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Estimating the economic impacts of bycatch in U.S. commercial fisheries

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ABSTRACT

Bycatch presents a challenge to optimizing yield in commercial fisheries, where bycatch can total more than 1 million mt per year in the United States. Yet the economic impacts of bycatch have rarely been evaluated in the scientific literature. These economic impacts largely occur from the loss of landings through (1) early closure of fisheries when catch limits of bycatch species are reached; and (2) discards of marketable catch due to regulatory requirements in the fishery. This paper illustrates the economic impacts of early closures due to bycatch in U.S. fisheries by describing past case studies, as well as evaluating the economic impacts of discarding fish in U.S. commercial fisheries. Premature closures in the fisheries reviewed resulted in potential losses ranging from $34.4 million to $453.0 million annually. Nationally, bycatch estimates in the form of regulatory discards are annually reducing the potential yield of fisheries by $427.0 million in ex-vessel revenues, and as much as $4.2 billion in seafood-related sales, $1.5 billion in income, and 64,000 jobs. Our review also shows that some of the most promising work to reduce bycatch over the last decade has been the development of gears or gear modifications, termed "conservation engineering."

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1. Introduction

Managing fisheries to provide current and future generations the optimum yield of living marine resources is a common goal of fishery managers around the world [1]. Managing a fishery to obtain its optimum yield without over- or under-exploiting its stocks, however, is a problem that fishery managers have been trying to solve for decades. Several factors make managing fish stocks difficult: political pressures to allow higher catches; biological uncertainties about the status of the resource that make it difficult to determine optimum yield; management uncertainties regarding timeliness and accuracy of landings data being reported; or fishing practices that result in high levels of bycatch, which reduces the economic yield of the fishery [2–5]. The latter of these factors, bycatch, is considered one of the most significant issues affecting fishery managers' ability to optimize yield [6–8].

Bycatch has several different meanings in fisheries, depending on whether the catch is retained or discarded, or the level of interaction (e.g., captured versus not captured but harmed by interaction with the fishing gear) [6,9,10]. For purposes of this paper, bycatch is defined as fish that are captured in a fishery but not retained for sale or personal use. Reasons for discarding catch vary, but some general reasons include: the species is protected by regulation; the fish is not marketable; lack of storage space onboard the boat; high grading for higher valued species; or the fisherman's quota has already been reached [6].

Bycatch potentially reduces the yield of a fishery in various ways, but this paper focuses on: (1) regulatory discards; and (2) early closures. Regulatory discards refers to catch that could have been retained if regulations had not prohibited retention. Regulations that prohibit retention of catch are a necessity in many fisheries, where they address such issues as recruitment overfishing through the use of size limits, derby fishing and stabilizing market demand through the use of trip limits, and reducing fishing effort to ensure annual catch quotas are not exceeded through time and area closures.

Early closures refer to situations where target fisheries are prematurely closed when catch limits of bycatch species are reached. Early closure of a fishery usually occurs in either multispecies fisheries or fisheries where there are high interaction rates with threatened or endangered species (i.e., protected species). Multispecies fisheries are unable to perfectly target a specific species of fish because the type of gear being used is insufficiently selective or because the fish assemblages are well mixed and thus difficult to target separately. Within the United States, multispecies fisheries are usually controlled by the status of the most vulnerable species within an assemblage, so as not to overexploit that species while in pursuit of other species. Therefore, when the catch limit of the most vulnerable species is obtained, the entire multispecies fishery can be closed.

Similar to the most vulnerable species concept, the United States also manages the "take" of protected species (e.g., sea turtles, marine mammals, sturgeon, etc.) in the execution of its fisheries, where take is generally defined as harassing, hunting, capturing, collecting or killing a species. For protected species, an incidental take statement among other things describes the

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number of takes allowed for a fishery before mitigations measures are triggered to conserve the species from being jeopardized. The types of mitigations measures used must follow the provisions of the Endangered Species Act, or in some cases the fishery is closed until mitigation measures are developed to resolve the excessive take of protected species.

Some examples of U.S. fisheries that have been closed due to either multispecies fisheries or protected resources over the past 10 years include:

- December 1999 to June 2002—Restrictions and closure of the Hawaii-based pelagic longline fishery (shallow-set sector targeting swordfish) to reduce sea turtle bycatch (see following section for additional information).
- July 2001—Closure of the Northeast Distant Statistical Reporting Area (NW Atlantic Ocean) to pelagic longline fishing for 3 years to reduce loggerhead and leatherback sea turtle bycatch. (An experimental fishery did operate in the Area during those 3 years, which offset economic losses to the fleet.)
- January 2007—Implementation of Amendment 16-4 to the Pacific Coast Groundfish FMP, which established an Ocean Salmon Conservation Zone that closes a fishery area when the Pacific whiting fishery is projected to take in excess of 11,000 Chinook salmon within a calendar year.
- July 2007—Early closure of 2007 Pacific whiting fisheries to minimize impacts on overfished widow rockfish.
- August 2008—Early closure of the Pacific whiting fisheries due to a canary rockfish bycatch limit being reached.
- May 2009—Closure of areas of the Gulf of Mexico to bottom longline fishing to reduce sea turtle bycatch.

Other impacts to yield are less direct but have implications for the sustainable management of fisheries and production of optimum yield, for more information see [11–13].

The focus of this research was to evaluate the economic impacts of bycatch on U.S. fishing yield. Economic impact analysis examines the interdependence of industries in an economy, based on the effects of an action (e.g., new policy or program) in a given geographic area [14]. Economic impacts are usually expressed in terms of employment, personal income, sales, and in some cases valued added. Today economic impact analysis are widely used in national economic analysis by the Department of Commerce and promoted by the United Nations as a practical planning tool for developing countries [14].

This paper begins with an analysis of forgone yield with some examples of how high-profile fisheries within the United States have either been prematurely closed or potentially face early closure due to bycatch interactions, and analyze the related economic impacts. In these examples, conservation engineering research in cooperation with the fishing industry has resulted in, or is in the process of developing, more selective fishing gear to allow these fisheries to stay open and harvest the full allowable quotas. The paper then evaluates the amount of bycatch in U.S. federal fisheries and estimates its related economic impacts. These examples and subsequent analysis illustrate why bycatch is one of the most significant issues affecting fishery managers' ability to optimize yield, and the related economic impacts incurred.

2. Forgone yield—premature closures

2.1. Hawaii-based shallow-set pelagic longline fishery

The Hawaii-based pelagic longline fisheries operate year-round out of Hawaii targeting bigeye tuna with deep-set longline gear and swordfish with shallow-set longline gear. The longline fisheries also catch a range of other pelagic finfish species for the fresh fish market. The fisheries are comprised of approximately 126 active fishing vessels in a limited entry program, and represent the largest commercial fisheries in Hawaii in both landings (10,766 mt in 2010) and revenue ($70.1 million ex-vessel revenue in 2010) [15]. The shallow-set swordfish fishery typically comprises about 25–30 of the overall number of active vessels. In addition, some vessels that shallow-set may also switch to deep-set fishing to target bigeye tuna during parts of the year. Both fisheries are tightly regulated to reduce the number and severity of protected species interactions and to minimize the risk of overexploitation.

In 2001, observer data demonstrated that the fishery had exceeded their incidental take statement for sea turtle interactions in the shallow-set longline fishery, which led to a lawsuit from a non-governmental organization. As a result of litigation, NMFS set forth regulations that prohibited fishing for swordfish by Hawaii-based longline vessels. Landings of swordfish dropped from 2819 mt in 2000 to 235 mt in 2001 (the 235 mt were non-targeted landings from the tuna longline fishery) [15,16], and ex-vessel revenues (i.e., dockside revenues) decreased by over $22.8 million from 2000 to 2001 [15]. Mitigation and regulatory procedures were not able to resolve this bycatch issue until 2004, when the Hawaii-based shallow-set swordfish fishery reopened with an effort cap of 2120 shallow sets annually, circle hook and mackerel bait requirements, a 100% observer coverage requirement, and a calendar year limit on sea turtle interactions (i.e., hooking or entangling) of 16 leatherbacks and 17 loggerheads. The hook and bait requirements were based on successful conservation engineering research conducted with the Atlantic Highly Migratory Species longline fleet [17] and reduced sea turtle interaction rates with the Hawaii-based shallow-set longline fishery by approximately 90% for loggerheads, 83% for leatherbacks, and 89% for combined species, compared to the previous period (1994–2002) when the fishery was operating without these requirements [18].

Following implementation of the new conservation engineering requirements and effort and interaction limits, swordfish landings increased from 249 mt in 2004 to 1600 mt in 2005 [15], and ex-vessel revenues increased by $17.9 million [15]. The sea turtle interaction limit has only been reached once since 2004, when the fishery for 2006 closed on March 20, 2006, after interacting with 17 loggerhead turtles.

The success of the conservation engineering requirements, as well as the effort and interaction limits that are monitored with 100% observer coverage, led to less-stringent regulations in 2010 that lifted the effort cap completely. The removal of the effort limit may eventually increase effort from the 2120 annual set limit to historical levels of 4000–5000 sets annually, which could result in up to a $14.2 million increase in ex-vessel revenues, a $34.4 million increase in direct and indirect business sales, and 475 additional jobs [16].

2.2. Atlantic mackerel, squid, and butterfish fishery

The Atlantic mackerel (*Scomber scombrus*), squid (*Loligo pealei* and *Illex illecebrosus*), and butterfish (*Peprilus triacanthus*) fishery is a multispecies fishery managed by coast-wide annual quotas, and operates throughout the year from ports ranging from North Carolina to Maine. The primary gear used in this fishery is a mid-water otter trawl, which is typically used to target Atlantic mackerel and squid independently. Butterfish is predominately a non-targeted species of the squid fishery, and is usually discarded as bycatch. In 2010, the ex-vessel revenue of this mixed stock fishery was $30 million, of which squid makes up 87% of the