

Marine Historical Ecology in Conservation

Applying the Past to Manage for the Future

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FOREWORD

Marine Historical Ecology in Conservation, the title of this book, may be hard on potential readers, in that each of its two nouns and two adjectives can be seen as potential challenges:

- “Ecology,” because some find it difficult to distinguish the scientific discipline of ecology from the passion of environmentalism;
- “Historical,” because until recently, many academic ecologists suffering from physics envy were attempting to ban history and contingency from ecology;
- “Marine,” because we are air-breathing, terrestrial animals with a strong bias against the watery world that covers most of the surface of our ill-named planet; and finally,
- “Conservation,” because the word implies, for still too many, a departure from what scientists are supposed to do (describe our world, as opposed to changing it, or in this case, developing the tools to prevent it from being dismantled).

Why do we need marine historical ecology and conservation? The fact is that since Darwin’s *On the Origin of Species*, we have become quite good at inferring what existed—in terms of animals and plants—if only because we have (a) fossils and (b) a powerful theory which allows, nay demands, that we interpolate between the forms we know existed, because we have fossils, and the forms for which we have no direct evidence but which we can link to present forms, including us humans.

Thus, in a sense, we know most of what *was there* since the Cambrian, and this knowledge becomes more precise and accurate the closer we come to the present. However, we don’t know *how much* of what was there actually was there, and this may be seen as the defining feature of historical ecology and its potential use in marine conservation.

One way to view this is that while evolution’s “central casting” provides us with a reliable stable of actors (e.g., a wide range of dinosaurs in the Triassic or a flurry of mammals in the

Pleistocene), it is for historical ecology to give them roles to play. (Note that these examples imply that historical ecology should mean the ecology of past systems and not only past ecology as recoverable through written documents, as one could assume when relying on a narrow interpretation of the word “history”.)

Thus, an ecosystem with, say, sea turtles in it will function in a radically different way if these turtles are very abundant (as they appear to have been, e.g., in the pre-Columbian Caribbean) than it will where sea turtles are marginal, as is now the case in the Caribbean.

The Earth’s ecosystems have all been modified by human activities, and this applies also to essentially all marine ecosystems, which whaling and hunting of other marine mammals, and later fishing, have reduced to shadows of their former selves in terms of the larger organisms they now support and the benefits they can provide us.

Some of these ecosystem modifications were unavoidable, as humans living on coastlines are largely incompatible with large populations of, say, sturgeons, sea turtles, or pinnipeds, and our appetite for fish implies that some fish populations will have to be reduced by fishing. But to a large extent, the depredations that we have imposed on the oceans have been entirely gratuitous: we need not have eradicated the great auk (*Pinguinus impennis*) or the Caribbean monk seal (*Monachus tropicalis*) to satisfy our seafood requirements, and thus it is perfectly reasonable to ask ourselves how we could prevent such catastrophes in the future (each species loss is a catastrophe) and whether we can rebuild now depleted populations of marine organisms so as to reduce the risk of this occurring again, and to have more to enjoy.

This is what marine historical ecology in conservation is for: to inform us about what these populations have been in the past, and under which conditions these populations could flourish so that we can start helping them do so. This is what the neat book you have in your hands is about.

Daniel Pauly
Vancouver
August 2013

Understanding Fisheries through Historical Reconstructions

Implications for Fishery Management and Policy

DALAL AL-ABDULRAZZAK, DIRK ZELLER, and DANIEL PAULY

Global fisheries catch statistics are often incomplete. The contribution of many sectors, including small-scale fisheries, illegal catches, and discards are frequently absent from or underreported in statistics submitted annually by member countries of the United Nations Food and Agriculture Organization (FAO). This incomplete accounting in official statistics, and the resulting distorted historical trends, impairs our understanding of the management and policy prescriptions necessary for fisheries sustainability. This chapter describes an approach to retroactively estimate catches where comprehensive time series data are lacking. Data are gathered from nontraditional sources, such as unpublished studies, gray literature, published studies, and surveys; or from sources unrelated to fisheries, such as satellite imagery. We present examples of the discrepancy between reported and reconstructed catches and discuss the implications of such misreporting for management and fisheries policy on national, regional, and global scales.

INTRODUCTION

Indisputably, the single most important piece of information about a fishery is the total catch, by species, over time (Froese et al. 2012). Catch data increase our knowledge of a fishery by determining two essential things: (1) the scale of the fishery (Zeller et al. 2006, 2011a) and (2) the status of the stock over time (Froese et al. 2012, Kleisner et al. 2012). Understanding long-term trends (decades to centuries) in catch is critical to managing fisheries sustainably because it allows us to assess the “health” of a fishery within the context of species life spans, human impacts, environmental disturbances such as El Niño events, as well as

long-term changes in oceanographic regimes. Temporal trends also allow us to establish viable restoration targets based on past abundances of species.

Since its creation, the FAO has been tasked to collect, analyze, and disseminate information related to food, nutrition, and agriculture, including fisheries (Ward 2004). Since 1950, the FAO has assembled, standardized, and distributed annual marine fishery landings reported by its member countries, broken down by taxa as well as by 19 large statistical areas. This global-capture fishery database, known as FishStat (www.fishstat.org), provides the only global time series of national fishery landings (Garibaldi 2012), and a detailed analysis of its contents is published every 2 years (see, e.g., FAO 2011).

FishStat has served as a major source of data in many global and regional fisheries studies that analyze and interpret fisheries trends. These global studies include, among others, the first estimation of the primary production required to sustain global fisheries (Pauly and Christensen 1995), evidence that humans are “fishing down” marine food webs (Pauly et al. 1998), the first global estimation of fuel usage by fishing fleets (Tyedmers et al. 2005), a prediction that fisheries will collapse in 2048 (Worm et al. 2006), and fish biomass trends since 1950 (Tremblay-Boyer et al. 2011, Watson et al. 2013). These data have also formed the core of global catch-mapping efforts (Watson et al. 2004), which, in turn, enabled a greater understanding of the spatial expansion of global fisheries (Swartz et al. 2010a) and, conversely, of the manner in which they supply fish markets (Swartz et al. 2010b).

Besides scientific studies, FAO data have been used to inform fisheries management policy. For example, organizations such as the World Resources Institute often use FAO catch data to estimate national earnings from fish exports, production trends, and per capita fish consumption rates. Additionally, the Marine Trophic Index (which was derived from the “fishing down” concept of Pauly et al. 1998) is partly based on FAO catch data and is one of the indicators used to measure the biodiversity of large fishes by the countries party to the Convention on Biological Diversity (Pauly and Watson 2005).

Despite their wide use, numerous studies have called into question how closely FAO data resemble reality (Zeller et al. 2006, 2007a; Clarke et al. 2006; Watson and Pauly 2001). Because catch data and other fishery statistics are generally submitted to FAO by national entities, the quality of FAO data is dependent on the accuracy and reliability of statistical data collection within these member countries (Garibaldi 2012). Thus, perverse incentives (for the case of China, see Watson and Pauly 2001), the historical legacies of governmental or institutional change (e.g., in Tanzania; see Jacquet et al. 2010), or political interference (e.g., in India; Bhathal and Pauly 2008) can cause such statistical reporting systems to underperform or decay.

In general, FAO data are recognized as incomplete in many regions; more than half of FAO member countries failed to report their annual fishery statistics over the past decade (Garibaldi 2012). Additionally, FAO does not account for discards in its database and, thus, implicitly requires countries to report fisheries “landings” rather than “catches.” By contrast, at least one regional fisheries management organization, the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), includes discarded catches obtained via onboard observer programs into their catch database (although they do not label these as

discards). Overall, however, the contribution of many sectors, including small-scale fisheries, recreational fishing, and illegal catches are frequently absent or substantially underreported (e.g., Zeller et al. 2007a, 2007b, 2011a, 2011b; Jacquet et al. 2010; Le Manach et al. 2012).

The chronic misreporting of fisheries data is not trivial; the consequences extend far beyond resource conservation and can lead to inequitable policy decisions that jeopardize food security (Jacquet et al. 2010, Le Manach et al. 2013), underestimate the contribution of small-scale fisheries to rural food security and GDP (Pauly 2006, Zeller et al. 2006), and incorrectly assume that global fish catches are increasing (Watson and Pauly 2001). This may lead to negative policy outcomes, such as when misreported catches undermine stock assessments and management plans (Zeller et al. 2008), potentially leading to overoptimistic investments or between-country access agreements, which consequently subvert the sustainability of fisheries.

Breaking this cycle requires estimating overall national catches from independent data if possible, or by complementing the data provided by countries to the FAO with estimates for all missing or underreported components. Pauly (1998) suggested that a complex, multifaceted sector of a given country's or territory's economy cannot operate without casting a "shadow" on the other sectors of that economy (ranging from boat building, repairs, and supplies to domestic fish consumption). Therefore, if catch data are unavailable, they can be indirectly inferred from other related sectors.

These ideas were operationalized by Zeller et al. (2007a), who devised an approach for retroactively estimating or "reconstructing" the catch of neglected fisheries, in order to enable a more accurate picture of historical catch patterns and trends. Often, catch reconstructions rely on information and data sources originally intended for other purposes. Such information can be found in a number of sources, including unpublished studies, gray literature, maritime records, aerial photos, and interviews with fishers, or obtained from published studies and surveys whose primary focus is other than catch reporting. (See Box 6.1, where Loren McClenachan relates her stories on how archival research can yield important—and sometimes unexpected—sources for marine historical ecologists.) These nontraditional sources can be used to derive estimates of catch and of catch rates per unit area, per fisher, or per capita for a given period. Using a series of such data "anchor points" (Zeller et al. 2007a), total-catch time-series estimates can then be derived for years with missing data using interpolations.

Fishing predates all other human activities in the ocean (Jackson et al. 2001), and data sets compiled over longer periods (decades to centuries) can be used to detect greater declines in large fishes (McClenachan 2009). However, the reconstruction method developed by Zeller and colleagues typically starts at 1950 for several reasons, including the following: (1) this is the year when FAO began to publish its annual "yearbook" of global fisheries statistics; (2) in many parts of the world, this period marks the start of industrialized fishing; and (3) greater data availability for this period allows for the development of more robust catch time series. As discussed in Box 6.2, these catch reconstructions can provide important information on fishery trends for conservation practitioners.

Marine fisheries catches have been successfully reconstructed in many regions of the world, including for Pacific Island countries and territories (Zeller et al. 2006, 2007a), East Africa and

BOX 6.1 Viewpoint from a Practitioner: The Detective Work of Historical Ecology— New Technologies Enhance, but Cannot Replace, Archival Research

Loren McClenachan

Historical research involves detective work: patient searching through piles of archival documents to find relevant sources, careful reading to understand context, and intuitive use of clues along the way to direct and redirect the search. Ecologists who use historical data must undertake this process as well, but with the added challenge that they are often interested in much longer time scales and larger geographic areas than individual historians typically investigate. For my PhD research, I made trips to dozens of archives in the United States, Europe, and the Caribbean. During my first—a three-month visit to the Archivo de Indias in Seville, Spain—I met many historians who were researching social changes within single nations over decades; I was researching change to large marine vertebrate populations across the entire Spanish Caribbean during the whole period of colonization. I needed to target my search and think creatively about the types of sources that might contain ecological data.

Targeting searches and interpreting documents involves understanding the motivations

of people in the past. Businessmen in the nineteenth century were not carefully recording tortoiseshell exports because they knew that ecologists two centuries later would be interested in the long-term dynamics of hawksbill turtle (*Eretmochelys imbricata*) populations. Rather, they were recording business transactions, many of which are still housed in colonial archives. Together with other sources, these documents can describe previously unknown change to marine species and ecosystems. After looking through a variety of sources, I focused my search on export records, travelers' diaries, and early natural histories. And after poring over hundreds of these types of documents, I was able to extract and compile information that described geographic changes in large marine vertebrates across the Caribbean (McClenachan et al. 2006, McClenachan and Cooper 2008).

The detective work of historical ecology often finds data in surprising places. In the last week of my final archival trip for my dissertation research—to the Monroe County

the Western Indian Ocean (Jacquet et al. 2010, Le Manach et al. 2012), South America (Wielgus et al. 2010), Europe (Zeller et al. 2011b), and the High Arctic (Zeller et al. 2011a). As part of the research of the Sea Around Us (www.seaaroundus.org), we now have complete global coverage of reconstructions for all maritime countries in the world. Here, we use the basic conceptual framework and approach outlined by these studies to discuss reconstructions and their policy implications at three different scales: national, regional, and global.

THE NATIONAL SCALE

To illustrate the need and scope for reconstructing catches at the national level, we use the nation of Kuwait. Like many countries, Kuwait possesses a diversity of coastal fishery types and faces challenges in data collection, accuracy, and lack of understanding of historical

Public Library in Key West, Florida—I found a box of photographs of tourists posing near fish caught on recreational fishing boats in the 1950s, '60s, '70s, and '80s. To most people, the photos would be interesting for their local flair, so they had not immediately come to mind when I initially described my interest in the history of Keys fisheries to the library's archivist. Finding the photographs—which contained a nearly unbroken record of data on the size structure and species composition of reef fisheries decades before traditional ecological or fisheries data existed (McClenachan 2009)—took weeks of following leads and conversing with librarians, local people, and other researchers. Similarly, after several archival visits and conversations with local residents, Kyle Van Houtan realized that decorative menus from Hawaiian seafood restaurants could be used to describe the historical harvest of reef fish, at a critical period at the beginning of the twentieth century for which no other data existed (Van Houtan et al. 2013).

As technology advances, the detective process of historical research becomes easier. Increasingly, we can search electronically the contents of digitized books, digital archives, and photographs (also see chapters 4 and 11, this volume). For example, the Monroe County Library has now digitized hundreds of their “Dead Fish” pictures and archived these online (Florida Keys Public Libraries n.d). Advances like this should encourage more ecologists to undertake historical research and expedite the use of the results for conservation and management. However, there is great value to elements of the detective process that cannot be replicated online: searching through a variety of sources to determine the best ones and following clues toward sources that may be unexpectedly rich. This process is enhanced through conversations with librarians, local people, and researchers sitting across the table at the archives. As historical ecology advances, ecologists should make full use of new technologies, but these cannot fully replace the detective process of historical research.

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trends in fisheries. Despite their predominantly small-scale nature, Kuwait's fisheries remain its second-most-important natural resource after oil (Carpenter et al. 1997). For centuries prior to the discovery of oil in 1938, pearl diving dominated the country's economy. Indeed, at the height of pearling, 80% of the world's natural pearls came from the Persian Gulf. However, the production of Japanese cultured pearls in the 1920s, the global recession in the 1930s, World War II, and the production of crude oil in the late 1940s dealt consecutive blows to the Gulf's pearl industry, leading to its rapid demise.

In general, Kuwait's fisheries are poorly managed, and officially reported catch data are haphazard at best. Substantial sectors are missing from reported data, including recreational catches, discards by the shrimp fishery, and illegal catches. Using catch reconstruction methods, we can see that the reported catches for Kuwait's artisanal and industrial fisheries potentially underestimate total catches by a factor of 7 over the 1950–2010 period (Figure 6.1).

BOX 6.2 Viewpoint from a Practitioner: The Value of Catch Reconstructions for Conservation Practitioners

Rod Fujita

The global fisheries catch is a key indicator of the status of one of the planet's most important ecosystem services. Conservation practitioners and funders interested in food security, ocean conservation, and sustainable development focus on global catch and its trend to set agendas for action and to generate urgency. Catch is the most salient attribute of fisheries to most people; as such, it has a strong effect on the dominant worldview regarding the status of fisheries. And of course, the dominant view determines demand for change and the amount of funding and political will for making change.

Knowing how many fish are being caught is just as important at other scales, for many different reasons. Catch statistics are often used to estimate the status of fish stocks, the very basis of scientific fisheries management—essential for setting sustainable catch limits, a primary fisheries conservation tool. And once a catch limit is set, of course, catch statistics are necessary for ensuring that the limit is not exceeded. Catch records are often used to allocate catch privileges, helping to establish rules for member states, regions, groups, or even individual fishermen that can alleviate the competition to maximize catch. This competition tends to deplete fish populations and make fisheries unprofitable in the absence of governance or rules.

Clearly, catch statistics are extremely important for fisheries management. But unfortunately, the reliability of these statistics is very uneven. Some countries collect high-quality catch information, while others do not. One way to remedy this is to reconstruct the catch, using whatever information is available to piece together the missing history of a fishery.

Catch reconstruction is easy to criticize, and there is an active debate among scientists about it (Pauly et al. 2013). But the bottom line is that the alternative—a massive new data-collection program—is infeasible in the short term. Moreover, it would not yield information on catches early in the history of fisheries, which is critically important for practitioners because it provides a baseline against which to measure the performance of a fishery.

The FAO's global fisheries database includes >19,000 unique entries, but only a few hundred fisheries have been assessed. The available evidence (stock status of unassessed fisheries extrapolated from catch statistics) suggests that most unassessed stocks are overfished and are becoming more overfished as time goes on. If we are to reverse this trend, one of the first things we need to do is assess as many stocks as possible, and that means reducing data requirements and developing

Such substantial differences between reported landings and reconstructed total catches illustrate the magnitude of the data-reporting problems faced by countries with small-scale, data-poor fisheries (e.g., Zeller et al. 2007a, 2011a, 2011b). It also points at a fundamental problem of fisheries catch data being viewed purely from a commercial, market perspective, which accounts only for what is landed and utilized for commercial sale or export (Zeller and Pauly 2004, Pauly and Zeller 2003). By contrast, fisheries data collection—and, hence, catch accounting—needs to account for total catches, particularly given the global move toward

assessment methods that are accessible to a much larger number of people.

One of my priorities is to remedy this situation, and I think that catch reconstructions will help. Most fisheries collect limited data; catch is virtually the only fishery statistic that is collected around the globe, however spotty that record may be. Fortunately, simple and rapid methods are now available for analyzing these kinds of stocks. However, they depend on estimates of unfished biomass—hard to come by in most fisheries, because few fisheries bother to collect data from day one. Catch reconstructions that yield estimates of historical catch may provide valuable insight into what unfished biomass might have been, facilitating the kinds of data-limited analytical methods that I and many others have been promoting.

While many fisheries collect catch data, and catch reconstruction can fill in many gaps, I often encounter fisheries that have no data whatsoever—particularly in developing countries. As the authors of this chapter assert, new data-collection efforts should focus on using assessment methods that require less time, fewer resources, and less expertise than conventional methods. We practitioners should also mine the available data more effectively. For example, my team is trying to generate abundance indices using visual cen-

sus data, which are often quite rich in coral reef countries that lack traditional fisheries data. Moreover, if every fishery included an unfished reference area, there would be less need for long historical catch records, as the unfished area provides a good baseline for assessing stock status. We are using ratios of abundance in fishing grounds to abundance in no-take marine reserves as an index of stock status, which we hope can serve as a performance indicator in combination with empirical thresholds for coral reef tipping points related to fish biomass in adaptive management. If the ratio stays above the threshold associated with coral-dominated reef systems, no change in fishing mortality is required. But if the ratio falls below thresholds associated with transitions to less desirable ecosystem states, a harvest control rule is triggered in order to reduce fishing mortality to levels that are likely to increase the ratio. Similarly, information on the distribution of size classes in a fish population can provide a snapshot of stock status useful for management without the need for many years of data. Methods that utilize unfished areas and size data are much simpler to use than conventional methods and offer hope that many more stocks will be assessed and managed, improving fishery outcomes for stocks, ecosystems, and society in the future.

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viewing and managing fisheries on an ecosystem scale (Pikitch et al. 2004). This requires comprehensive accounting for the entire catch of fish and invertebrates, including the recording (or estimation) and reporting of discarded catch, and the estimation and reporting of catches from unregulated sectors such as subsistence, cultural, and recreational fisheries. Given the high costs of monitoring such sectors using traditional catch-monitoring approaches, alternative methods such as utilizing national surveys and census opportunities have been suggested for the more widely dispersed and hard-to-monitor small-scale and

BOX 6.3 Viewpoint from a Practitioner: The Value of Household Income and Expenditure Surveys in Reconstructing Catches of Small-scale Fisheries

Johann Bell

A practical way to reconstruct basic information on small-scale commercial and subsistence fisheries where it is not collected by fisheries agencies, or to verify such information where it is available, is to use the household income and expenditure survey (HIES). These surveys are usually conducted every 5 years by national statistics offices to calculate the consumer price index and other socioeconomic measures.

Provided that the HIES reflects national trends and contains questions on how much fish is purchased, caught, received as gifts, and sold by the household, it provides important information for sustainable management of coastal fish stocks. For example, a well-designed HIES can provide estimates of the total quantities of different types of fish consumed within the country (reef fish, oceanic fish, freshwater fish, etc.) and whether these fish were derived from commercial or subsistence fishing. Each of these categories of fish can be divided into simple classes (e.g., herbivorous and carnivorous reef fish, the main species of tuna) within the HIES to provide catch estimates for important groups of species or to determine the extent of selective fishing where independent data are available on the relative abundance of these groups in the wild.

The information from HIES not only provides useful snapshots of the total catch from small-scale fisheries and per capita fish consumption, but can also be used to monitor the performance of management and conservation measures. Because the HIES is done at regular intervals, trends in fish catch and consumption can be assessed and the results can be used to adapt management as required.

In Pacific Island countries and territories, coastal communities are being encouraged to shift some of their fishing effort from coral reef fish to oceanic fish (especially skipjack and yellowfin tuna) by fishing around fish aggregating devices (FADs) anchored close to shore to attract large pelagic fish. This measure is designed to help provide more fish for food security as human populations grow, and as an adaptation to the declines in coral-reef fish production projected to occur as the climate changes. Fishing around inshore fish aggregating devices also has the conservation benefit of reducing pressure on coral reef fisheries. HIES is a powerful tool for measuring whether this management option changes the percentages of reef fish and tuna in the catches of small-scale commercial and subsistence fisheries.

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recreational fisheries sectors (Zeller et al. 2007b). For example, in the Pacific Islands, household income and expenditure surveys are undertaken periodically to assess fisheries' performance and importance to local economies (Box 6.3). Al-Abdulrazzak and Pauly (2014) use Google Earth to "ground truth" weir fish catches, speaking to the potential of satellite technologies for monitoring fisheries remotely, particularly in areas that were once considered too dangerous or expensive for fisheries surveillance and enforcement.

The reconstructed time series also illustrates the magnitude and importance of discards (Figure 6.2). In terms of tonnage, discards amounted to almost 10 times the total amount of

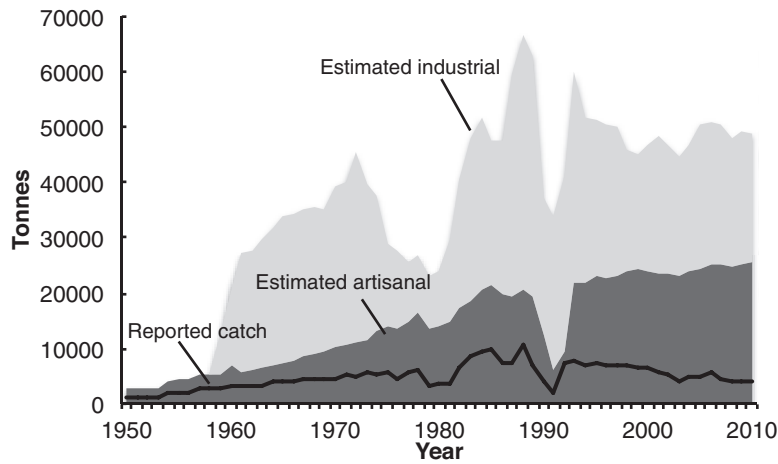


FIGURE 6.1 Reconstructed estimates of small-scale and industrial catches in Kuwait compared to officially reported catch.

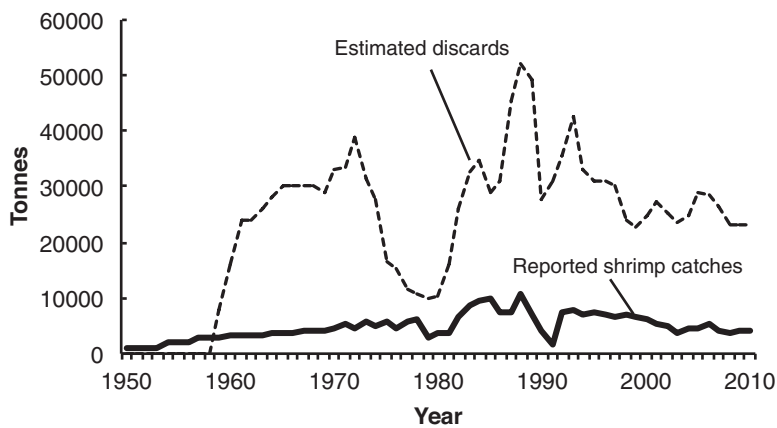


FIGURE 6.2 Estimated discards from Kuwait's industrial shrimp fishery.

landed finfish in Kuwait. Although local fisheries are currently not essential to Kuwait's food security (because the country's food resources are largely imported), recent climate-change studies predict that the Persian Gulf may lose 50% of its fisheries in the coming decades (Huelsenbeck 2012), prompting a greater demand for imports in the near future. To adequately prepare for climate-change impacts, as well as for sound fisheries management, managers should consider policies that reduce discarding practices. Such approaches may also help bolster local food-security policy as fisheries resources shift under global climate change. In general, a more complete estimate of total fisheries extractions is fundamental to

effectively manage fisheries resources in order to mediate potential threats to food security and to assess ecological resilience. The future success of many countries relies, in part, on their ability to keep pace with an increasingly global economy while maintaining a healthy supply of resources for domestic purposes.

THE REGIONAL SCALE

The importance of historical reconstructions for food security policy can also be examined from a regional perspective. Historical catches have been reconstructed for almost all small island states and territories of the Caribbean (e.g., see Frotté et al. 2009, Harper et al. 2009), thus enabling some generalizations. The first is that catches are systematically underreported in the region, by 32–35% in Guadeloupe and Martinique and by 430% in Jamaica (with a median of 250% for all islands in the region). Such underreporting—which includes only a small amount of the discarded fish that is reported to FAO—implies that the fisheries of the Caribbean are systematically underreported in terms of their contribution to food security and GDP, just as in other areas of the world (Zeller et al. 2007b).

As in the Caribbean, catches by Pacific Island countries have also been systematically underreported (see, e.g., Zeller and Harper 2009, Harper and Zeller 2011). Most small Pacific Island countries have shifted their focus to lucrative pelagic tuna fisheries. These fisheries are conducted almost exclusively through foreign fishing interests, whether via fishing access agreements, through so-called joint venture or charter operations, or even by reflagging of foreign vessels to permit easier and cheaper access to Pacific Island countries' waters. Fishing access fees often provide a major share of a country's foreign exchange earnings (Gillett et al. 2001; Gillett 2009, 2011) in this region, but such approaches also discount future production from domestic fisheries, which may provide for current and future food security in a region with few other domestic protein sources (Secretariat of the Pacific Community 2008). See Box 6.3 on how regional initiatives in the Pacific are being undertaken to provide local communities more access to pelagic fishery resources and how fisheries experts are helping us better understand the role of fisheries in food security in this region.

Catch reconstructions can also benefit public policy by providing improved catch statistics and a better accounting of the role of fisheries in national, regional, and global economies. For example, reconstructed catches for Mozambique and Tanzania (Jacquet and Zeller 2007a, 2007b; Jacquet et al. 2010) contributed directly to changes in how these two countries estimate and report their data. Mozambique, which was shown to have 6 times higher catches than the reported data suggested at the time (mid-2000s), has subsequently been able to improve its catch sampling program, which is reflected in substantially improved catch data in recent years. Such increased accuracy of reported catch data can assist during foreign fishing-access negotiations, which often focus on a perceived "surplus production." Catch reconstructions can reveal the true catch landed by domestic fisheries, thus preventing excessive allocation to foreign fishing and reducing the likelihood of "selling the same

fish twice” to both domestic and foreign fishers operating in the same waters (also see Le Manach et al. 2012, 2013).

Another example comes from Tanzania, where catch statistics from a major region of the country (the island group of Zanzibar), despite being collected by the Zanzibar fisheries agency, were missing entirely from the data reported by the government of Tanzania to FAO (Jacquet and Zeller 2007b). These catch statistics were retroactively included as of 2000 (Jacquet et al. 2010). This reporting oversight was likely brought to light through catch reconstructions, which were shared with local authorities, thus influencing the subsequent data correction.

THE GLOBAL SCALE

Reconstructed time series can also be used to influence policy in the international arena. For example, in recent years the representatives of Caribbean countries sided with Japan in voting for whaling in successive meetings of the International Whaling Commission, citing the need to maintain a “balance in the ecosystem” (Swartz and Pauly 2008). Robust time-series data on catch, which include all withdrawals from fisheries ecosystems, can provide an important first step in provisioning data for ecosystem-based fisheries management, and one that is required for any kind of “balance” to be assessed. This is especially important because it has shown that fisheries have strong impacts on the structure and functioning of Caribbean marine ecosystems (Jackson et al. 2001, Mora 2008). By contrast, marine mammals in general, and whales in particular, have only negligible effects on these ecosystems, even when abundant (Gerber et al. 2009).

One major insight emerging from catch reconstructions is the global footprint of fisheries and the full extent of living-marine-resource extraction. Reconstructions are illustrating the trajectories of fisheries and how they are changing over time, which can contrast with official reported statistics and challenge existing assumptions about global trends. For example, contrary to the FAO’s (2011) description of global fisheries being “stable,” reconstructed catches, when pooled for the whole world, show a declining trend. This suggests that increased catches from newly exploited areas are no longer replacing those from depleted stocks, as was the case for the past few decades when geographically expanding fisheries masked the overfishing of traditional stocks (Swartz et al. 2010a). These insights, which have critical consequences for the way global fisheries are managed, are not possible without a historical perspective.

CONCLUSIONS

When fisheries managers rely solely on conventional quantitative data (i.e., data collected from mainly commercial fisheries using logbook or landings site/port or market sampling), catch data often suffer from massive underreporting. Such approaches can result in incorrect assumptions that small-scale fishery catches are small or negligible, leading to

inappropriate management, often with unintended outcomes and consequences both for fisheries resources and coastal communities. Researchers are increasingly paying more attention to methods that make use of imperfect records of the past. Researchers are accessing and using a wide range of nontraditional sources such as historical anecdotes, which can be “as factual as a temperature record” (Pauly 1995). As we show in the context of fishery reconstructions, marine historical ecology approaches can counter the underestimation of traditionally neglected sectors and the shifting baselines syndrome, which can result in mismanagement of fisheries resources.

Despite data uncertainties and the need to appropriately qualify data assumptions, catch reconstruction approaches are preferable to the alternative, which assumes low levels of catch or—even worse—leaves whole sectors out of reported data, which may be erroneously interpreted as “zero” catch in the policy and management arena (Zeller et al. 2006). Such “zero” interpretations of missing data components will certainly be more misleading than reconstructed estimates (despite uncertainties), especially if reconstructions remain conservative. Some managers and practitioners may be understandably uneasy with the imprecision of catch reconstructions, given the uncertainty of the data and the information sources that underlie them, rather than valuing the trends and improved accuracy they provide (i.e., by accounting for sectors ignored in reported data). However, as the economist John Maynard Keynes is reported to have said, “It is better to be vaguely right than precisely wrong.”

With increased availability of catch reconstructions for historical fisheries, managers and policymakers will be able to focus on trends in the available data rather than focusing on the uncertainty surrounding these data (Rosenberg et al. 2005). We hope the increased acceptance of such approaches—and recognition of their validity and value—will help inform much-needed shifts in data collection and accounting toward considering and embedding fisheries in long-term reconstructions of marine ecosystems. As we have shown here, the incorporation of missing fishery sectors often results in distinctly different baselines of past catches, and these can have strong policy and management implications.

Even among fisheries scientists, there remain debates about the global status of fisheries and even the value and need for basic fisheries data such as catch (Pauly et al. 2013). Many believe that rigorous quantification of the uncertainties surrounding stock assessments and the subsequent delivery of results to managers in the form of risk assessments sufficiently address the overfishing crisis (Pauly and Zeller 2003). Yet the major challenges in fisheries are based in the realm of public policy. Issues of equitable resource allocation require public involvement, participatory democratic planning, and provisioning of decision making with the most accurate and reliable data. As we have shown here, fishery reconstructions can provide a critical long-term view on fisheries performance, sectoral contributions, and risks associated with various management strategies (e.g., not managing discards appropriately).

Fishery reconstructions and other data from marine historical ecology can be critical in informing the public, and the public-policy decision makers who represent them, of the true status and trend of fisheries and their associated effects on ocean health (Pauly and Zeller

2003). Findings from marine historical ecology will continue to be challenged, but continuous efforts on behalf of the scientific and practitioner community to effectively communicate this emerging area not only to scientific colleagues, but also to policymakers and the general public, are making headway. Historical reconstruction approaches have much potential to remove “lack of data” from the list of excuses used to maintain the status quo, and to increase public transparency and involvement in fishery policy by the true owners of the marine resources, the present and future global citizens.

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