Pêches

Un exemple frappant de surexploitation
Exemple par excellence du problème de la récolte d’une richesse commune

- Les océans n’appartiennent à personne
- Les ressources marines qui s’y trouvent n’appartiennent à personne
- Divers pays récoltent cette richesse commune sans quotas, sans règlements et sans organisation qui chapeaute cette activité
- Il y a surexploitation flagrante de cette ressource
Paleontological baselines for evaluating extinction risk in the modern oceans

Seth Finnegan, Sean C. Anderson, Paul G. Harnik, Carl Simpson, Derek P. Tittensor, Jarrett E. Byrnes, Zoe V. Finkel, David R. Lindberg, Lee Hsiang Liow, Rowan Lockwood, Heike K. Lotze, Craig R. McClain, Jenny L. McGuire, Aaron O’Dea, John M. Pandolfi

Marine taxa are threatened by anthropogenic impacts, but knowledge of their extinction vulnerabilities is limited. The fossil record provides rich information on past extinctions that can help predict biotic responses. We show that over 23 million years, taxonomic membership and geographic range size consistently explain a large proportion of extinction risk variation in six major taxonomic groups. We assess intrinsic risk—extinction risk predicted by paleontologically calibrated models—for modern genera in these groups. Mapping the geographic distribution of these genera identifies coastal biogeographic provinces where fauna with high intrinsic risk are strongly affected by human activity or climate change. Such regions are disproportionately in the tropics, raising the possibility that these ecosystems may be particularly vulnerable to future extinctions. Intrinsic risk provides a prehuman baseline for considering current threats to marine biodiversity.
World’s whaling slaughter tallied

Commercial hunting wiped out almost three million animals last century.

BY DANIEL CRESSEY
Systematic distortions in world fisheries catch trends

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Over 75% of the world marine fisheries catch (over 80 million tonnes per year) is sold on international markets, in contrast to other food commodities (such as rice)\(^1\). At present, only one institution, the Food and Agriculture Organization of the United Nations (FAO) maintains global fisheries statistics. As an intergovernmental organization, however, FAO must generally rely on the statistics provided by member countries, even if it is doubtful that these correspond to reality. Here we show that misreporting by countries with large fisheries, combined with the large and widely fluctuating catch of species such as the Peruvian anchoveta, can cause globally spurious trends. Such trends influence unwise investment decisions by firms in the fishing sector and by banks, and prevent the effective management of international fisheries.
Fisheries

Mislabelling of a depleted reef fish

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Vivaneau rouge
Évidence de surexploitation
Towards sustainability in world fisheries

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Fisheries have rarely been ‘sustainable’. Rather, fishing has induced serial depletions, long masked by improved technology, geographic expansion and exploitation of previously spurned species lower in the food web. With global catches declining since the late 1980s, continuation of present trends will lead to supply shortfall, for which aquaculture cannot be expected to compensate, and may well exacerbate. Reducing fishing capacity to appropriate levels will require strong reductions of subsidies. Zoning the oceans into unfished marine reserves and areas with limited levels of fishing effort would allow sustainable fisheries, based on resources embedded in functional, diverse ecosystems.
Figure 1 Estimated global fish landings 1950–1999. Figures for invertebrates, groundfish, pelagic fish and Peruvian anchoveta are from FAO catch statistics, with adjustment for over-reporting from China\(^\text{26}\). Fish caught but then discarded were not included in the FAO landings; data relate to the early 1990\(^\text{53}\) were made proportional to the FAO landings for other periods. Other illegal, unreported or unregulated (IUU) catches\(^\text{65}\) were estimated by identifying, for each 5-year block, the dominant jurisdiction and gear use (and hence incentive for IUU)\(^\text{84}\); reported catches were then raised by the percentage of IUU in major fisheries for each 5-year block. The resulting estimates of IUU are very tentative (note dotted y-axis), and we consider that complementing landings statistics with more reliable estimates of discards and IUU is crucial for a transition to ecosystem-based management.
Rapid worldwide depletion of predatory fish communities

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Serious concerns have been raised about the ecological effects of industrialized fishing\(^1\)\(^-\)\(^3\), spurring a United Nations resolution on restoring fisheries and marine ecosystems to healthy levels\(^4\). However, a prerequisite for restoration is a general understanding of the composition and abundance of unexploited fish communities, relative to contemporary ones. We constructed trajectories of community biomass and composition of large predatory fishes in four continental shelf and nine oceanic systems, using all available data from the beginning of exploitation. Industrialized fisheries typically reduced community biomass by 80% within 15 years of exploitation. Compensatory increases in fast-growing species were observed, but often reversed within a decade. Using a meta-analytic approach, we estimate that large predatory fish biomass today is only about 10% of pre-industrial levels. We conclude that declines of large predators in coastal regions\(^5\) have extended throughout the global ocean, with potentially serious consequences for ecosystems\(^5\)\(^-\)\(^7\). Our analysis suggests that management based on recent data alone may be misleading, and provides minimum estimates for unexploited communities, which could serve as the ‘missing baseline’\(^8\) needed for future restoration efforts.
Figure 2: Spatial patterns of relative predator biomass in 1952 (a), 1958 (b), 1964 (c) and 1980 (d). Colour codes depict the number of fish caught per 100 hooks on pelagic longlines set by the Japanese fleet. Data are binned in a global 5° × 5° grid. For complete year-by-year maps, refer to the Supplementary Information.
Fishing Down Marine Food Webs

Daniel Pauly,* Villy Christensen, Johanne Dalsgaard, Rainer Froese, Francisco Torres Jr.

The mean trophic level of the species groups reported in Food and Agricultural Organization global fisheries statistics declined from 1950 to 1994. This reflects a gradual transition in landings from long-lived, high trophic level, piscivorous bottom fish toward short-lived, low trophic level invertebrates and planktivorous pelagic fish. This effect, also found to be occurring in inland fisheries, is most pronounced in the Northern Hemisphere. Fishing down food webs (that is, at lower trophic levels) leads at first to increasing catches, then to a phase transition associated with stagnating or declining catches. These results indicate that present exploitation patterns are unsustainable.
GLOBAL FOOD SUPPLY

China’s aquaculture and the world’s wild fisheries

Curbing demand for wild fish in aquafeeds is critical

By Ling Cao1, Rosamond Naylor1, Patrik Henriksson2, Duncan Leadbitter3, Marc Metian4, Max Troell4,5, Wenbo Zhang6,7
Signature of ocean warming in global fisheries catch

William W. L. Cheung¹, Reg Watson² & Daniel Pauly³

Marine fishes and invertebrates respond to ocean warming through distribution shifts, generally to higher latitudes and deeper waters. Consequently, fisheries should be affected by ‘tropicalization’ of catch¹-⁴ (increasing dominance of warm-water species). However, a signature of such climate-change effects on global fisheries catch has so far not been detected. Here we report such an index, the mean temperature of the catch (MTC), that is calculated from the average inferred temperature preference of exploited species weighted by their annual catch. Our results show that, after accounting for the effects of fishing and large-scale oceanographic variability, global MTC increased at a rate of 0.19 degrees Celsius per decade between 1970 and 2006, and non-tropical MTC increased at a rate of 0.23 degrees Celsius per decade. In tropical areas, MTC increased initially because of the reduction in the proportion of subtropical species catches, but subsequently stabilized as scope for further tropicalization of communities became limited. Changes in MTC in 52 large marine ecosystems, covering the majority of the world’s coastal and shelf areas, are significantly and positively related to regional changes in sea surface temperature³. This study shows that ocean warming has already affected global fisheries in the past four decades, highlighting the immediate need to develop adaptation plans to minimize the effect of such warming on the economy and food security of coastal communities, particularly in tropical regions⁶⁷."
Figure 1 | Changes in catch species composition in relation to ocean warming and the resulting changes in MTC. Species distributions are related to ocean temperature (coloured bars) and temperature preferences of the exploited species (grey curves). Increase and decrease in abundance due to ocean warming are indicated by green curves and the reduction in area under the grey curves, respectively. The vertical black and red arrows represent MTC in the initial and subsequent decades, respectively. ΔMTC represents the difference in MTC relative to the initial decade. Species local extinction and invasion because of warming are indicated by red and green dotted curves, respectively. The expected changes in MTC over time are shown on the right.
Large benefits to marine fisheries of meeting the 1.5°C global warming target

William W. L. Cheung, Gabriel Reygondeau, Thomas L. Frölicher

Translating the Paris Agreement to limit global warming to 1.5°C above preindustrial level into impact-related targets facilitates communication of the benefits of mitigating climate change to policy-makers and stakeholders. Developing ecologically relevant impact-related targets for marine ecosystem services, such as fisheries, is an important step. Here, we use maximum catch potential and species turnover as climate-risk indicators for fisheries. We project that potential catches will decrease by more than 3 million metric tons per degree Celsius of warming. Species turnover is more than halved when warming is lowered from 3.5° to 1.5°C above the preindustrial level. Regionally, changes in maximum catch potential and species turnover vary across ecosystems, with the biggest risk reduction in the Indo-Pacific and Arctic regions when the Paris Agreement target is achieved.
Fig. 1. Conceptual diagram explaining the framework of this study to establish ecologically relevant impact-related targets and the implications of such targets for understanding the benefits of meeting the Paris Agreement global warming target.
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Several studies have documented fish populations changing in response to long-term warming. Over the past decade, sea surface temperatures in the Gulf of Maine increased faster than 99% of the global ocean. The warming, which was related to a northward shift in the Gulf Stream and to changes in the Atlantic Multidecadal Oscillation and Pacific Decadal Oscillation, led to reduced recruitment and increased mortality in the region’s Atlantic cod (Gadus morhua) stock. Failure to recognize the impact of warming on cod contributed to overfishing. Recovery of this fishery depends on sound management, but the size of the stock depends on future temperature conditions. The experience in the Gulf of Maine highlights the need to incorporate environmental factors into resource management.
Changing recruitment capacity in global fish stocks

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Edited by James A. Estes, University of California, Santa Cruz, CA, and approved November 3, 2015 (received for review March 7, 2015)

Marine fish and invertebrates are shifting their regional and global distributions in response to climate change, but it is unclear whether their productivity is being affected as well. Here we tested for time-varying trends in biological productivity parameters across 262 fish stocks of 127 species in 39 large marine ecosystems and high-seas areas (hereafter LMEs). This global meta-analysis revealed widespread changes in the relationship between spawning stock size and the production of juvenile offspring (recruitment), suggesting fundamental biological change in fish stock productivity at early life stages. Across regions, we estimate that average recruitment capacity has declined at a rate approximately equal to 3% of the historical maximum per decade. However, we observed large variability among stocks and regions; for example, highly negative trends in the North Atlantic contrast with more neutral patterns in the North Pacific. The extent of biological change in each LME was significantly related to observed changes in phytoplankton chlorophyll concentration and the intensity of historical overfishing in that ecosystem. We conclude that both environmental changes and chronic overfishing have already affected the productive capacity of many stocks at the recruitment stage of the life cycle. These results provide a baseline for ecosystem-based fisheries management and may help adjust expectations for future food production from the oceans.

Significance

Marine fish stocks play an important role in marine ecosystems and provide a source of protein for billions of people worldwide. Recent environmental changes have affected the distribution of many stocks, but it is yet unclear whether their productivity is affected as well. We show that recruitment capacity (the ability of stocks to produce surviving offspring) has been significantly altered by both environmental changes and biological changes brought about by overfishing. In total, these effects have reduced recruitment capacity by 3% of the historical maximum per decade, on average. This paper helps us to understand and track previously unrecognized changes in fish stock productivity during the early stages of their life cycle.
Conséquences écosystémiques de la surexploitation
Historical Overfishing and the Recent Collapse of Coastal Ecosystems

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Ecological extinction caused by overfishing precedes all other pervasive human disturbance to coastal ecosystems, including pollution, degradation of water quality, and anthropogenic climate change. Historical abundances of large consumer species were fantastically large in comparison with recent observations. Paleoenvironmental, archaeological, and historical data show that time lags of decades to centuries occurred between the onset of overfishing and consequent changes in ecological communities, because unfished species of similar trophic level assumed the ecological roles of overfished species until they too were overfished or died of epidemic diseases related to overcrowding. Retrospective data not only help to clarify underlying causes and rates of ecological change, but they also demonstrate achievable goals for restoration and management of coastal ecosystems that could not even be contemplated based on the limited perspective of recent observations alone.
Simplified coastal food webs showing changes in some of the important top-down interactions due to overfishing; before (left side) and after (right side) fishing. (A and B) Kelp forests for Alaska and southern California (left box), and Gulf of Maine (right box). (C and D) Tropical coral reefs and seagrass meadows. (E and F) Temperate estuaries.
Cascading Effects of the Loss of Apex Predatory Sharks from a Coastal Ocean

Ransom A. Myers,¹ Julia K. Baum,¹* Travis D. Shepherd,¹
Sean P. Powers,² Charles H. Peterson³*

Impacts of chronic overfishing are evident in population depletions worldwide, yet indirect ecosystem effects induced by predator removal from oceanic food webs remain unpredictable. As abundances of all 11 great sharks that consume other elasmobranchs (rays, skates, and small sharks) fell over the past 35 years, 12 of 14 of these prey species increased in coastal northwest Atlantic ecosystems. Effects of this community restructuring have cascaded downward from the cownose ray, whose enhanced predation on its bay scallop prey was sufficient to terminate a century-long scallop fishery. Analogous top-down effects may be a predictable consequence of eliminating entire functional groups of predators.
Impacts of Fishing Low–Trophic Level Species on Marine Ecosystems

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Elizabeth A. Fulton,¹ Penny Johnson,¹ Isaac C. Kaplan,⁴ Hector Lozano-Montes,⁵
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Low–trophic level species account for more than 30% of global fisheries production and contribute substantially to global food security. We used a range of ecosystem models to explore the effects of fishing low–trophic level species on marine ecosystems, including marine mammals and seabirds, and on other commercially important species. In five well-studied ecosystems, we found that fishing these species at conventional maximum sustainable yield (MSY) levels can have large impacts on other parts of the ecosystem, particularly when they constitute a high proportion of the biomass in the ecosystem or are highly connected in the food web. Halving exploitation rates would result in much lower impacts on marine ecosystems while still achieving 80% of MSY.
Chronic and intensive bottom trawling impairs deep-sea biodiversity and ecosystem functioning

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Edited by David M. Karl, University of Hawaii, Honolulu, HI, and approved April 17, 2014 (received for review March 26, 2014)

Bottom trawling has many impacts on marine ecosystems, including seafood stock impoverishment, benthos mortality, and sediment resuspension. Historical records of this fishing practice date back to the mid-1300s. Trawling became a widespread practice in the late 19th century, and it is now progressively expanding to greater depths, with the concerns about its sustainability that emerged during the first half of the 20th century now increasing. We show here that compared with untrawled areas, chronically trawled sediments along the continental slope of the north-western Mediterranean Sea are characterized by significant decreases in organic matter content (up to 52%), slower organic carbon turnover (ca. 37%), and reduced meiofauna abundance (80%), biodiversity (50%), and nematode species richness (25%). We estimate that the organic carbon removed daily by trawling in the region under scrutiny represents as much as 60–100% of the input flux. We anticipate that such an impact is causing the degradation of deep-sea sedimentary habitats and an infaunal depauperation. With deep-sea trawling currently conducted along most continental margins, we conclude that trawling represents a major threat to the deep seafloor ecosystem at the global scale.

**Significance**

Deep-sea ecosystem processes play a key role in global functioning of the planet. These functions are largely dependent upon deep-sea biodiversity. Industrial fisheries, after the depletion of fish stocks and destruction of the marine habitats on continental shelves, are now rapidly moving deeper into the ocean interior. We show here that bottom trawling along continental slopes has a major impact on deep-sea sedimentary ecosystems, causing their degradation and infaunal depauperation. Deep-sea fisheries, indeed, cause the collapse of benthic biodiversity and ecosystem functions, with potential consequences on the biogeochemical cycles. These findings support the claim of immediate actions for a sustainable management of fisheries in deep-sea environments.
How Fisheries Affect Evolution

Andrea Belgrano and Charles W. Fowler

Commercial fishing alters the genetic traits of fish stocks.

Multispecies catch. Recent research has shown that size-selective commercial fishing causes genetic changes in fish, with wide-ranging implications for sustainable fishing.
Roles of density-dependent growth and life history evolution in accounting for fisheries-induced trait changes

Anne Maria Eikeset, Erin S. Dunlop, Mikko Heino, Geir Storvik, Nils C. Stenseth, and Ulf Dieckmann

The relative roles of density dependence and life history evolution in contributing to rapid fisheries-induced trait changes remain debated. In the 1930s, northeast Arctic cod (Gadus morhua), currently the world’s largest cod stock, experienced a shift from a traditional spawning-ground fishery to an industrial trawl fishery with elevated exploitation in the stock’s feeding grounds. Since then, age and length at maturation have declined dramatically, a trend paralleled in other exploited stocks worldwide. These trends can be explained by demographic truncation of the population’s age structure, phenotypic plasticity in maturation arising through density-dependent growth, fisheries-induced evolution favoring faster-growing or earlier-maturing fish, or a combination of these processes. Here, we use a multitrait eco-evolutionary model to assess the capacity of these processes to reproduce 74 y of historical data on age and length at maturation in northeast Arctic cod, while mimicking the stock’s historical harvesting regime. Our results show that model predictions critically depend on the assumed density dependence of growth: when this is weak, life history evolution might be necessary to prevent stock collapse, whereas when a stronger density dependence estimated from recent data is used, the role of evolution in explaining fisheries-induced trait changes is diminished. Our integrative analysis of density-dependent growth, multitrait evolution, and stock-specific time series data underscores the importance of jointly considering evolutionary and ecological processes, enabling a more comprehensive perspective on empirically observed stock dynamics than previous studies could provide.

Significance

Rapid anthropogenic trait changes in fish stocks is a highly publicized ocean conservation issue, yet the relative contributions of evolutionary and ecological dynamics are unknown. We present an integrative empirically based simulation model to determine the role of these contributions in the world’s largest cod stock. We quantitatively evaluate predictions with different density-dependent growth models using historical stock-specific data. The amount of evolution required for explaining observed maturation trends is small, yet with weakly density-dependent growth, critical for preventing stock collapse. The role of evolution in explaining trends is diminished when density-dependent growth is present. Our study reveals how interactions among evolution, ecology, and fisheries influence stock dynamics and harvest sustainability, emphasizing the need for integrated approaches to fisheries management.
Le futur des pêches
The Future for Fisheries

Daniel Pauly¹* Jackie Alder,¹ Elena Bennett,² Villy Christensen,¹ Peter Tyedmers,³ Reg Watson¹

Formal analyses of long-term global marine fisheries prospects have yet to be performed, because fisheries research focuses on local, species-specific management issues. Extrapolation of present trends implies expansion of bottom fisheries into deeper waters, serious impact on biodiversity, and declining global catches, the last possibly aggravated by fuel cost increases. Examination of four scenarios, covering various societal development choices, suggests that the negative trends now besetting fisheries can be turned around, and their supporting ecosystems rebuilt, at least partly.
Fig. 1. Fraction of the sea bottom and adjacent waters contributing to the world fisheries from 1950 to 2000 (30) and projected to 2050 by depth (logarithmic scale). Note the strong reversal of trends required for 20% of the waters down to 100-m depth to be protected from fishing by 2020.
Status and Solutions for the World’s Unassessed Fisheries

Christopher Costello,¹* Daniel Ovando,¹ Ray Hilborn,² Steven D. Gaines,¹ Olivier Deschenes,³ Sarah E. Lester¹,⁴

Recent reports suggest that many well-assessed fisheries in developed countries are moving toward sustainability. We examined whether the same conclusion holds for fisheries lacking formal assessment, which comprise >80% of global catch. We developed a method using species’ life-history, catch, and fishery development data to estimate the status of thousands of unassessed fisheries worldwide. We found that small unassessed fisheries are in substantially worse condition than assessed fisheries, but that large unassessed fisheries may be performing nearly as well as their assessed counterparts. Both small and large stocks, however, continue to decline: 64% of unassessed stocks could provide increased sustainable harvest if rebuilt. Our results suggest that global fishery recovery would simultaneously create increases in abundance (56%) and fishery yields (8 to 40%).
Transient dynamics of an altered large marine ecosystem

Kenneth T. Frank¹, Brian Petrie¹, Jonathan A. D. Fisher² & William C. Leggett²

Overfishing of large-bodied benthic fishes and their subsequent population collapses on the Scotian Shelf of Canada’s east coast¹² and elsewhere³⁴ resulted in restructuring of entire food webs now dominated by planktivorous, forage fish species and macroinvertebrates. Despite the imposition of strict management measures in force since the early 1990s, the Scotian Shelf ecosystem has not reverted back to its former structure. Here we provide evidence of the transient nature of this ecosystem and its current return path towards benthic fish species domination. The prolonged duration of the altered food web, and its current recovery, was and is being governed by the oscillatory, runaway consumption dynamics of the forage fish complex. These erupting forage species, which reached biomass levels 900% greater than those prevalent during the pre-collapse years of large benthic predators, are now in decline, having outstripped their zooplankton food supply. This dampening, and the associated reduction in the intensity of predation, was accompanied by lagged increases in species abundances at both lower and higher trophic levels, first witnessed in zooplankton and then in large-bodied predators, all consistent with a return towards the earlier ecosystem structure. We conclude that the reversibility of perturbed ecosystems can occur and that this bodes well for other collapsed fisheries.
Resilience and Recovery of Overexploited Marine Populations

Philipp Neubauer, Olaf P. Jensen, Jeffrey A. Hutchings, Julia K. Baum

Recovery of overexploited marine populations has been slow, and most remain below target biomass levels. A key question is whether this is due to insufficient reductions in harvest rates or the erosion of population resilience. Using a global meta-analysis of overfished stocks, we find that resilience of those stocks subjected to moderate levels of overfishing is enhanced, not compromised, offering the possibility of swift recovery. However, prolonged intense overexploitation, especially for collapsed stocks, not only delays rebuilding but also substantially increases the uncertainty in recovery times, despite predictable influences of fishing and life history. Timely and decisive reductions in harvest rates could mitigate this uncertainty. Instead, current harvest and low biomass levels render recovery improbable for the majority of the world’s depleted stocks.
Predicting overfishing and extinction threats in multispecies fisheries

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Contributed by Stephen Polasky, July 30, 2013 (sent for review November 21, 2012)

Threats to species from commercial fishing are rarely identified until species have suffered large population declines, by which time remedial actions can have severe economic consequences, such as closure of fisheries. Many of the species most threatened by fishing are caught in multispecies fisheries, which can remain profitable even as populations of some species collapse. Here we show for multispecies fisheries that the biological and socioeconomic conditions that would eventually cause species to be severely depleted or even driven extinct can be identified decades before those species experience high harvest rates or marked population declines. Because fishing effort imposes a common source of mortality on all species in a fishery, the long-term impact of a fishery on a species is predicted by measuring its loss rate relative to that of species that influence the fishery’s maximal effort. We tested our approach on eight Pacific tuna and billfish populations, four of which have been identified recently as in decline and threatened with overfishing. The severe depletion of all four populations could have been predicted in the 1950s, using our approach. Our results demonstrate that species threatened by human harvesting can be identified much earlier, providing time for adjustments in harvesting practices before consequences become severe and fishery closures or other socioeconomically disruptive interventions are required to protect species.
Giant Marine Reserves Pose Vast Challenges

Huge no-fishing zones might save widely traveled tuna and other species, but monitoring their effectiveness—and enforcing catch bans—will require new approaches.
A Fleet of New Protected Areas

- **Existing reserve, no fishing**
- **Proposed reserve, no fishing**
- **Existing reserve, allows fishing**

**Northwestern Hawaiian Islands**
- Size: 363,000 km² (created 2006)

**New Caledonia**
- Size: 1,300,000 km² (created 2012)

**Coral Sea**
- Size: 503,000 km² (created 2012)

**Kermadec Islands**
- Size: 620,000 km²

**Phoenix Islands**
- Size: 408,000 km² (created 2008)

**Pitcairn**
- Size: 830,000 km²

**Easter Island**
- Size: 700,000 km²

**Cook Islands**
- Size: 1,000,000 km² (created 2012)

**Bermuda**
- Size: 400,000 km²

**Chagos**
- Size: 640,000 km² (created 2010)
Global conservation outcomes depend on marine protected areas with five key features

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In line with global targets agreed under the Convention on Biological Diversity, the number of marine protected areas (MPAs) is increasing rapidly, yet socio-economic benefits generated by MPAs remain difficult to predict and under debate¹². MPAs often fail to reach their full potential as a consequence of factors such as illegal harvesting, regulations that legally allow detrimental harvesting, or emigration of animals outside boundaries because of continuous habitat or inadequate size of reserve³⁴. Here we show that the conservation benefits of 87 MPAs investigated worldwide increase exponentially with the accumulation of five key features: no take, well enforced, old (>10 years), large (>100 km²), and isolated by deep water or sand. Using effective MPAs with four or five key features as an unfished standard, comparisons of underwater survey data from effective MPAs with predictions based on survey data from fished coasts indicate that total fish biomass has declined about two-thirds from historical baselines as a result of fishing. Effective MPAs also had twice as many large (>250 mm total length) fish species per transect, five times more large fish biomass, and fourteen times more shark biomass than fished areas. Most (59%) of the MPAs studied had only one or two key features and were not ecologically distinguishable from fished sites. Our results show that global conservation targets based on area alone will not optimize protection of marine biodiversity. More emphasis is needed on better MPA design, durable management and compliance to ensure that MPAs achieve their desired conservation value.
Making marine protected areas work

Globally consistent surveys of five factors influencing the success of marine protected areas — age, size, isolation, protection and enforcement — reveal that only when all five are present does nature thrive.

Figure 1 | Five factors for effective protection. Edgar et al.1 tested how five features — full protection, enforcement of protection, age greater than 10 years, size more than 100 km² and isolation — affect conservation benefits of marine protected areas (MPAs). They find that, compared with unprotected areas, there is no benefit gained from an MPA with none of these features (for example (a), a young MPA that is still fished by recreational and small-scale commercial fishermen, is too small to encompass the reef and in which protection is not well enforced), or even from an MPA with one or two features. But the conservation value of an MPA rises exponentially as the number of features increases from three (for example (b), an older MPA that protects an isolated reef and is enforced, but that is small and not fully protected) to all five (c).
Capacity shortfalls hinder the performance of marine protected areas globally

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Marine protected areas (MPAs) are increasingly being used globally to conserve marine resources. However, whether many MPAs are being effectively and equitably managed, and how MPA management influences substantive outcomes remain unknown. We developed a global database of management and fish population data (433 and 218 MPAs, respectively) to assess: MPA management processes; the effects of MPAs on fish populations; and relationships between management processes and ecological effects. Here we report that many MPAs failed to meet thresholds for effective and equitable management processes, with widespread shortfalls in staff and financial resources. Although 71% of MPAs positively influenced fish populations, these conservation impacts were highly variable. Staff and budget capacity were the strongest predictors of conservation impact: MPAs with adequate staff capacity had ecological effects 2.9 times greater than MPAs with inadequate capacity. Thus, continued global expansion of MPAs without adequate investment in human and financial capacity is likely to lead to sub-optimal conservation outcomes.
Recovering the potential of coral reefs

An analysis of fish declines in coral reefs shows that simple fishing limits and implementation of marine protected areas can be enough to support recovery of coral ecosystem resilience.

NICHOLAS K. DULVY
& HOLLY K. KINDSVATER
Recovery potential of the world’s coral reef fishes

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Continuing degradation of coral reef ecosystems has generated substantial interest in how management can support reef resilience1,2. Fishing is the primary source of diminished reef function globally3-5, leading to widespread calls for additional marine reserves to recover fish biomass and restore key ecosystem functions6. Yet there are no established baselines for determining when these conservation objectives have been met or whether alternative management strategies provide similar ecosystem benefits. Here we establish empirical conservation benchmarks and fish biomass recovery timelines against which coral reefs can be assessed and managed by studying the recovery potential of more than 800 coral reefs along an exploitation gradient. We show that resident reef fish biomass in the absence of fishing ($B_0$) averages ~1,000 kg ha$^{-1}$, and that the vast majority (83%) of fished reefs are missing more than half their expected biomass, with severe consequences for key ecosystem functions such as predation. Given protection from fishing, reef fish biomass has the potential to recover within 35 years on average and less than 60 years when heavily depleted. Notably, alternative fisheries restrictions are largely (64%) successful at maintaining biomass above 50% of $B_0$, sustaining key functions such as herbivory. Our results demonstrate that crucial ecosystem functions can be maintained through a range of fisheries restrictions, allowing coral reef managers to develop recovery plans that meet conservation and livelihood objectives in areas where marine reserves are not socially or politically feasible solutions.
Reconsidering the Consequences of Selective Fisheries

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Balanced harvesting ... distributes a moderate mortality from fishing across the widest possible range of species, stocks, and sizes in an ecosystem.

Balanced fishing across a range of species, stocks, and sizes could mitigate adverse effects and address food security better than increased selectivity.
Dynamic ocean management increases the efficiency and efficacy of fisheries management

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In response to the inherent dynamic nature of the oceans and continuing difficulty in managing ecosystem impacts of fisheries, interest in the concept of dynamic ocean management, or real-time management of ocean resources, has accelerated in the last several years. However, scientists have yet to quantitatively assess the efficiency of dynamic management over static management. Of particular interest is how scale influences effectiveness, both in terms of how it reflects underlying ecological processes and how this relates to potential efficiency gains. Here, we address the empirical evidence gap and further the ecological theory underpinning dynamic management. We illustrate, through the simulation of closures across a range of spatiotemporal scales, that dynamic ocean management can address previously intractable problems at scales associated with coactive and social patterns (e.g., competition, predation, niche partitioning, parasitism, and social aggregations). Furthermore, it can significantly improve the efficiency of management: as the resolution of the closures used increases (i.e., as the closures become more targeted), the percentage of target catch forgone or displaced decreases, the reduction ratio (bycatch/catch) increases, and the total time–area required to achieve the desired bycatch reduction decreases. In the scenario examined, coarser scale management measures (annual time–area closures and monthly full-fishery closures) would displace up to four to five times the target catch and require 100–200 times more square kilometer-days of closure than dynamic measures (grid-based closures and move-on rules). To achieve similar reductions in juvenile bycatch, the fishery would forgo or displace between USD 15–52 million in landings using a static approach over a dynamic management approach.

Significance

Food security and the economic well-being of millions of people depend on sustainable fisheries, which require innovative approaches to management that can balance ecological, economic, and social objectives. We offer empirical evidence that dynamic ocean management, or real-time ocean management, can increase the efficacy and efficiency of fisheries management over static approaches by better aligning human and ecological scales of use. Furthermore, we show that dynamic management can address critical ecological patterns previously considered to be largely intractable in fisheries management (e.g., competition, niche partitioning, predation, parasitism, or social aggregations) at appropriate scales. The evidence and theory offered supports the use of dynamic ocean management in a range of scenarios to improve the ecological, economic, and social sustainability of fisheries.
Secure sustainable seafood from developing countries

Require improvements as conditions for market access


Science (2015) 348: 504-506
Catch shares slow the race to fish

Anna M. Birkenbach1,2, David J. Kaczan1,2 & Martin D. Smith1,3

In fisheries, the tragedy of the commons manifests as a competitive race to fish that compresses fishing seasons, resulting in ecological damage, economic waste, and occupational hazards1–8. Catch shares are hypothesized to halt the race by securing each individual’s right to a portion of the total catch, but there is evidence for this from selected examples only2,9. Here we systematically analyse natural experiments to test whether catch shares reduce racing in 39 US fisheries. We compare each fishery treated with catch shares to an individually matched control before and after the policy change. We estimate an average policy treatment effect in a pooled model and in a meta-analysis that combines separate estimates for each treatment–control pair. Consistent with the theory that market-based management ends the race to fish, we find strong evidence that catch shares extend fishing seasons. This evidence informs the current debate over expanding the use of market-based regulation to other fisheries.
Étude de cas sur la prise accidentelle

Tortues dulcicoles de l’est de l’Ontario
Tortues de l’Ontario
Historique de la prise accidentelle de tortues en Ontario

Carrière MA. 2007. Movement patterns and habitat selection of common map turtles (Graptemys geographica) in St. Lawrence Islands National Park, Ontario, Canada. Thèse MSc, Département de biologie, Université d’Ottawa.
Freshwater Commercial Bycatch: An Understated Conservation Problem

GRAHAM D. RABY, ALISON H. COLOTELO, GABRIEL BLOUIN-DEMERS, AND STEVEN J. COOKE

Bycatch from marine commercial fisheries has been regarded as a global conservation concern for decades. Fortunately, some headway has been made in mitigating bycatch problems in marine fisheries. Freshwater commercial fisheries, however, have been relatively understudied. Although freshwater yields comprise 11% of the global commercial catch, bycatch research focusing on freshwater commercial fisheries represents only about 3% of the total bycatch literature. This paucity of research is particularly alarming given that so many of the world’s threatened species live in freshwater. The limited literature that does exist includes examples of population declines attributed to commercial bycatch (e.g., the Yangtze River dolphin) and illustrates that bycatch is substantial in some systems (e.g., lake trout in Laurentian Great Lakes fisheries). Encouraging results from the marine realm can serve as models for bycatch research and development in freshwater and can lead to measurable gains in the conservation of freshwater ecosystems. We summarize existing work on inland bycatch in an effort to draw attention to this understated and understudied conservation problem.
management issue, bycatch in marine fisheries has generated significant concern (Crowder and Murawski 1998), and there is little reason to believe that bycatch rates are lower in inland freshwater fisheries. Currently, there is a dearth of freshwater bycatch literature available, and with a handful of exceptions, there is a complete lack of data identifying bycatch species and rates from inland commercial fisheries (figure 2). Commercial fisheries operate in lakes and rivers around the globe. Some of the largest freshwater commercial fisheries are in the Amazon River in South America (McDaniel 1997), the Laurentian Great Lakes of North America (Johnson et al. 2004), lakes Victoria and Malawi in Kenya (Preikshot et al. 1998), the Yangtze and Mekong rivers in China (Allan et al. 2005, Turvey et al. 2007), and the Danube River (Hensel and Holcik 1997), as well as countless additional commercial fisheries operating in smaller inland waters (e.g., Lowry et al. 2005, Siira et al. 2006, Scholten and Bettoli 2007, Fratto et al. 2008, Hyvarinen et al. 2008).

Allan and colleagues (2005) asserted that globally, inland (freshwater) fisheries are being overexploited. If this claim is valid, then it is logical to suggest that bycatch of fish, bird, mammal, and reptile species may be commonplace, given the evidence from marine fisheries (Soykan et al. 2009). Although the global bycatch of marine commercial fisheries has been estimated (Alverson 1994, Kelleher 2005), no such estimates have been attempted for freshwater fisheries. In the absence of estimates for freshwater, we can use target catch as an indicator of the potential scale of bycatch, since target catch is positively correlated with bycatch in most fisheries (Kelleher 2005). The vast majority of the world’s documented freshwater commercial catch occurs in the developing world; only 5% of the global catch is taken by commercial fishers in industrialized and transitioning economies, where the focus has shifted toward recreational fishing (Arlinghaus et al. 2002, Allan et al. 2005, FAO 2009). Regardless, more than 10 million metric tons of freshwater commercial catch was reported globally for 2006, a 12.8% increase from each of the previous two years (FAO 2009). Inland commercial catches were greatest in Asian countries (66.9% of the total global capture), followed by African fisheries (23.5%), the Americas (5.9%), Europe (3.5%), and Oceania (0.2%; FAO 2009). Given the somewhat sporadic and incomplete way that inland fisheries capture rates are reported, it is possible that these figures are underrepresented of the scale of commercial fisheries in some freshwater systems (Allan et al. 2005). Many significant catches are not included in the estimates above because they are taken in unregulated fisheries, including artisanal, subsistence, and aboriginal fisheries, especially in the developing world. Although not commercial, these other fisheries may employ the same fishing gear, such as hoop nets, gill nets, trap nets, seines, and so on, and thus are expected to generate the

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**Figure 2.** Quantitative comparison of the number of peer-reviewed commercial fisheries bycatch and discard papers from the marine and freshwater environments by year. A total of 1152 papers were found: 1114 from the marine realm and 38 from freshwater.
research in the marine environment has led to solutions for major conservation concerns, such as the bycatch of dolphins in the Pacific tuna fishery, where the development of new gear and fishing techniques resulted in an impressive decrease in bycatch rates (Hall 1998). Further, there has been extensive research into the effects of discarding in freshwater recreational fisheries (i.e., catch and release), generating considerable understanding of the survival rates and behavior of discarded fish (Cooke and Wilde 2007, Donaldson et al. 2008). Commercial fisheries in inland waters tend to be small scale, and for the purpose of this paper we have extended them to include artisanal fisheries, which tend to be common in developing countries.

The three objectives of this article are to (1) draw attention to freshwater commercial bycatch as a potential conservation concern, (2) synthesize bycatch principles from the marine realm that are relevant to freshwater research, and (3) indicate where further research is needed and provide a framework for addressing key issues associated with commercial bycatch in freshwater systems.

Potential scale of commercial bycatch in inland waters

Bycatch in freshwater commercial fisheries is a potentially significant contributor to the alteration of ecosystems (figure 1). As an ethical, ecological, and resource-taking activity, commercial fisheries can have substantial impacts on the biodiversity and ecosystem services of freshwater environments. Understanding bycatch is crucial for the sustainable management of these fisheries and the conservation of vulnerable species. The figure illustrates examples of nontarget animals caught in various freshwater fisheries around the globe.

Figure 1. Examples of nontarget animals caught around the globe. (a) Macquarie turtle (Emydura macquarii) caught in carp and eel trap fisheries (Lowry et al. 2005). (b) Platypus (Ornithorhynchus anatinus) caught in carp, yabby, and eel trap fisheries (Grant et al. 2004). (c) European otter (Lutra lutra) caught in eel fyke nets—endangered in Denmark (Koed and Dieperink 1999). (d) Nile crocodile (Crocodylus niloticus) caught in various fisheries (Shirley et al. 2009). (e) Critically endangered European eel (Anguilla anguilla) threatened by various commercial fisheries in coastal streams and rivers (Bevacqua et al. 2009). (f) White sturgeon (Acipenser transmontanus) being killed by lost gill nets in the Columbia River (Washington, Oregon, United States; Kappenman and Parker 2007). (g) Endangered pallid sturgeon (Scaphirhynchus albus) caught in a shovelnose sturgeon fishery (Bettoli et al. 2009). (h) Threatened bull trout (Salvelinus confluentus) caught as bycatch in river fisheries for other salmonids (Brenkman and Corbett 2005). (i) Sockeye salmon (Onchorynchus nerka) escaping gill nets targeting various salmonids (Baker and Schindler 2009). Photographs: (a) Roger Smith, (b) Shane Makinen, (c) Henning Leweke, (d) Geof Wilson, (e) Håkon Haraldseide, (f) Oregon Department of Fish and Wildlife, (g–h) US Fish and Wildlife Service, (i) Sonja Mills.
Pêche commerciale dulcicole dans l’est de l’Ontario

- Débute dans les années 1960

- Présentement 12 pêcheurs commerciaux dans l’est de l’Ontario

- Jusqu’à 80 verveux par pêcheur par jour (un pêcheur par lac)

- Pêcheurs ciblent les centrarchidés, les barbottes et les meuniers
Pêche commerciale dulcicole dans l’est de l’Ontario

• Quotas historiques donnent annuellement aux pêcheurs 50% de la biomasse récoltable de chaque lac

• Conflit avec la pêche sportive

• Aucune stratégie de réduction des prises accidentelles et aucun devoir de documentation des prises en Ontario
Objectifs

1. Documenter la fréquence et l’amplitude de la prise accidentelle de tortues dans la pêche commerciale dans l’est de l’Ontario

2. Évaluer la possibilité d’utiliser des restrictions saisonnières pour réduire la mortalité des tortues

3. Tester de simple modifications aux filets pour réduire la prise accidentelle et la mortalité des tortues
Utilisation des méthodes de pêche commerciale
Seasonal patterns in bycatch composition and mortality associated with a freshwater hoop net fishery

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Keywords
turtles; species at risk; gamefish; commercial fisheries; temporal restrictions.

Abstract

Although bycatch is well known and well studied in marine fisheries, comparatively little is known about bycatch in freshwater fisheries. Even basic information on bycatch composition and mortality in freshwater is unavailable, given that few inland jurisdictions require reporting of bycatch. A small-scale inland hoop net fishery that targets pan fish (e.g. sunfish, Lepomis spp.) and operates primarily in the spring and fall was simulated in two lakes in south-eastern Ontario to characterize both bycatch composition and mortality. We fished one lake in both spring and fall to compare catch rates, while in the other lake we set nets for 2 or 6 days during the spring to assess fish mortality associated with different net tending frequencies. In both lakes, bycatch consisted of gamefish, turtles (including several species at risk), and mammals. For fish, there was no difference in spring and fall catches. Turtles, however, were captured more often in spring. Fish mortality of both target and non-target species increased from 0.3–0.9% to 3.0–3.7% (4–10 times) when set net duration increased from 2 to 6 days. Despite the provision of an air breathing space in our nets, we documented severe turtle mortality (33% in one lake) and all mammals died, suggesting that provision of air spaces is not always effective. Although all bycatch mortality is a concern, turtles are prone to population declines even with low levels of non-natural mortality. As such, regulators may consider limiting commercial fishing to the fall in this region to reduce turtle captures. Seasonal restrictions on fishing or use of frequent net tending (e.g. < 2 days) will not prevent all turtle bycatch and therefore gear modifications should be investigated to further reduce turtle captures and mortality associated with hoop nets.
1- Prises suite à 101 installations de filets

lac Opinicon

lac Newboro

Animal Conservation (2012) 15: 53-60
1- Prises de tortues suite à 101 installations de filets

lac Opinicion

- tortue peinte: 95
- tortue serpentine: 4
- tortue géographique: 13

lac Newboro

- tortue peinte: 28
- tortue musquée: 25
- tortue géographique: 1

Animal Conservation (2012) 15: 53-60
Comment solutionner le problème de la prise accidentelle de tortues?

• Fermetures saisonnières

• Modifications aux filets de pêche
  • Exploite les différences physiques
  • Tente d’exclure, de permettre la sortie ou de garder en vie
2- Différences saisonnières dans les prises

- **taux de capture (par heure)**

  - **printemps**
  - **automne**

- **poissons ciblés**

  - Printemps: 4 poissons
  - Automne: 2 poissons

- **poissons**

  - Printemps: 0,2
  - Automne: 0,1

- **tortues**

  - Printemps: 0,1
  - Automne: 0,1

- *Animal Conservation (2012) 15: 53-60*
A breath of fresh air: avoiding anoxia and mortality of freshwater turtles in fyke nets by the use of floats

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ABSTRACT

1. Freshwater turtles are susceptible to drowning in commercial fishing nets and this is a major conservation concern. Methods to mitigate turtle bycatch mortality typically involve reducing the capture of bycatch using gear modifications. Another method to reduce mortality is to keep bycatch alive following capture.

2. Using physiological measures of anoxia, this study determined whether providing air spaces using floats within fyke nets could prevent turtles from drowning. In a controlled setting, blood lactate and pH of painted turtles (\textit{Chrysemys picta}) experimentally introduced into submerged nets, nets with floats, and nets that breached the surface were compared. While emulating commercial fishing practices – where turtles and fish voluntarily entered nets – catch rates and compositions as well as blood lactate in turtles captured were compared in submerged nets with and without floats.

3. Painted turtles in submerged nets exhibited elevated blood lactate and pronounced acidosis compared with turtles from nets with floats and surfaced nets.

4. Catch rates and compositions from emulated fishing were statistically similar in nets with and without floats; however, total fish catches were roughly one-third less in nets with floats. The same pattern of physiological disturbance was observed with turtles captured in submerged nets with and without floats as in the controlled experiment.

5. Overall, blood physiology indicated that anoxia occurred in turtles in submerged nets while nets with floats reduced physiological disturbance. However, variation in blood lactate levels when fishing fyke nets with floats suggests that turtles were experiencing slight anoxia and so the size of air spaces may be important in allowing access to air. Creating air spaces in fyke nets using floats is a simple and cost-effective method to avoid the drowning of turtles.

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KEY WORDS: bycatch; commercial fisheries; conservation physiology; net modifications; painted turtles; eastern musk turtles

INTRODUCTION

Bycatch, the inadvertent capture of non-targeted fauna, is a growing conservation concern in commercial fisheries (Alverson et al., 1994; Hall et al., 2000; Lewison et al., 2004; Lewison and Crowder, 2007). This concern is particularly acute when long-lived organisms with late maturation and naturally low recruitment, such as turtles, are incidentally captured as adults in a fishery and...
3a- Pouvons-nous empêcher la noyade grâce à des flotteurs?

Filets à la surface

Flotteurs

Filets submergés

3a- Pouvons-nous empêcher la noyade grâce à des flotteurs?

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<th>Surface</th>
<th>Flotteur</th>
<th>Submergé</th>
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</tbody>
</table>

Mitigating bycatch of freshwater turtles in passively fished fyke nets through the use of exclusion and escape modifications

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\textbf{ABSTRACT} \\
Turtles are vulnerable to population declines in response to even low levels of additional adult mortality, for instance bycatch mortality. Inland commercial fisheries that use passive gears such as fyke nets cause the drowning of some freshwater turtles. To reduce fisheries impacts on turtles, bycatch reduction devices (BRDs) successfully implemented in marine systems may be adapted to freshwater systems. We tested the efficacy of two BRDs designed to exclude turtles from fyke nets by comparing catch rates and composition to unmodified nets. We also tested the efficacy of a BRD designed to let turtles escape the net by comparing turtle and fish escape capacities to a large hole in the net. The exclusion device with bars across the net opening significantly reduced turtle catch rates, and both exclusion devices did not affect fish catch rates. With the escape device, all turtles escaped (using painted turtles, \textit{Chrysemys picta}, as an experimental model) and most (88\%) fish were retained while a large hole allowed 60\% and 77\% of turtles and fish to escape, respectively. The escape device was the most effective for avoiding turtle bycatch mortality while retaining fish. Implementing the escape device or a combination of both exclusion and escape devices would reduce turtle bycatch mortality within fyke net fisheries. However, evaluations are needed to test the effectiveness of escape designs on additional turtle species and in different environments.
\end{tabular}
3b- Pouvons-nous exclure les tortues?
3b- Taux de capture dans les filets modifiés

- poisson ciblé non-modifié
- poisson ciblé modifié
- tortue

Taux de capture (par heure):

- Sans modification: 0,073
- Avec modification: 0,147
- Poissons: 0,22
- Tortues: 0,073

70% moins
3c- Pouvons-nous permettre aux tortues de sortir?
3c- Pouvons-nous permettre aux tortues de sortir?

![Bar graph showing fish and turtle distribution]

- poissons
- tortues

Fisheries Research (2012) 125: 149-155
Refinement of bycatch reduction devices to exclude freshwater turtles from commercial fishing nets

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ABSTRACT: The capture of non-target species is a conservation issue in many commercial fisheries. Bycatch reduction devices (BRDs) are commonly used as mitigation tools to improve selectivity of fishing gear and thus reduce bycatch. The aim of this paper was to refine a simple BRD to exclude 4 species of freshwater turtles from commercial fyke nets in a fishery in eastern Ontario, Canada, that targets a variety of fish species. We tested the efficacy of modified exclusion devices (vertically oriented exclusion bars and a constriction rectangle) using an adaptive approach including in situ observations, controlled behavioural experiments and field trials. In situ observations made by camera were used to estimate turtle catchability and to document turtle behaviour during net interactions, which was used to inform BRD design and placement. In controlled behavioural experiments, the passage rates of target fish (i.e. sunfish), bycatch fish (e.g. game fish) and turtles across a modified net throat suggested that a 5 cm constriction rectangle should be suitable for reducing bycatch in this fishery; turtles readily turned sideways to pass through larger openings. Paired field trials indicated that a 5 cm constriction rectangle reduced turtle bycatch for all species. The constriction rectangle also reduced captures of non-target game fish. In controlled behavioural experiments, there was little evidence of a reduction in catches of target sunfish; however, in paired field trials, there was a 23.4% reduction in sunfish catches. We recommend the use of a 5 cm constriction rectangle for fisheries targeting sunfish in areas where freshwater turtles are present.
Accidental Bait: Do Deceased Fish Increase Freshwater Turtle Bycatch in Commercial Fyke Nets?

Sarah M. Larocque · Paige Watson · Gabriel Blouin-Demers · Steven J. Cooke

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Abstract Bycatch of turtles in passive inland fyke net fisheries has been poorly studied, yet bycatch is an important conservation issue given the decline in many freshwater turtle populations. Delayed maturity and low natural adult mortality make turtles particularly susceptible to population declines when faced with additional anthropogenic adult mortality such as bycatch. When turtles are captured in fyke nets, the prolonged submergence can lead to stress and subsequent drowning. Fish die within infrequently checked passive fishing nets and dead fish are a potential food source for many freshwater turtles. Dead fish could thus act as attractants and increase turtle captures in fishing nets. We investigated the attraction of turtles to decomposing fish within fyke nets in eastern Ontario. We set fyke nets with either 1 kg of one-day or five-day decomposed fish, or no decomposed fish in the cod-end of the net. Decomposing fish did not alter the capture rate of turtles or fish, nor did it alter the species composition of the catch. Thus, reducing fish mortality in nets using shorter soak times is unlikely to alter turtle bycatch rates since turtles were not attracted by the dead fish. Interestingly, turtle bycatch rates increased as water temperatures did. Water temperature also influences turtle mortality by affecting the duration turtles can remain submerged. We thus suggest that submerged nets to either not be set or have reduced soak times in warm water conditions (e.g., >20 °C) as turtles tend to be captured more frequently and cannot withstand prolonged submergence.

Keywords Inland commercial fisheries · Bycatch mortality · Decomposition · Olfaction · Fyke nets · At-risk species
Physiological disturbances and behavioural impairment associated with the incidental capture of freshwater turtles in a commercial fyke-net fishery

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ABSTRACT: Turtles are caught as bycatch in commercial fisheries in both inland and marine waters. Turtle mortality associated with bycatch is concerning, as life-history characteristics of turtles, including high juvenile mortality and delayed sexual maturity, make them particularly susceptible to population declines following small increases in adult mortality. In eastern Ontario, Canada, freshwater turtles are encountered as bycatch in an inland commercial fyke-net fishery. Although some temperate turtle species can tolerate prolonged submergence, their ability to withstand submergence decreases as water temperatures increase such that turtles may experience severe physiological disturbances and mortality following prolonged forced submergence. The purpose of our study was to evaluate the sublethal physiological consequences and related behavioural impairments associated with fyke-net capture for 3 species of freshwater turtles (eastern musk turtle Sternotherus odoratus, northern map turtle Graptemys geographica and painted turtle Chrysemys picta). Individuals that were entrapped for 3 h at elevated water temperatures (23 to 29°C) displayed considerably higher blood lactate and lower blood pH compared to free-living individuals. This trend was consistent across species and sexes. Despite having the largest increase in blood lactate, musk turtles did not exhibit behavioural impairment from entrapment, whereas both map and painted turtles displayed low responsiveness to behavioural assessments following entrapment. Our results suggest that sub-lethal responses can be used to identify potential harm or fitness impacts even in the absence of immediate mortality. Assessment of behavioural impairments, which could compromise activity and potentially result in post-release mortality, is important for protected and at-risk species that exhibit high juvenile mortality and delayed sexual maturity.
Assisted Recovery Following Prolonged Submergence in Fishing Nets Can Be Beneficial to Turtles: An Assessment with Blood Physiology and Reflex Impairment

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ABSTRACT. – We conducted an experiment using freshwater painted turtles (Chrysemys picta) to determine if keeping turtles out of water for an hour enhances anoxia recovery following a simulated bycatch event in nets (i.e., 12 hrs of submergence at 25°C). Traditional blood physiology measures and the novel application of a reflex impairment index (e.g., responses to gravity, light, and tactile stimuli) indicated that keeping turtles in or out of water for an hour did not yield a significant improvement in anoxia recovery; however, when the majority of reflexes are impaired, in particular the tactile response (e.g., limb movements), it appears that assisted recovery (keeping turtles out of water) can reduce the chance of postrelease mortality. The use of the reflex impairment index is a simple and inexpensive way to determine turtle bycatch condition after submergence in nets and discern whether assisted recovery may be required.
Bycatch mortality can cause extirpation in four freshwater turtle species

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ABSTRACT

1. Bycatch of non-target species in commercial fishing nets can have adverse impacts on their populations. Freshwater turtle populations are particularly susceptible to increases in adult mortality, and freshwater turtles are among the most threatened vertebrates.

2. As a case study, the population-level impacts of bycatch mortality on freshwater turtles were evaluated in Lake Opinicon, Ontario, Canada, a lake that supports a small-scale commercial fishery. Using population viability analyses, the impacts of bycatch on common snapping turtles (Chelydra serpentina), eastern musk turtles (Sternotherus odoratus), northern map turtles (Graptemys geographica), and painted turtles (Chrysemys picta) were evaluated.

3. In all four species, even low levels of additional annual female mortality as a result of bycatch were sufficient either to reduce population size or to cause extirpation of the local population within 500 years. Bycatch reduction programmes, such as seasonal closures and implementation of bycatch reduction devices, can help alleviate the risk of extirpation. Changes to fishing season length could help reduce the number of snapping turtles and musk turtles captured. Installation of simple bycatch reduction devices can exclude between 95% and 100% of snapping turtles and between 0% and 97% of the other three species, depending on the width of the exclusion device. If combined, these two bycatch reduction methods would help prevent adult female mortality and help maintain turtle populations in Lake Opinicon.

4. Although these findings are specific to the study area, the same principles apply to other areas where similar simple bycatch reduction strategies can be employed to prevent the extirpation of other freshwater turtle species. Considering the consequences of bycatch and of bycatch reduction programmes on populations provides managers with important information to support development of risk-averse conservation strategies.
Perspectives of fishers on turtle bycatch and conservation strategies in a small-scale inland commercial fyke net fishery

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ABSTRACT: We compiled information on the perspectives of fishers on turtle bycatch, turtle conservation, and turtle bycatch reduction strategies (BRSs). Our research efforts focused on a small-scale inland fyke net commercial fishery in Ontario, Canada, where turtle bycatch has been identified as a potential conservation concern. We conducted 18 complete and 3 partial telephone interviews with fishers (41% participation rate). Rates of turtle encounters varied between fishing behaviours (e.g. preferred depth of sets, habitat), and between water bodies, regions, and fishing seasons, resulting in varying perspectives with respect to turtle bycatch. There was a general lack of understanding as to the reasons why turtles are protected. None of the respondents recognized turtle bycatch as a conservation issue. They felt that threats to turtle populations were external to the fishery, resulting in negative feedback regarding various BRSs. Other barriers to adopting BRSs were costs (e.g. of reduced fishing opportunities, changes to gear, time and effort) and apprehension of potential changes to the fishery. Few fishers would voluntarily modify their gear; therefore, incentives (e.g. compensation, increased quota) may be needed to convince fishers to adopt mitigation strategies. Some fishers had already adopted their own BRS for turtles (e.g. moving nets upon encounter of turtles, using air spaces to improve turtle survival). Therefore, sharing fisher-driven, grass roots success stories with other fishers could promote support for changes in fishing practices. Greater awareness about the impacts of turtle mortalities may help build understanding and support for turtle conservation initiatives.
Conclusions

• Pêche à l’automne seulement

• Des modifications simples aux filets diminuent les prises accidentelles de tortues

• Des modifications peuvent permettre aux tortues prises de s’évader