



Convention on the Conservation of Migratory Species of Wild Animals

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16TH MEETING OF THE CMS SCIENTIFIC COUNCIL

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Agenda Item 9.0

FOLLOW-UP OF CMS RESOLUTION 9.18 ON BY-CATCH AND RELATED ISSUES

(Prepared by the CMS Secretariat)

1. The Resolution on By-Catch adopted at the 9th Meeting of the Conference of Parties to CMS in December 2008 (Resolution 9.18) calls for various actions from both the CMS Secretariat and the Scientific Council, in addition to the work undertaken by the Appointed Councillor for By-Catch, Barry Baker.

2. This document reports on actions the Secretariat has taken so far in follow-up of the Resolution, outlines next steps and serves to remind the Council of the tasks set by the COP. The report of the Appointed Councillor for By-Catch will be published separately.

Secretariat Actions

a) Soliciting of assessments and reviews

3. In view of the unsuccessful tender for an Assessment of Migratory Species By-catch in Global Fisheries, which had been advertised in early 2008, the 15th Scientific Council Meeting (November 2008) recommended that the Terms of Reference be amended to take into account the available resources, which had kindly been provided by the Government of the United Kingdom. Resolution 9.18 (para. 8) accordingly requests the Secretariat to investigate the feasibility of producing a review with simplified requirements:

- an assessment of the impact of fisheries by-catch and discarding on the conservation status of species listed on the Appendices
- a review to identify priority fisheries, regions and species for cooperative action

4. Following the meetings in 2008, the By-Catch Councillor had undertaken further attempts at finding a suitable candidate willing to undertake the study with its original scope. Unfortunately, these have proven to be unsuccessful, although work covering part of the review has, in the meantime, been undertaken by other organizations, notably with respect to by-catch of seabirds. The Appointed Councillor and the Secretariat are now working on a revision of the tender document with a view to re-advertising in the coming weeks.

5. Australia had given a voluntary contribution for a review on mitigation measures for reducing migratory species by-catch. This was originally foreseen to focus on turtles. However, a review for this species group has recently been published (available online at

<http://www.fao.org/docrep/012/i0725e/i0725e00.htm>, English only). The Appointed Councillor and Secretariat therefore propose to focus on other species or specific types of fisheries (e.g. gillnets).

b) By-catch information from RFMOs and other bodies

6. The CMS Secretariat was also requested (para. 9) to write to relevant RFMOs and other competent international bodies to invite them to share available information on migratory species by-catch policy and management; migratory species by-catch in the fisheries under their management; impact assessments of their fisheries on seabirds, sharks, turtles and cetaceans; by-catch monitoring, control and surveillance measures they adopt; and best practices on the basis of any performance reviews that are underway.

7. The CMS Secretariat sent letters requesting such information to the relevant bodies. CMS daughter agreements and Scientific Councillors have equally been invited to share information on steps they have taken to address migratory species by-catch. Responses already received will be made available as information documents.

8. As requested in paragraph 11 (b), the CMS Secretariat has also compiled a list of directly relevant reports and papers published between 2008 and 2010 as a result of the work of project GLoBAL (Global Bycatch Assessment of Long-Lived Species). This compilation, including bibliographic information, abstracts and links to the articles, is contained in the Annex (English only) to this document.

9. In this connection, the “bycatch and mitigation bibliography” of the project GLoBAL of Duke University and the Blue Ocean Institute, containing more than 1,500 relevant articles (English only), should be mentioned. It can be accessed online at <http://bycatch.env.duke.edu/Collaborators/bycatch-bibliography>.

10. The bycatch Councillor has also identified a number of other peer-reviewed research papers describing results of other studies describing by-catch in fisheries and progress in developing mitigation devices and strategies to ameliorate incidental mortality in fisheries. These have been compiled into an electronic bibliographic database held by the Secretariat and which can be made available to CMS Parties and others on request.

Scientific Council Actions

11. Resolution 9.18 further requests the Scientific Council to prioritise the identification of emerging and best-practice by-catch mitigation techniques as relevant to Convention-listed species. This should be done in coordination with relevant international competent bodies.

12. The Council is also requested to consider any scientific and technical information submitted by Range States or other relevant bodies relating to impacts of by-catch on migratory species.

13. The Appointed Councillor for By-Catch and the By-catch Working Group will lead on these actions and will draw also from the information currently being gathered by the Secretariat.

Action requested:

- a) Endorse the proposal regarding the scope and focus of the Assessment of Migratory Species By-catch in Global Fisheries and the review on mitigation measures for reducing fisheries by-catch of migratory species;
- b) Present relevant information on mitigation measures and impacts of by-catch on migratory species to the Council; and
- c) Provide guidance on recent mitigation research and appropriate application of mitigation techniques relevant to migratory species that have not been identified in this paper and others under consideration at the meeting.

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LIST OF PUBLICATIONS AND REPORTS OF PROJECT “GLOBAL” WITH DIRECT RELEVANCE TO CMS FOR THE PERIOD OF 2008-2010

- 1) Brothers, N. 2008. **How accurate are observer reported kills of albatrosses on longlines? Final Report to Project GloBAL.** Duke University and Blue Ocean Institute. October 2008. 62 pp.

<http://bycatch.env.duke.edu/publicationsandreports/Brothers2008.pdf>

This project set out to more accurately determine the number of albatrosses that are killed on longline hooks every year in the world's oceans today. Conventional estimates have been based on numbers of dead birds observed actually hauled aboard. This figure has long been regarded as an underestimate, because not all birds that are killed are brought aboard. Quantifying the magnitude of bird mortality from longline hooks accurately is of critical importance because of the conservation implications for affected seabird species and has long been recognised as a priority (Brothers *et al* 1999, Gilman *et al* 2003, Gilman *et al* 2007). The collection of the data used in this study was gathered from 305 longline sets. Bird interactions with over 600,000 longline hooks were observed in various oceans of the world over a 15-year period between June 1988 and May 2003. Seldom if ever, has data of this type been collected from longline fisheries. This study's findings indicate that actual seabird mortality could be around 50% higher than the existing global seabird catch estimate. Evidence that these additional numbers of birds were captured on longline hooks is presented in detail and discussed. Entanglement of seabirds in longline fishing gear and subsequent loss from the hook is responsible for many previously unaccounted for deaths. The survival rate of birds that escape after capture is brought into question. The study has also suggested that, based on the overall ratio of one dead bird recovered for every 20 baits observed taken, the resultant relatively low economic impact on fishing is likely to be a key reason why the problem of seabird bycatch persists in the industry today.

- 2) Dunn, D.C., C.Y. Kot, and P.N. Halpin. 2008. **A comparison of methods to spatially represent pelagic longline fishing effort in catch and bycatch studies.** Fisheries Research 92: 268-276.

<http://bycatch.env.duke.edu/publicationsandreports/Dunn2008.pdf>

Bycatch in fisheries has been recognized as a threat to many endangered populations of sea turtles, sea birds and marine mammals. Interactions between pelagic longline fisheries and critically endangered populations of leatherback sea turtles (*Dermochelys coriacea*) have led to temporary closures of the Hawaiian pelagic longline swordfish fishery and severe bycatch quotas. The negative impact of these events on both the populations of certain endangered species and the economic livelihood of the fishermen has resulted in a strong push from all sides to better understand bycatch events. Typically, analyses of longline catch and bycatch have examined fishing effort summarized over large areas ($\geq 1^\circ$). Although aggregation of effort to this level may be necessary to account for uncertainty, confidentiality concerns, or to make comparisons across regions, it specifically limits the researcher's ability to characterize the local oceanographic factors that may drive individual bycatch events. Higher resolution analyses must be undertaken to identify such features. However, for these higher resolution analyses, the methods currently used to spatially represent pelagic longline fishing effort may significantly affect researcher's results. Here, we look at different methods to represent this fishing effort (i.e., points, centroids, polylines and polygons) at various resolutions (2 km to 5°) to better understand which method and spatial resolution are most appropriate. Our results validate the use of point features to represent fishing effort in previous low resolution studies of the Hawaiian pelagic longline fishery by showing that the set point method is suitable for studies with resolutions lower than 15 km. However, at higher resolutions (≤ 15 km) and in areas with more sparsely distributed fishing, aggregated effort values differed significantly between spatial representation methods. We demonstrate that the use of polygons to describe pelagic longline fishing effort is more representative and necessary for such high resolution analyses.

- 3) Finkelstein M, V. Bakker, D.F. Doak, B. Sullivan, R. Lewison, et al. 2008. **Evaluating the potential effectiveness of compensatory mitigation strategies for marine bycatch.** PLoS ONE 3(6): e2480. doi:10.1371/journal.pone.0002480.

<http://bycatch.env.duke.edu/publicationsandreports/Finkelstein2008.pdf>

Conservationists are continually seeking new strategies to reverse population declines and safeguard against species extinctions. Here we evaluate the potential efficacy of a recently proposed approach to offset a major anthropogenic threat to many marine vertebrates: incidental bycatch in commercial fisheries operations. This new approach, compensatory mitigation for marine bycatch (CMMB), is conceived as a way to replace or reduce mandated restrictions on fishing activities with compensatory activities (e.g., removal of introduced predators from islands) funded by levies placed on fishers. While efforts are underway to bring CMMB into policy discussions, to date there has not been a detailed evaluation of CMMB's potential as a conservation tool, and in particular, a list of necessary and sufficient criteria that CMMB must meet to be an effective conservation strategy. Here we present a list of criteria to assess CMMB that are tied to critical ecological aspects of the species targeted for conservation, the range of possible mitigation activities, and the multi-species impact of fisheries bycatch. We conclude that, overall, CMMB has little potential for benefit and a substantial potential for harm if implemented to solve most fisheries bycatch problems. In particular, CMMB is likely to be effective only when applied to short-lived and highly-fecund species (not the characteristics of most bycatch-impacted species) and to fisheries that take few non-target species, and especially few non-seabird species (not the characteristics of most fisheries). Thus, CMMB appears to have limited application and should only be implemented after rigorous appraisal on a case-specific basis; otherwise it has the potential to accelerate declines of marine species currently threatened by fisheries bycatch.

- 4) Kiszka, J., C. Muir, C. Poonian, T.M. Cox, O.A. Amir, J. Bourjea, Y. Razafindrakoto, N. Wambitji, and N. Bristol. 2009. **Marine mammal bycatch in the southwest Indian Ocean: Review and need for a comprehensive status assessment.** Western Indian Ocean J. Mar. Sci. 7(2): 119–136.

<http://bycatch.env.duke.edu/publicationsandreports/Kiszka2009.pdf>

Incidental catch in fishing gears is a serious, worldwide threat to marine megafauna (particularly sea turtles, sharks and marine mammals). In order to inform the implementation of effective bycatch management strategies, an important first step is to conduct an assessment of the extent of this threat. In the southwest Indian Ocean (SWIO) (from 0 to 25°S, from eastern Africa to 60°E), there is a paucity of published data describing marine mammal bycatch. This review collates available information from a range of sources relating to marine mammal bycatch for nine SWIO countries: Mozambique, Tanzania (including Zanzibar), Kenya, the Seychelles, the Comoros, Mayotte, Madagascar, Reunion Island and Mauritius. An overview of the bycatch issue within each country is provided by considering the following key points: status of marine mammals, fishing effort, bycatch information and mitigation measures. Quantitative information, especially with respect to number of bycaught animals and impact on local populations, was found to be limited (except for Zanzibar). However, it is clear that several fisheries do incidentally catch marine mammals in the region, those of greatest concern being gillnets catching dugong (*Dugong dugon*) and coastal dolphins (*Tursiops aduncus* and *Sousa chinensis*) in Zanzibar and southwest Madagascar. To date, mitigation measures, particularly efforts to reduce the use of these gears, have not been employed effectively. From the information provided in this review, it is evident that it is critical to initiate the collection of quantitative data for marine mammal bycatch (particularly in gillnets) and its impact on local marine mammal populations and to implement relevant and effective mitigation measures.

- 5) Kot, C.Y., A. Boustany, and P. Halpin. 2010. **Temporal patterns of target catch and sea turtle bycatch in the U.S. Atlantic pelagic longline fishing fleet.** Canadian Journal of Fisheries and Aquatic Sciences, Canadian Journal of Fisheries and Aquatic Sciences, 67:42-57.

<http://bycatch.env.duke.edu/publicationsandreports/Kot2010.pdf>

Sea turtle bycatch in pelagic longline fishing gear is an ongoing threat to the conservation of sea turtle populations. However, these bycatch events do not occur uniformly in space or time. Leatherback (*Dermochelys coriacea*) and loggerhead (*Caretta caretta*) bycatch rates reported in large fishing regions exhibited different degrees of interannual variability. Target catch and sea turtle bycatch in most regions displayed strong periodicity that corresponded to seasons (~365 days) and/or moon phase (~29 days). When trends in catch and bycatch rates were examined by month and moon phase, the significant periods of higher and lower catch and bycatch related to swordfish (*Xiphias gladius*), yellowfin tuna (*Thunnus albacares*), and sea turtle temporal distributions in foraging and spawning/nesting, oceanographic and prey conditions, and foraging behavior. Catch and bycatch rates tended to depend more on a seasonal rather than a lunar time scale, although there is likely an interaction between the two. These findings provide insights to the susceptibility of target catch and bycatch, regional and temporal patterns of fishing effort, and potential guidance for resource management and conservation.

6) Lewison, R.L., C.U. Soykan, and J. Franklin. 2009. **Mapping the bycatch seascape: multispecies and multi-scale spatial patterns of fisheries bycatch.** *Ecological Applications*. 19(4):920–930.

<http://bycatch.env.duke.edu/publicationsandreports/Lewison2009.pdf>

Fisheries bycatch is a worldwide conservation issue. Despite a growing awareness of bycatch problems in particular ocean regions, there have been few efforts to identify spatial patterns in bycatch events. Furthermore, many studies of fisheries bycatch have been myopic, focusing on a single species or a single region. Using a range of analytical approaches to identify spatial patterns in bycatch data, we demonstrate the utility and applications of area and point pattern analyses to single and multispecies bycatch seascape of pelagic longline fisheries in the Atlantic and Pacific Oceans. We find clear evidence of spatial clustering within bycatch species in both ocean basins, both in terms of the underlying pattern of the locations of bycatch events relative to fishing locations and for areas of high bycatch rates. Furthermore, we find significant spatial overlap in the pattern of bycatch across species relative to the spatial distribution in fishing effort and target catch. These results point to the importance of considering spatial patterns of both single and multispecies bycatch to meet the ultimate goal of reducing bycatch encounters. These analyses also highlight the importance of considering bycatch relative to target catch as a way of identifying areas where fishing effort reduction may help to reduce multispecies bycatch with minimal impact on target catch.

7) Lewison, R., S. Hooker, D. Hodgson, D. Agnew, D. Oro, C. Tisdell, H. Marsh, R. Wilson, B. Godley, S. Cooke, A. Cunningham, J. Matthiopoulos, C. Hammer, J. Seminoff (eds.). 2008. **Fisheries bycatch: problems and solutions, ESR Theme Section.** *Endangered Species Research* 5 (2-3). (Available via Open Access, subscription required)

<http://bycatch.env.duke.edu/publicationsandreports/Lewison2008.pdf>

THEME SECTIONS of *Endangered Species Research* (ESR) present integrated multi-author syntheses initiated and coordinated by acknowledged experts. They highlight cutting-edge research areas or problems and/or bring together cogent bodies of literature on key taxa. Typically, they are led by one or more of ESR Editorial Staff, sometimes including Guest Editors. This ESR THEME SECTION explores the burgeoning field of bycatch research, focusing primarily on bycatch of sea turtles, sea birds and marine mammals. The challenges to studying bycatch are many: lack of direct bycatch observations, limited information on fishing effort, incomplete knowledge of species distributions. The research presented in this THEME SECTION, spanning 2 issues of ESR (Vol. 5, Nos. 2 and 3) highlights some of the innovative approaches scientists around the world are employing to tackle fisheries bycatch. The current THEME SECTION was catalyzed by the ongoing work of Project GloBAL (Global Bycatch Assessment of Long Lived Species, <http://bycatch.env.duke.edu>) that seeks to address this pressing conservation problem through innovative research approaches and collaborative efforts.

- 8) McClusky, S.M. and R.L. Lewison. 2008. **Quantifying fishing effort: a synthesis of current methods and their applications**. *Fish and Fisheries* 9: 188-200.

<http://bycatch.env.duke.edu/publicationsandreports/McClusky2008.pdf>

The need to accurately quantify fishing effort has increased in recent years as fisheries have expanded around the world and many fish stocks and non-target species are threatened with collapse. Quantification methods vary greatly among fisheries, and to date there has not been a comprehensive review of these methods. Here we review existing approaches to quantify fishing effort in small-scale, recreational, industrial, and illegal, unreported and unregulated (IUU) fisheries. We present the strengths and limitations of existing methods, identifying the most robust methods and the critical knowledge gaps that must be addressed to improve our ability to quantify and map fishing effort. Although identifying the 'best' method ultimately depends on the intended application of the data, in general, quantification methods that are based on information on gear use and spatial distribution offer the best approaches to representing fishing effort on a broad scale. Integrating fisher's knowledge and involving fishers in data collection and management decisions may be the most effective way to improve data quality and accessibility.

- 9) Moore, J.E. and A.J. Read. 2008. **A Bayesian uncertainty analysis of cetacean demography and bycatch mortality using age-at-death data**. *Ecological Applications* 18(8): 1914–1931.

<http://bycatch.env.duke.edu/publicationsandreports/Moore2008b.pdf>

Wildlife ecologists and managers are challenged to make the most of sparse information for understanding demography of many species, especially those that are long lived and difficult to observe. For many odontocete (dolphin, porpoise, toothed whale) populations, only fertility and age-at-death data are feasibly obtainable. We describe a Bayesian approach for using fertilities and two types of age-at-death data (i.e., age structure of deaths from all mortality sources and age structure of anthropogenic mortalities only) to estimate rate of increase, mortality rates, and impacts of anthropogenic mortality on those rates for a population assumed to be in a stable age structure. We used strandings data from 1977 to 1993 ($n = 96$) and observer bycatch data from 1989 to 1993 ($n = 233$) for the Gulf of Maine, USA, and Bay of Fundy, Canada, harbor porpoise (*Phocoena phocoena*) population as a case study. Our method combines mortality risk functions to estimate parameters describing age-specific natural and bycatch mortality rates. The median estimate for potential population growth (r_{nat}) was 0.046 (90% credible interval [CRI] 0.004–0.116). The median for actual growth (r) was 0.030 (90% CRI 0.192 to 0.065). The probability of population decline due to added fisheries mortality, prior to management to reduce bycatch, was 0.690. Our approach takes into account multiple sources of uncertainty in data and process, and it provides posterior distributions for a rich set of demographic rate parameters that are unknown for most cetaceans. This method should be easily adaptable to other taxa for which fertility and age-at-death data are available.

- 10) Moore, J.E., B.P. Wallace, R.L. Lewison, R. Žydelis, T.M. Cox, and L.B. Crowder. 2008. **A review of marine mammal, sea turtle, and seabird bycatch in USA fisheries and the role of policy in shaping management**. *Marine Policy* doi:10.1016/j.marpol.2008.09.003.

<http://bycatch.env.duke.edu/publicationsandreports/Moore2009.pdf>

This paper reviews the available information (observer programs, estimates, statutes, regulations) for bycatch of marine mammals, sea turtles, and seabirds in fisheries of the United States. Goals of the review were to evaluate the state of knowledge of bycatch and the role of existing protective legislation in shaping bycatch management for different taxa. Pressing issues are identified, as well as knowledge gaps and policy limitations that hinder multi-species bycatch reduction. The USA has made important progress toward reducing bycatch in its fisheries, but the efficacy of its management has been limited somewhat by a focus on taxon- and fishery-specific regulation and the lack of consistent mandate across taxa for taking

a cumulative perspective on bycatch. Applying consistent criteria across taxa for setting bycatch limits (e.g., extending the approach used for marine mammals to sea turtles and seabirds) would be the first step in a multi-species approach to bycatch reduction. A population-based multi-species multi-gear approach to bycatch would help identify priority areas where resources are needed most and can be used most effectively.

11) Moore, J.E. and R. Žydelis. 2008. **Quantifying seabird bycatch: where do we go from here?** *Animal Conservation* 11: 257-259. (Commentary)

<http://bycatch.env.duke.edu/publicationsandreports/Moore2008.pdf>

12) Moore, J.E., T.M. Cox, R.L. Lewison, A.J. Read, R. Bjorkland, S.L. McDonald, L.B. Crowder, E. Aruna, I. Ayissi, P. Espeut, C. Joynson-Hicks, N. Pilcher, C. Poonian, B. Solarin, and J. Kiszka. 2010. **An interview-based approach for triaging marine mammal and sea turtle captures in artisanal fisheries.** *Biological Conservation* 143: 795–805.

<http://bycatch.env.duke.edu/publicationsandreports/Moore%20et%20al%202010.pdf>

Recent case studies have highlighted high bycatch mortality of sea turtles and marine mammals in artisanal fisheries, but in most countries there are few data on artisanal fishing effort, catch, or bycatch. With artisanal fisheries comprising >95% of the world's fishermen, this knowledge gap presents a major challenge to threatened species conservation and sustainable fisheries initiatives. We report on results from an intensive pilot study to evaluate whether interview surveys can be effective in assessing fishing effort and threatened species bycatch. Fisheries and bycatch data from interviews with >6100 fishermen in seven developing countries were collected in <1 year for approximately USD \$47,000, indicating that this approach may rapidly yield coarse-level information over large areas at low cost. This effort provided the first fisheries characterizations for many areas and revealed the widespread nature of high bycatch in artisanal fisheries. Challenges to study design and implementation prevented quantitative estimation or spatial comparisons of bycatch during this pilot research phase, but results suggested that annual sea turtle bycatch may number at least in the low thousands of individuals per country. Annual odontocete bycatch may number at least in the low hundreds per country. Sirenian bycatch occurred in all study areas but was frequent only in West Africa. We discuss lessons learned from this survey effort and present a revised protocol for future interview-based bycatch assessments.

13) Poonian, C.N.S., M.D. Hauzer, A.B. Allaoui, T.M. Cox, J.E. Moore, A.J. Read, R.L. Lewison, L.B. Crowder. 2009. **Rapid assessment of sea turtle and marine mammal bycatch in the Union of the Comoros.** *Western Indian Ocean Journal of Marine Sciences*.

<http://bycatch.env.duke.edu/publicationsandreports/Poonian2009.pdf>

Capture of turtles by fishers, particularly on Grande Comore, was shown to be a serious threat to these species in the Comoros. Since turtles are rarely likely to be captured completely accidentally, awareness-raising and alternative income generation for fishers are potential means to reduce turtle mortality. Gillnets were identified the primary bycatch-related threat to dugong, however their use in the Comoros appeared to be minimal and they are already prohibited by Mohéli Marine Park and a number of village associations. Cetaceans were rarely captured, and mortality was low.

14) Project GloBAL. 2009. **Workshop Proceedings - Tackling Fisheries Bycatch: Managing and reducing sea turtle bycatch in gillnets.** Project GloBAL Technical Memorandum No. 1, 57pp.

<http://bycatch.env.duke.edu/publicationsandreports/GloBAL%20ISTS%20Proceedings%202008.pdf>

The objectives of this workshop were to focus attention on gillnet bycatch; share information on the importance and likely impacts of gillnet bycatch; discuss mitigation options and strategies to address

gillnet bycatch; identify the obstacles to reducing turtle bycatch in gillnets and finally to document our discussion and the information shared. Our speakers and workshop participants were fishers, scientists and fisheries managers. We focused our attention on some three key questions:

- 1) What is the magnitude of the gillnet bycatch problem? How much gear is deployed? How do we measure/quantify this? How many turtles are caught and killed? What type of data are required (direct/interview)? Are there bycatch patterns in space and time?
- 2) How can scientists, activists and fishers partner and collaborate effectively to tackle gillnet bycatch? What examples exist of successful approaches?
- 3) What are the options and obstacles for mitigation/bycatch reductions? What lessons or models do we have from existing work?

All speakers and participants felt that bycatch of sea turtles in gillnets was part of a larger issue of fisheries sustainability in gillnet fisheries in coastal areas. It was commonly reported that fishing effort had increased over the past decade as catches of all species had declined. There was general support for more specific terminology to be used to promote a clearer standardization of bycatch reporting practices. Having more common gear and bycatch currency and terminology was seen as an important step toward information sharing among very distinct geographic regions regarding bycatch reduction successes and obstacles. There was some cautious optimism that a combination of community-level approaches with fishers and gear adaptation and modification may help reduce turtle bycatch. The workshop proceedings include contributions by the invited speakers and other workshop participants organized into three broad categories – gillnet impacts on sea turtles in Mexico, gillnet impacts on sea turtles outside of Mexico, and mitigation of sea turtle bycatch in gillnets.

15) Read, A.J. 2008. The looming crisis: interactions between marine mammals and fisheries. Journal of Mammalogy 89(3):541-548.

<http://bycatch.env.duke.edu/publicationsandreports/Read2008.pdf>

The conservation threat caused by direct fisheries interactions is most dire for small populations of cetaceans and dugongs. Immediate action is needed to assess the magnitude of bycatch, particularly in many areas of Africa and Asia where little work has been conducted. New and innovative solutions to this problem are required that take account of the socioeconomic conditions experienced by fishermen and allow for efficient transfer of mitigation technology to fisheries of the developing world.

16) Sims, M., T. Cox, and R. Lewison. 2008. Modeling spatial patterns in fisheries bycatch: Improving bycatch maps to aid fisheries management. Ecological Applications 18(3): 649-661.

<http://bycatch.env.duke.edu/publicationsandreports/Sims2008.pdf>

Fisheries bycatch, or incidental take, of large vertebrates such as sea turtles, seabirds, and marine mammals, is a pressing conservation and fisheries management issue. Identifying spatial patterns of bycatch is an important element in managing and mitigating bycatch occurrences. Because bycatch of these taxa involves rare events and fishing effort is highly variable in space and time, maps of raw bycatch rates (the ratio of bycatch to fishing effort) can be misleading. Here we show how mapping bycatch can be enhanced through the use of Bayesian hierarchical spatial models. We compare model-based estimates of bycatch rates to raw rates. The model-based estimates were more precise and fit the data well. Using these results, we demonstrate the utility of this approach for providing information to managers on bycatch probabilities and cross-taxa bycatch comparisons. To illustrate this approach, we present an analysis of bycatch data from the U.S. gill net fishery for groundfish in the northwest Atlantic. The goals of this analysis are to produce more reliable estimates of bycatch rates, assess similarity of spatial patterns between taxa, and identify areas of elevated risk of bycatch.

17) Wallace B.P., S.S. Heppell, R.L. Lewison, S. Kelez, and L.B. Crowder. 2008. **Impact of fisheries bycatch on loggerhead turtles worldwide inferred from analyses of reproductive values.** *Journal of Applied Ecology* 45: 1076–1085. doi: 10.1111/j.1365-2664.2008.01507.x.

<http://bycatch.env.duke.edu/publicationsandreports/Wallace2008.pdf>

Sizes and reproductive values of loggerheads varied significantly based on spatial overlap in fisheries and ontogenetic habitat as well as on fishing gear. Thus, fisheries operating in areas occupied by larger, older turtles (e.g. trawls in neritic areas) tended to interact with more reproductively ‘valuable’ turtles than fisheries that operated in areas occupied by smaller, younger turtles (e.g. oceanic and pelagic longlines). We also found evidence of size-selectivity among different fishing gears (e.g. wider size variation among loggerheads taken in driftnets and trawls than in longlines) and gear configuration (e.g. smaller loggerheads in shallow longline sets using small hooks). These results suggest that evaluation of fishery impacts on marine megafauna require characterization of fishery activities; understanding of species biology must be considered in order to determine population impacts of fisheries bycatch. Data access and quality can be improved and uncertainty reduced by increasing independent observer coverage on fishing vessels throughout the world’s oceans.

Syntheses and applications: Our analyses demonstrate that application of reproductive values can allow fisheries managers and biologists alike to identify the most influential bycatch threats to geographically widespread populations of long-lived marine vertebrates, thereby facilitating prioritization of conservation actions and successful management of these animals. For example, our results suggest that effective management of loggerhead catch in trawl gear should be one of the top priorities for conservation of loggerhead populations worldwide.

18) Zydelski, R., J. Bellebaum, H. Österblom, M. Vetemaad, B. Schirmeister, A. Stipniece, M. Dagys, M. Van Eerden, and S. Garthe. 2009. **Bycatch in gillnet fisheries – an overlooked threat to waterbird populations.** *Biological Conservation* 142:1269–1281.

<http://bycatch.env.duke.edu/publicationsandreports/Zydelski2009.pdf>

Bird mortality in fishing gear is a global conservation issue and it is recognised that bycatch in industrial longline and trawl fisheries threatens several seabird species. Little is known however about the effects of bycatch in small-scale gillnet fisheries on bird populations. Here we review 30 studies reporting bird bycatch in coastal gillnet fisheries in the Baltic Sea and the North Sea region in order to assess the magnitude of this problem and potential effects on bird populations. All species of diving birds that occur in the study region, including divers (loons), grebes, sea ducks, diving ducks, auks and cormorants, have been reported as dying in fishing nets. The cumulative bycatch estimate extracted from several localized studies providing such information, suggests that about 90,000 birds die in fishing nets annually, a number that is almost certainly a substantial underestimate. We conclude that it is likely that between 100,000 and 200,000 waterbirds are killed per year. Geographic and temporal patterns of bycatch generally matched species distribution and periods of presence. Also, bycatch rates varied depending on species’ foraging technique and were influenced by net parameters and fishing depth. To evaluate effects of additive mortality on bird populations, we applied the Potential Biological Removal (PBR) concept to three species with the most extensive bycatch information. Agreeing with PBR assumptions we conclude that bycatch is a matter of concern for at least two of the three assessed species. We suggest that bycatch research in Europe and beyond should aim at unification of principles for bycatch assessment, setting new standards for the monitoring of waterbird populations so that vital rates and mortality data are recorded, and implementing quantifiable criteria for evaluating effects of fisheries bycatch.

19) Zydelski, R., B.P. Wallace, E.L. Gilman, and T.B. Werner. 2009. **Conservation of Marine Megafauna through Minimization of Fisheries Bycatch.** *Conservation Biology* 23(3):608-616.

<http://bycatch.env.duke.edu/publicationsandreports/Zydelis2009b.pdf>

Many populations of marine megafauna, including seabirds, sea turtles, marine mammals, and elasmobranchs, have declined in recent decades due largely to anthropogenic mortality. To successfully conserve these long-lived animals, efforts must be prioritized according to feasibility and the degree to which they address threats with the highest relative impacts on population dynamics. Recently, Wilcox and Donlan (2007, *Frontiers in Ecology and the Environment*) and Donlan and Wilcox (2008, *Biological Invasions*) proposed a conservation strategy of “compensatory mitigation” in which fishing industries offset bycatch of seabirds and sea turtles by funding eradication of invasive mammalian predators from the terrestrial reproductive sites of these marine animals. Although this is a creative and conceptually compelling approach, we find it flawed as a conservation tool because it has narrow applicability among marine megafauna, it does not address the most pervasive threats to marine megafauna, and it is logistically and financially infeasible. Invasive predator eradication does not adequately offset the most pressing threat to most marine megafauna populations—fisheries bycatch. For seabird populations, fisheries bycatch and invasive predators infrequently are overlapping threats. Invasive predators have limited population-level impacts on sea turtles and marine mammals and no impacts on elasmobranchs, all of which are threatened by bycatch. Implementing compensatory mitigation in marine fisheries is unrealistic due to inadequate monitoring, control, and surveillance in the majority of fleets. Therefore, offsetting fisheries bycatch with eradication of invasive predators would be less likely to reverse population declines than reducing bycatch. We recommend that efforts to mitigate bycatch in marine capture fisheries should address multiple threats to sensitive bycatch species groups, but these efforts should first institute proven bycatch avoidance and reduction methods before considering compensatory mitigation.