and they have already begun to be implemented by local small-scale fishers. The current study demonstrates that prior evaluation of the discards profile of various métiers is required to achieve species specific gear modifications and emphasizes the importance of collaboration among scientists, fishers, and gear manufacturers.

Keywords: small-scale fisheries, trammel-nets, discards, Mediterranean

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CM 536: Assessing bycatch of the European shag (*Gulosus aristotelis)* by fishing activities in the Basque coast (Bay of Biscay)

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Fishing activities can significantly affect non-target marine species of different biological groups (e.g., seabirds, marine mammals, sea turtles, etc.) indirectly (e.g., competing for the same food resources, disturbing feeding and/or nesting habitats, etc.) and directly, through bycatch. Seabirds are a key component of marine ecosystems. Seabirds are caught in all the world's oceans in different types of fishing gears and fisheries. It is calculated that more than 200,000 seabirds are killed annually in Europe due to bycatch. Worldwide, a large decline of seabird populations has been observed since the middle of the past century and bycatch in fishing gears is one of the main anthropogenic causes of this decline. Furthermore, bycatch is significantly affecting some seabird species critically endangered. Hence, there is an urgent need for a better knowledge of bycatch fishing mortality, its population effects, the spatial and temporal patterns of bycatch, and for viable and effective implementation of bycatch mitigation measures.

The European shag (*Gulosus aristotelis*) is a coastal seabird which breeds along the rocky coasts of the NE Atlantic and the Mediterranean Sea. The global population of this species was estimated at c. 100,000 pairs in 1990s. Population sizes display very large fluctuations, with highly variable trends both within and between regions. Current threats include climate-mediated effects, introduced predators, oil spills, bycatch in fishing gears, etc. In the Basque coast (Bay of Biscay) the breeding population of the European shag is around 160 pairs. The species is under the category "Vulnerable" in the Basque list of threatened species and there is a plan for its management in part of the region. Although there is evidence of bycatch in coastal artisanal fisheries, no estimates on the magnitude of this interaction have been carried out. The objective of this study is to integrate different approaches and methodologies for improving the assessment of bycatch of the European shag in artisanal fishing activities in the Basque coast. Different approaches, methodologies and lines of evidence are considered:

- Literature-based state of the art.
- Surveys to fishermen.
- Direct records of incidental catches through shipments.
- Fishing-related mortality records in fauna recovery centres.
- Risk assessment of bycatch based on type of fishing gears; spatial and temporal patterns of fishing effort; spatial and temporal patterns of the species distribution; habitat preferences.

The results from these approaches will be presented and discussed under an integrated assessment, towards the implementation of measures in the framework of the ecosystem approach to fisheries.

Keywords: European shag, Bay of Biscay, bycatch, integrated assessment, ecosystem approach

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CM 542: Drivers of the distribution of two demersal batoids in the Balearic Islands (western Mediterranean) during the last two decades

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Elasmobranchs are intrinsically sensitive to fishing exploitation, because of their K-selected strategy and represent an important fraction of the by-catch of bottom trawling. As a result, more than half of the sharks and batoids in the Mediterranean are threatened. However, the assessment of their populations is limited by the lack of reliable specific data on fishing catches.

Although the conservation status of more than 20% of sharks and rays in the Mediterranean has worsened during the last decades, the demersal populations of the Balearic Islands present certain stability and even signs of recovery, especially for batoids. This is probably due to the decrease in the intensity of bottom trawling in the area over the last decades. In addition to this, habitat degradation and climate change have also been linked to elasmobranchs distributional shifts and bathymetric range reductions. Fisheries exploitation can lead to truncated age-structures, increasing population sensitivity to environmental factors. However, there is a knowledge gap in identifying drivers of their spatial distribution and population trends. In this sense, fishery-independent scientific surveys provide valuable standardized data of non-target species for fisheries.

Here we selected two species of batoids, *Raja clavata* and *Raja polystigma,* and developed generalized additive models to describe the spatial distribution of these species in the Balearic Islands as a function of environmental variables and fishing effort. *R. clavata* has a wide distribution along the whole latitudinal gradient of the eastern Atlantic, from Iceland to South Africa, while *R. polystigma* is endemic of the Mediterranean. The first species is the most important batoid in the by-catch of the bottom trawling in the Balearic Islands, while the second one is also abundant in the by-catch of this fishery. In this area, both species have a wide bathymetric range, between 50 and 350 m, with optimum depths at 162 and 147 m, respectively.

Data on occurrence, density and standardized biomass was obtained from the bottom trawl MEDITS surveys around the Balearic Islands from 2001 to 2022. Geographic coordinates, depth, sea bottom temperature, substrate type and fishing effort were considered as explanatory variables. The results will provide some insights on the drivers of species distribution and abundance, which is crucial to predict the potential impacts of fishing pressure, climate change and habitat loss on the dynamics and conservation status of the populations of these vulnerable species. In addition, distribution maps of these by-catch batoids are needed for the development of an ecosystem-based approach to fisheries assessment and management.

Keywords: elasmobranchs, by-catch, assessment, conservation, vulnerable species, Mediterranean, climate change

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CM 545: By-catch monitoring methods for small, coastal fisheries boats. Lesson from the Szczecin Lagoon (Baltic Sea)

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By-catch of birds and marine mammals in fishing nets is one of the currently publicized manifestations of the negative impact of fishing on the natural environment. At the same time, the scale of additional mortality caused by by-catch is largely based on inaccurate estimates, which results from the small amount of scientific data, the availability of which is affected by a number of difficulties in research and monitoring of this phenomenon. The fishing sector in which the by-catch occurs most often is small boats, coastal, gillnets fishery. At the same time, it is the sector which, for technical reasons (e.g. construction and boat size), is one of the most difficult to cover by research and monitoring.

During 2014/15 autumn – spring season we conducted complex by-catch monitoring project focused on birds by-catched by small boats fishing on the Szczecin Lagoon (southern Baltic Sea coast lagoon). The Lagoon is a body of water with numerous concentrations of migratory and wintering water birds, being at the same time a water body intensively used for small scale and small boats gillnets fishery. This made it an ideal test area.

As part of the project, three methods of by-catch monitoring were tested here: using an observer on board the boat, video monitoring (Remote Electronic Monitoring), and a by-catch self-register kept by fishermen. In the case of observation by an observer on the boat, which is considered the most objective method of by-catch monitoring, coverage of 5.6% of the total fishing effort in the period under study (58 fishing days) was achieved. In the small-scale fishing sector, this is a unique result, significantly increasing the quality of the results obtained.

Based on the results obtained from direct observations, additional mortality caused by fishing nets among birds migrating and wintering in the Szczecin Lagoon was estimated. For this purpose, the Generalized Linear Model (GLM) was used, which took into account many components affecting the by-catch (type of gear, fishing time, net length, fishing time, etc.).

Keywords: by-catch, lagoon, birds, bycatch monitoring, small scale fisheries

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CM 548: Blue shark by-catch in the south Adriatic Sea (central Mediterranean): catch rate, distribution and post release survival

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Pelagic sharks play an important role in marine ecosystems through diverse mechanisms and the decline of predatory sharks may initiate trophic cascades affecting overall community structure. Although there are no big commercial fisheries targeting sharks in the Mediterranean, the presence and abundance of these species are declining due to excessive fishing pressure. In the Central Mediterranean, sharks are not a specific target of commercial fisheries, but are taken and kept onboard as by-catch of small-scale, trawl and longline fishing. Pelagic longlines (PL) commonly target swordfish and tuna, and the blue shark *Prionace glauca*, a highly migratory species, is a quite common by-catch of these fisheries. The blue shark is evaluated by IUCN as Critically Endangered in the Mediterranean, while in Atlantic as Near Threatened, a condition that requires management actions. In the Mediterranean, shark and ray by-catch represents around 10-15% of the catch analysed in tuna and swordfish longlines. The highest catch rate of sharks for PL was found in the Alboran Sea followed by the Adriatic Sea. Therefore, the area of this case study is one of the most important in term of pelagic shark by-catch rate in Mediterranean basin.

In this study, the by-catch of PL targeting swordfish was monitored during the fishing season (summer) in three consecutive years (2019-2021). Moreover, 32 blue sharks were tagged using pop-up satellite tags to assess the post release survival. MaxEnt was used to model the spatial distribution of blue shark using environmental co-variates (e.g., sea surface temperature, chlorophyll-a concentration, currents). The model performance was evaluated by cross-validation with pop-up data from tagging.

The mean by-catch rate (Sum of number of specimens caught in sampled fishing days/Number of sampled fishing days) of blue shark was 2.16 with a higher probably of presence in the central part of the south Adriatic Sea around Bari pit. About 70% of the position detected by pop-up tags are included in this area with blue shark presence probability higher than 60%. The overall post release survival of caught specimens was about 80%.

The localization of areas where the species is more present and the estimates of survival of captured and released blue shark provide useful information to support the implementing of management measures in the southern Adriatic Sea and adjacent areas.

Keywords: longline bycatch, blue shark, MaxEnt, pop-up tag, post release survival

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CM 558: Effectiveness assessment of cetacean bycatch reduction strategies and fishing technical measures in Iberian waters and Bay of Biscay

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Several European fisheries have been flagged for evidence of high dolphin bycatch rates. Some of the pelagic trawl fisheries operating off southwestern Europe have been having high bycatch rates of short-beaked common dolphins, *Delphinus delphis*, and other species of small cetaceans. Reducing the incidental bycatch of common dolphins is an objective for the European Commission to not exceed the maximum removals rate for a sustainable population. The International Council for the Exploration of the Sea (ICES), which acts as an advisor to the European Union, has recommended several scenarios to limit bycatch through the application of time-area closures and the use of mitigation measures. In this context, the CetAMBICion project aims to bring an international dimension to the problem of bycatch by bringing together France, Spain and Portugal in a joint program to adopt a coordinated approach in the monitoring of cetacean species in the Bay of Biscay and Iberian coasts, improved bycatch assessment, and in the joint development of measures to reduce these captures.

Case studies were performed onboard commercial fishing vessels and to assess the efficacy of different technical measures for achieving a reduction in bycatch mortality of cetaceans.

Results of a series of pilot studies on trawl, fixed nets and purse seining are presented using bycatch reduction technical possibilities for the fisheries in the area: acoustic deterrent devices, dolphin excluder devices and spatial move- on rules.

Keywords: bycatch, cetacean, pingers, fisheries impact, technical measures

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CM 588: Quantifying and understanding cetacean bycatch

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Fishery bycatch mortality is generally considered to be the main threat to cetaceans in European Atlantic waters. The marine waters in the Northwest of the Iberian Peninsula are among the richest in fishery resources in Europe and, consequently, they are also very important for fisheries. Analysis of cause of death and life history data from strandings in Galicia suggested that the bycatch is a major threat in common dolphins (*Delphinus delphis*) and harbour porpoises (*Phocoena phocoena*). The mortality rate in the Iberian population of the harbour porpoise could be well above safe limits. MERMACIFRA ("*Monitoring, Assessment and Reduction of Accidental Mortality of Cetaceans due to Interactions with the Spanish Fleet - Review and Action*") is a national Project funded by the Fishery Ministry of Spain, the main objective of which is to monitor, assess and reduce bycatch of cetacean species in Spanish Atlantic waters. This includes acquisition of information on bycaught animals from strandings and on-board monitoring, to quantify bycatch mortality and to build a "profile" of bycaught animals in terms of their sex, size, age, reproductive status and health status. The project collaborates with the Galician stranding network, which attends stranded cetaceans on the Galician coast. Between 1990 and 2020, 3,404 strandings of common dolphins (on average 114 per year) and 344 strandings of harbour porpoises (on average 11 per year) were reported. It was observed that, over the last decade, the number of strandings with bycatch evidence has tended to increase. For 2021, considering only those carcasses examined which preservation state were from fresh to slight (n = 52 for common dolphin, and n = 13 for harbour porpoise), it was obtained that 54% of common dolphins (n = 28) and 23% of harbour porpoises (n = 3) had evidence of fishery interaction. During 2022-2023, we received two notifications from fishers regarding bycaught dolphins. In the first, two common dolphins were collected and studied in the north of Galicia. In the second case, two bycaught common dolphins were thrown overboard by the crew. These data are useful to better understand the reasons for bycatch as well as the resulting mortality. MERMACIFRA also aim to assess methods to reduce bycatch in nets and purse seine fisheries (e.g., using net modifications and observers on-board). Pilots using three types of acoustic deterrent devices indicates different efficacy depending on the species and fishery.

Keywords: cetacean bycatch, Northwest Iberian Peninsula, common dolphin, harbour porpoise

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CM 589: Bycatch mitigation measures to reduce the impact of fisheries-related mortality of cetaceans in north Spanish gillnet and purse seine fisheries

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Mitigation measures and improvement of scientific knowledge to reduce accidental captures of cetaceans during fishing activities are the focus of regulations that respond to the need to adopt measures based on the EU request on "emergency measures to prevent the bycatch of cetaceans in the northeast Atlantic". These emergency measures are aimed at eliminating, in particular, incidental catches of common dolphins (*Delphinus delphis*) in the Bay of Biscay. The most important and best documented threat to cetaceans in Spanish fishing grounds in the ICES area is that produced by entanglement in commercial fishing gear. The problem of accidental capture in different fishing grounds of the Iberian Peninsula has been known since ancient times and causes mortality rates that can be serious in some areas/species.

Acoustic deterrent devices test pilots have been carried out in NW Spain. Several different models of pingers have been used in the short distance gillnet fisheries in Galicia, to test their effectiveness in reducing catches of common dolphin and common porpoise (*Phocoena phocoena*). In the sardine purse seine fishery, the use of pingers has been tested to avoid the effect of predation and damage to the nets of bottlenose dolphins (*Tursiops truncatus*). The effectiveness of bycatch reduction devices such as pingers depends on the behavior of cetaceans in and around the fishing gear. Although there have been several previous studies, such behavior is likely to be species, gear, and catch reduction device specific and may vary regionally and over time, as responses may involve learned behavior. An approximation to the problem is carried out with the input of the fishing sector to study future directions. Lessons learned and potential measures are proposed based on the opinions of fishermen collected in surveys carried out on boats.

Keywords: bycatch, cetacean, pingers, fisheries impact, technical measures

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CM 593: Northern Fulmar (*Fulmarus glacialis*) bycatch in the North Atlantic

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Northern Fulmars are tubenosed seabirds, using scent to find prey, and are attracted to fishing vessels. These qualities make Northern Fulmars particularly vulnerable to bycatch in a wide variety of fisheries and gear types. This species has a circumpolar distribution, seasonally traversing thousands of kilometers annually. In the North Atlantic, Northern Fulmars breed in large and small colonies on offshore islands, and forage on the surface of the water, often coming into conflict with offshore fisheries operations. Due to this wide-ranging life history strategy, Northern Fulmars often traverse multiple fishery management regions and geopolitical boundaries annually. Bycatch data is collected in many fisheries, but until this effort, no attempt has been yet made to collate this data to understand the minimum number of bycaught northern fulmars across reporting boundaries. This study seeks to calculate a minimum number of fulmars recorded as bycatch between 2010-2021 annually through data collected in government and fishery mandated At-sea Observer (ASO) programs, electronic monitoring, self-reported through catch logs, and through targeted bycatch studies by academic researchers.

Data were contributed from partners in seven areas (United Kingdom, Iceland, Greenland, Norway, the Faroe Islands, Canada, and the United States), and published and unpublished data was included from an additional five countries (Russia, Spain, France, Portugal, and Ireland). In total, over 50,000 Northern Fulmars were recorded as bycatch across the North Atlantic between 2010-2021. Fulmars were recorded as bycatch in five different gear types (benthic gillnet, pelagic gillnet, longlines, trawlers, and hand-lines). Bycatch of fulmars occurred in fisheries certified by the Marine Stewardship Council (MSC) as well as fisheries not represented by the MSC. This represents the first attempt to calculate a total number of bycaught individuals across their entire North Atlantic range. Differences in observer rates, bycatch reporting methodology, and data sharing and availability were apparent across partner countries. Fulmars were caught in multiple ICES and NAFO fishery regions, transcending management boundaries. This study highlights the need for standardization of bycatch data collection, and more importantly, data reporting and data sharing.

Keywords: bycatch, seabird

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CM 603: Vulnerability assessment of marine resources caught in industrial bottom trawl shrimp fishery in the Amazon Continental Shelf

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In most shrimp trawl fisheries, there is significant disproportionality between bycatch and shrimp production. Bycatch is one of the most significant impacts on fisheries ecosystems. Discard shows an average capture of around 9.1 million tonnes each year globally, the bottom trawls are responsible for at least 45% of this total. These several damages to ecosystems and biological communities occur more frequently in underdeveloped and developing countries, jeopardizing the sustainability in the long term of the business, fisheries resources, and biodiversity conservation. The non-target species may be divided into two groups, species that are retained to consume and species with some value that is retained for marketing (byproduct), the low-value unwanted species that are discarded to the sea, dead or alive (bycatch). The non-target species problem is a concern for fisheries managers, especially in the tropics, known for its high diversity. Most efforts on fishery management and sustainability are made by performing a traditional single-species assessment, based only on target-specie by measuring stock assessment and defining the maximum sustainable yield. These approaches have become a global standard to manage fisheries and fishery stock. However, only quantitative ecological indicators based on a target species have been pointed out as one of the causes of failures in ecosystem management. In this work, we applied the Productivity and Susceptibility Analysis to assess species vulnerability. The underlying premise of this approach is that the relationship between weighted productivity and susceptibility attributes may be used to quantify how vulnerable a particular stock is to overexploitation. The vulnerability was assessed through seven Productivity attributes and seven Susceptibility attributes. A total of 47 species were evaluated in the PSA, 12 species were classified with low vulnerability, 23 with medium vulnerability, and 12 species were highly vulnerable to the impacts of fishing. The range of productivity values was from 1 to 3, and those of susceptibility varies from 1.29 to 2.71. The vulnerability score shows a broad range from the minimum score of 0.30 to the highest score, 2.29. The target species show moderate vulnerability, 1,71. About 38.7% (12 sp) and 61,29% (19 sp) of the bycatch species show a low and moderate/high vulnerability score respectively. 100% (15 sp) of byproduct species show a moderate/high vulnerability score. All the Critical, Endangerous and Vulnerable IUCN species show a high vulnerability. fishing gear modification, such as a bycatch exclude device was employed to decrease the species' vulnerability, with satisfactory preliminary results.

Keywords: industrial fisheries, trawl, shrimp, bycatch, productivity and susceptibility analysis, amazon coast

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CM 618: Towards dynamic ocean management of prioritized species in tuna fisheries

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The Inter-American Tropical Tuna Commission (IATTC) is mandated by the Antigua Convention to ensure the sustainability of not only principal tuna target species, but also a diverse suite of dependent and associated species that are directly or indirectly impacted by the tuna and tuna-like fisheries for which the IATTC is responsible. Managing such a diversity of co-occurring species from teleosts to sea turtles is a significant challenge owing to the dynamic biophysical environment of the Eastern Pacific Ocean (EPO) (e.g., sea surface temperature, mixed layer depth, dissolved oxygen concentration) that has a profound influence on the behavior and distribution of these oceanic animals and their susceptibility to particular fishing gears in space and time.

Understanding the likelihood of species-fishery interactions requires knowledge of a species' spatio-temporal distribution relative to that of fishing effort under specific environmental conditions. Using spatially dynamic models can facilitate the assessment of the potential vulnerability of species and broader ecological functional groups (e.g., hammerhead sharks, juvenile tunas, sea turtles) to existing or predicted levels of fishing using assessment models such as the Ecological Assessment for the Sustainable Impacts of Fisheries (EASI-Fish) approach recently developed by the IATTC.

Additionally, dynamic species-environment models can be used to generate standardized and biologically meaningful assemblage-level indicators for both target species (e.g., the yellowfin/bigeye/skipjack complex) and non-target species. This can facilitate adaptive spatially explicit decision making in the EPO to minimize the ecological risks posed by fishing. For example, understanding the likelihood of encountering target and non-target species under different oceanographic conditions may help to avoid species of conservation concern, such as the scalloped hammerhead (*Sphyrna lewini*), the silky shark (*Carcharhinus falciformis*) or the leatherback turtle (*Dermochelys coriacea*). Furthermore, avoiding such interactions would also improve the efficiency, profitability, and safety of fishing operations.

While translating species-interaction models into spatial decision-making will take time and meaningful stakeholder engagement, the models have immediate applicability for the IATTC in assessing bycatch vulnerability and exploring the development of alternative dynamic mitigation approaches, thus helping international fisheries organizations meet their management goals.

Keywords: Dynamic Ocean Management, tuna fisheries, bycatch, adaptive management, spatial management

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CM 635: Exploring fishers' perceptions of gear pollution and bycatch and their willingness to engage with mitigation measures

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The commercial fishing industry inflicts several deleterious impacts upon oceanic environments, including pollution from discarded gear and population declines in incidentally caught species. Yet, there has been little investigation into fishers' attitudes towards such issues, and their willingness to implement mitigative measures. UK and Ireland fishers' perceptions of gear pollution and bycatch and willingness to adopt relevant pro-environmental fishing behaviours (PEFBs) were investigated using a survey and interviews. Significant positive associations were identified between (a) fishers' environmental awareness and concern, (b) level of concern and use of PEFBs, and (c) personal experiences with degradation and level of awareness and concern. Sociodemographics, however, were not deemed influential, conflicting with numerous studies. Fishers typically showed greater concern and willingness to mitigate gear pollution than bycatch, although socio-economic concerns seemed to take precedence overall. The findings have several implications for conservation efforts, highlighting means for overcoming barriers in engaging with PEFBs and suggestions for improving environmental communication programmes. Due to study scope limitations, further investigations are needed to explore the role of factors such as political standing in greater detail. The study provides a foundation for understanding fishers' environmental perceptions and behaviour and could be pivotal in strengthening sustainable fishery management.

Keywords: sociodemographics, risk perceptions, awareness, bycatch, abandoned-lost-and-discarded fishing gear, pro-environmental behaviour

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CM 640: Catchsnappers: making co-created bycatch registrations from smartphone apps sharable with global biodiversity databases

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Despite the ubiquitous use of biodiversity-logging apps, in-build functionalities to share geo-tagged observations with global backends such as the global biodiversity information facility (GBIF) are often lacking. To allow for an improved transnational monitoring of biodiversity and ecosystem change for science and society, an Open Sea lab hackathon solution is offered here to standardize data integration by mapping data standards and providing, where necessary, the wrappers to maintain platform interoperability. To expand spatiotemporal coverage of hard-to-get biodiversity observations such as those of rare and protected species (bycatch), conventional survey science more and more tabs into co-created knowledge by engaged citizens and community. Recreational and commercial fishers are an underutilized pool of users to register more marine biodiversity observations using readily available catch registration apps (frontends). We present results from a hackathon where the quest was to make such observations ready to flow through via EMODnet biology to global biodiversity database backends such as OBIS and GBIF and then to animate the occurrence data on a timeline (e.g., upload to GBIF or OBIS in Darwin core format). Given the widespread sampling intensity in space and time, fishers are most likely to encounter and register bycatch events of rare species. For all these pioneering blue guardians who are willing to share information that may be of little value to them but of great value to society, this will allow them demonstrating transparent practices and adding value by being able to share their biodiversity observations easily.

Keywords: biodiversity; community science; co-creation; smartphone technology; PET species

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CM 647: Modelling bycatch related factors: loggerhead turtle (*Caretta caretta*; Cheloniidae) caught by trawlers in South Adriatic Sea (Central Mediterranean) case study

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By-catch is the catch fraction “unintentionally” captured during a fishing operation, in addition to the target species. It may refer to the capture of other marketable species that are landed, to commercial species that cannot be landed (e.g., undersized, damaged individuals), to non-commercial species, or to incidental catches of endangered, vulnerable or rare species (e.g., sea turtles, chondrichthyans, marine mammals).

One of the non-targeted species impacted by fishing activity in Mediterranean Sea are sea-turtles. Indeed, pelagic and demersal longlines, trawlers and fixed net show a consistent number of sea-turtle caught by these gears. Three sea turtle species are present in the Mediterranean: the leatherback turtle (*Dermochelys coriacea*; Cheloniidae), the green turtle (*Chelonia mydas*; Cheloniidae) and the loggerhead turtle (*Caretta caretta*; Cheloniidae). However, only few specimens of leatherback turtle enter into the Mediterranean from the Atlantic, without breeding in the basin. The other two species present in the Mediterranean are mostly impacted by fishing activity as by-catch. In particular for Southern Adriatic Sea (Geographical Sub-Area GSA18 *sensu* FAO-GFCM) the species more common is *C. caretta*.

In Mediterranean basin the bottom trawlers represent the second gear in term of bycatch rate and third in term of mortality. Thus, the interaction between the sea turtles and the bottom trawler is not negligible. In this case of study, they were analysed data collected in the Pilot study of bycatch monitoring within the Data Collection Framework in GSA 18 on the bottom trawl (OTB) in 2018. In total they were monitored 374 fishing trips for a total 1415 hauls.

In order to explore the driver that are most important to describe sea turtles bycatch phenomenon in GSA18 they were modelled (Generalized Additive Models) as explanatory variables data collected both onboard (e.g. day/night catch, season, duration of haul) as well as geographic/environmental variables (e.g. depth, distance from the coast, sea surface temperature, bottom temperature) obtained from external sources (e.g. Copernicus Marine Environment Monitoring Service, CMEMS).

The drivers, identified in this study, which significantly influence the bycatch of loggerhead sea turtle caught by trawlers represent important knowledge elements in a perspective of reducing the bycatch of this species. Indeed, several drivers have been identified significantly affect the bycatch of sea turtles: latitude, longitude, periods of the year (autumn), area (costal area of 2 km), part of the daytime (day), bottom temperature and depth. Moreover, GAM model provides spatial-time information to implement more effectiveness protection actions.

Keywords: bycatch drivers, loggerhead turtle, GAM, bottom trawlers

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CM 653: EASI-Fish – A Flexible Catch-Independent Assessment Tool for Quantifying the Vulnerability of Bycatch Species to the Cumulative Impacts of Fisheries in Data-Limited Settings

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Ecosystem approaches to fisheries are being increasingly adopted by fisheries to demonstrate ecologically sustainability. However, for fisheries that interact with many data-poor species, demonstrating sustainability of each species is often not feasible using conventional stock assessment methods. Ecological Risk Assessment (ERA) approaches, such as Productivity-Susceptibility Analysis, have been a popular alternative in data-limited fisheries to identify potentially vulnerable species. Unfortunately, most existing ERA methods produce only a relative measure of vulnerability, lack biologically meaningful reference points, cannot assess the cumulative impact of co-occurring fisheries, or lack the capability to characterise existing spatio-temporal and input control management measures. This paper introduces a spatially-explicit ERA approach designed to assess the cumulative impact of multiple fisheries on bycatch species in data-limited settings by producing a quantitative estimate of fishing mortality using a flexible susceptibility analysis independent of catch data. Fishing mortality is compared to conventional biological reference points derived from length-based per-recruit models to determine a species' vulnerability status. EASI-Fish allows fisheries managers to more confidently identify vulnerable species in which to direct resources to either implement mitigation measures or collect further data for further assessment. Furthermore, EASI-Fish can be used to explore 'what if' scenarios in the development of conservation and management measures aimed to reduce bycatch vulnerability, such as spatial closures or changes to gear configurations. The development of EASI-Fish is described in the context of its application to a subset of teleost, elasmobranch, sea turtle and cetacean bycatch species caught by industrial and artisanal tuna fisheries in the eastern Pacific Ocean where many developing coastal states lack fishery data collection programs. Examples are provided of applications of EASI-Fish to assess the vulnerability of shark bycatch species and assessing the efficacy of proposed conservation measures for the spinetail devil ray (*Mobula mobular*) and the critically endangered leatherback sea turtle (*Dermochelys coriacea*).

Keywords: Ecological Risk Assessment, sharks, elasmobranchs, sea turtles

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CM 654: Patterns in the landed catches and determinants of catch composition in the South African inshore trawl fishery

Natasha Besseling

The inshore trawl fishery, which nominally targets *Merluccius capensis* (shallow water hake) and *Austroglossus pectoralis* (east coast sole), has the second highest bycatch rate of all South African fisheries. For over one hundred years there has been concern about the sustainability of the harvests in this fishery. To enable effective management of the many species harvested, I aim to describe patterns in the effort, landed catches, catch composition, and bycatch rate in the inshore trawl fishery from 1990 to 2019. In a second analysis, I aim to determine the driving factors that influence landed catch composition in the fishery, with a specific focus on area and vessel effects, which can be used to improve management strategies.

The total size of the fishery has decreased from 40 vessels in 1990 to 15 vessels in 2019 and has a total bycatch rate of 36%. A total of 48 nominal species were recorded among the landings, but only thirteen made up 99% of the total landed catch composition by weight. Total effort and landed catch decreased by 70% and 62% respectively from 1990 to 2019, but bycatch rate increased by 22.7%.

The landed catch composition per trip was influenced by the *vessel* ($F(1, 21) = 32.7$, $p < 0.001$, $R^2 = 0.31$), *year* ($F(1, 29) = 16.0$, $p < 0.001$, $R^2 = 0.21$), and *season* ($F(1, 3) = 30.0$, $p < 0.001$, $R^2 = 0.04$). Direct comparisons were then made between landed catches of vessels fishing in the same area during the same year and season. The trawls were aggregated using a 20x20' commercial grid system. The landed catch composition per trawl was influenced by the *grid cell* ($F(1, 9) = 15.5623$, $p < 0.001$, $R^2 = 0.12$), *vessel* ($F(1, 4) = 25.2$, $p < 0.001$, $R^2 = 0.08$) and *year* ($F(1, 1) = 22.9$, $p < 0.001$, $R^2 = 0.02$).

The grid cells in all clusters were grouped spatially, except for one grid cell in group four. Each group showed distinct species assemblages that could be used to tailor management strategies for bycatch in the fishery. The ability to control the catch composition is posited to be a function of the fishers' skill level, the fishing strategy employed, the vessel specifications, and decisions regarding discarding and retention of bycatch species. Knowledge of the effect of the vessel on the landed catch composition implies that there is scope for targeting fisher behaviour when designing new mechanisms to control bycatch.

Keywords: Bycatch, inshore trawl fishery, *Merluccius capensis*, *Austroglossus pectoralis*, discarding

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CM 658: The role of GFCM in minimizing and mitigating negative impacts of fisheries on marine biodiversity and ecosystems, especially in relation to vulnerable species

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Understanding incidental catch of vulnerable species (i.e., elasmobranchs, sea turtles, seabirds and marine mammals), as well as dolphin depredation, and adopting effective measures to reduce them, are essential steps towards minimising these interactions and, more generally, conserving marine ecosystems, as well as ensuring a sustainable fishery sector providing long-term biological and socioeconomic benefits.

For the Mediterranean and the Black Sea, two semi-enclosed seas highly susceptible to human induced stressors, the absolute numbers of the incidental catch of vulnerable species are not (yet) fully available to fishery managers.

In this context the General Fisheries Commission for the Mediterranean (GFCM) of the Food and Agriculture Organization of the United Nations (FAO) has made many positive strides in this direction, including through adopting *ad-hoc* recommendations, publishing protocols with standardized methodologies and regional reviews on the issue, implementing monitoring programmes and awareness campaigns, and proposing the recent "*Regional Plan of Action to monitor and mitigate interactions between fisheries and vulnerable species in the Mediterranean and the Black Sea"*. This contribution intends to present and introduce the many activities undertaken, and still ongoing, by the GFCM towards the identification of priorities for the management of incidental catch and the conservation of vulnerable species, by providing some examples of outcomes of these activities.

Keywords: vulnerable species, incidental catch, mitigation measures, management, Mediterranean Sea, Black Sea, GFCM

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