Title: Evaluating seafood eco-labeling as a mechanism to reduce collateral impacts of fisheries in an ecosystem-based fisheries management context

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Abstract

By considering not only target species catch but also bycatch of non-target species and habitat damage, ecosystem-based fisheries management (EBFM) has the potential to minimize the environmental impact of fisheries. Defining and benchmarking EBFM strategies for these incidental environmental impacts has been challenging, and this lack of consensus has, in part, resulted in a proliferation of eco-labeling schemes with variable and vague criteria for environmental targets. The performance of fisheries certified by the Marine Stewardship Council (MSC), the most prominent eco-labeling certifier, was compared to non-certified fisheries and evaluated against target reference points for a suite of metrics derived from the EBFM literature. Specifically we compared marine mammal bycatch, finfish discard rates, and gear impacts between MSC-certified fisheries and non-certified fisheries. Discards of non-target finfish and bycatch rates of marine mammals were no different between certified and non-certified U.S. fisheries. Observer coverage was no higher in certified fisheries, and many fisheries failed to meet the coverage level thought adequate to document bycatch of protected species. MSC-certified fisheries did have lower average gear destructiveness scores than non-certified stocks when weighted by landings but not when weighted by the number of fisheries. Our analysis indicates that MSC-certified fisheries perform better on some ecosystem-based sustainability metrics but are indistinguishable from non-certified stocks on others, and improvement is needed for all certified fisheries to meet quantitative goals for the collateral impacts of fishing.

Keywords: Eco-label; sustainability; ecosystem-based management; fisheries; collateral impacts

1. Introduction

Marine fisheries support the livelihoods of over 38.5 million people and represent 16.6% of global animal protein intake [1]. At the same time, 30% of fisheries are considered overexploited, and the number of over-exploited stocks is increasing [1]. Wild capture production of seafood has leveled off in recent decades [1], and the increasing demand for seafood of a growing human population will likely lead to increased pressure on stocks already harvested at or near their limits. To prevent future fisheries collapse and ensure food security, there has been a growing call to reform marine fisheries management based on scientific, policy and market-based approaches [2–5].

Many of these approaches have focused on stock-specific outcomes. Conventional stock assessments rely on catch, effort and surveyed abundances in order to estimate current stock biomass, and compare this estimate to predefined trigger points [6,7]: the limit reference point, and the target reference point (UN Convention on the Law of the Sea [8], UN Fish Stocks Agreement [9]). Typically, catch is reduced when the stock abundance drops below the target, and is prohibited when it reaches the limit reference point [10]. Traditionally, trigger points have applied only to the target stock, reflecting both the broader priorities of the management agencies and the availability of information.

Despite the historical focus on single stock metrics of sustainability, there is a growing recognition that fishing, which exists within the context of a complex ecosystem, has far reaching consequences [11]. Ecosystem Based Fisheries Management (EBFM) puts greater emphasis on comprehensive ecosystem health [11–14] and calls for the avoidance of ecosystem and habitat degradation, reductions in incidental mortality of

non-target species (i.e. bycatch), as well as the maintenance of ecological community composition. In principle, EBFM should lead to the integration of wider ecosystem considerations into the aforementioned trigger points. In this regard, EBFM ideals have begun to be incorporated into US fisheries policy, especially with respect to bycatch (Magnuson Stevens Fishery Conservation and Management Act (MSA), Endangered Species Act (ESA), Marine Mammal Protection Act (MMPA)). However, enacting EBFM presents considerable difficulties due to the challenge of quantifying ecosystem impacts, as well as conflict between EBFM objectives. While government policies mandating ecosystem-based management are increasing (e.g. U.S. National Ocean Policy), many EBFM principles have yet to be integrated into fisheries management as scientifically implementable targets.

Consumer awareness of fishing's wider ecosystem impacts has outpaced the development of quantitative EBFM metrics, resulting in the proliferation of seafood grading schemes [15] that attempt to capture EBFM goals via qualitative criteria. While a holistic grading scheme to evaluate sustainability in terms of not only the harvested species but also its collateral impacts has the potential to provide a more comprehensive view of the cumulative impacts of fishing, the absence of concrete metrics with which to measure the incidental impacts of fishing has obscured the already vague notion of EBFM [16].

Here the collateral impacts of fisheries certified by the largest and most prominent seafood eco-labeling program, the Marine Stewardship Council (MSC) were compared to non-certified fisheries. The MSC recognizes seafood sourced in a manner consistent with their criteria, providing a mechanism by which demand for sustainability can incentivize

70 stewardship [17–19]. To attain certification, fisheries must meet criteria in three equally
71 weighted categories, namely 1) target stock health 2) ecosystem health and 3)
72 management agency responsiveness. A fishery can be certified even if they do not meet
73 all of these criteria provided they agree to enact pre-specified changes within a specific
74 time frame. Two recent studies showed that MSC-certified fisheries on average met their
75 stock-specific management targets more often than non-certified fisheries [20,21], though
76 some fisheries classified as overfished were certified, and MSC has been criticized for
77 allowing fisheries to maintain certification despite declines in target stock biomass [16].
78 Fishery performance on ecosystem metrics has been harder to assess [22,23]. In the era of
79 “dolphin-safe” tuna labels the modern consumer likely defines “sustainable” seafood as
80 products sourced in a manner that limits negative ecosystem impacts [24]. Like much of
81 the EBFM literature regarding collateral impacts of fishing, the MSC’s vague definition,
82 which requires that fishing practices “allow for the maintenance of the structure,
83 productivity, function and diversity of the ecosystem”, is both subjective and difficult to
84 implement [22]. This subjectivity has led to inconsistent application of certification
85 requirements [22,25]. To address this and other stakeholder concerns, MSC is currently
86 reviewing its standards and drafting new certification criteria with assistance from a panel
87 of experts [26]. The MSC therefore has the opportunity to make its ecological criteria
88 both more concrete and reflective of EBFM ideals.

89 EBFM implementation has been impeded by a lack of quantitative metrics and
90 reference points for collateral impacts with which to grade performance [27,28].
91 Evaluating EBFM performance has been further limited by the lack of data on fisheries-
92 specific impacts. Three metrics were constructed that encapsulate key components of the

collateral impacts of fisheries in an EBFM context and also have quantitative data available. The ability of currently certified fisheries to meet literature-based reference points was compared against non-certified fisheries. Specifically 1) marine mammal bycatch rates, 2) finfish discard ratios, and 3) gear impacts of MSC-certified fisheries were compared to with those of non-certified fisheries to evaluate whether MSC-certified fisheries do represent “the best environmental choice in seafood,” as the MSC tagline claims [25]. The objective of this analysis is to provide information consumers can use to evaluate the environmental impact of currently certified seafood relative to seafood alternatives, and to compare performance of these fisheries relative to quantitative metrics of ecosystem-based sustainability.

1.1 Rationale for Metrics of Collateral Impacts Chosen

Bycatch is defined as the unintentional capture of living marine resources that are harvested by a fishery and discarded dead. Incorporating fishing impacts on non-target species, or bycatch, is a universal tenet of EBFM [14,29]. It represents two of the five Ecosystem Impacts for which fisheries are evaluated. Certified fisheries must ensure that bycatch levels do not pose a risk of serious harm to their populations, and monitoring is adequate to estimate impacts on bycatch species [30]. No quantitative targets of adequate observer coverage nor quantitative metrics for serious harm are given within the certification guidelines, however. Instead, bycatch must be within “biologically-based limits”, which are defined as those that avoid serious harm. For Endangered, Threatened or Protected (ETP) Species, the fishery must also meet national and international requirements for protection of these species, if they are established. Given these explicit

requirements for bycatch of protected species like marine mammals, certified fisheries were expected to meet these targets as well as perform better than non-certified fisheries on marine mammal bycatch.

Fishery performance was also evaluated on a second component of bycatch: overall finfish discard rates. The discarding of fish at sea is widely regarded as a waste of fish resources [31], a threat to the long-term sustainability of fisheries and maintenance of biodiversity [32], and a serious impediment to the management and rebuilding of stocks [33]. Given these wide-ranging negative effects, discards have been deemed inconsistent with the FAO Code of Conduct for Responsible Fisheries [34]. The overall discard rate by a fishery has been widely used to evaluate the ecological sustainability of fisheries [31,35,36]. However, the current MSC certification scheme only considers whether discards negatively affect the sustainability of those species that are discarded, and not the overall discard rate relative to catch and its more wide-ranging ecological and social consequences. As public opinion rallies around minimizing discard rates or banning discards entirely, as was done recently in Europe [37], consumers may expect eco-labeled fisheries to meet discard rate limits considered sustainable. The quantitative scoring scheme developed by Pitcher et al. [38] was used to evaluate whether discard rates comply with the FAO Code of Conduct by scoring fisheries with a discard rate of $\leq 15\%$ of the total catch as “good” [39]. Because discard rates are not taken into account within the MSC certification process, certified fisheries were not expected to outperform non-certified fisheries or meet this literature-based target, unless achieving sustainability on some ecosystem metrics indirectly leads to improved performance on other metrics of collateral impacts.

Effective ecosystem-based fisheries management hinges upon having adequate knowledge of the environmental impacts of fisheries. In particular, observer programs are considered necessary to effectively evaluate fisheries' performance on bycatch [40] and discards. MSC currently requires information to be "adequate" to determine fishery impacts on retained, bycatch, and ETP species; however no quantitative framework is established. According to Babcock et al. [41] and Lawson et al. [42], 20% is the minimum level of observer coverage required to accurately estimate bycatch for common species (>30% of catch), while rare species (< 0.1% of catch) need considerably higher coverage, with almost 100% needed for the rarest species. Given its importance in determining whether information is adequate to evaluate fisheries' environmental impacts, observer coverage was used to evaluate the reliability of the discard and bycatch metrics.

The collateral impacts of fishing on habitat and non-target species depend in large part on the gear and methods used to catch the fish [43]. As such, scientists have advocated that gear impacts be taken into account as a critical part of an ecosystem-based approach to fisheries management [44]. MSC requires that a fishery does not pose "serious or irreversible harm" to habitat structure and function [30], but does not prescribe the types of gear that may be used. Because habitat damage occurs underwater and is typically unobserved, reference points are still being developed [45]. In the absence of reference points, we used the severity rankings for each gear type established by Chuenpagdee et al. [43] weighted by landings as a proxy for gear impacts. This approach is comparable to that of Essington [46], who used effort employed using habitat-damaging gears as one metric of the ecological impact of fisheries. While no

scientific consensus exists regarding a benchmark for sustainable gear impacts, a lower score indicates lower ecological impact. Collectively, the portfolio of certified fisheries was expected to use less destructive gear than non-certified fisheries and therefore receive a lower average score.

Together these three quantitative metrics provide a measure of the collateral impacts of fishing. The metrics we have chosen span a range of specificity in terms of how they are incorporated within the MSC certification criteria. Certified fisheries are expected to outperform non-certified fisheries for criteria with quantitative targets explicitly considered within the certification process, such as marine mammal bycatch. Other metrics like gear impacts, for which MSC criteria are currently based on expert opinion, may have more variable performance relative to non-certified fisheries and may or may not meet the literature-based reference points described here. For metrics not currently considered by MSC, such as finfish discard ratios, certified fisheries may only outperform non-certified fisheries and meet targets if complying with some criteria of sustainability leads to indirect reductions in other collateral impacts.

2. Methods

2.1 Data

2.1.1 Discards, Bycatch and Observer Coverage

Comprehensive bycatch and discard data on certified and non-certified fisheries were not available on a global basis, nor were they available in a standardized way for European fisheries. In contrast, a mandate to minimize bycatch under the MSA, a long history of observer programs, and additional observer requirements under the MMPA

185 have made some data available for U.S. fisheries. The analyses of marine mammal
186 bycatch and finfish discards were constrained to U.S. fisheries, which represent 30% of
187 the landings of the certified fisheries as of November 8, 2013 (Table A.1).

188 A unique dataset on discards and bycatch was compiled for this study including
189 data from the U.S. National Bycatch Report [40], the 2013 update to the National
190 Bycatch Report [47], the 2012 NMFS List of Fisheries (LOF) [48], and NOAA Marine
191 Mammal Stock Assessment Reports [49–51]. Discards by finfish species, total landings,
192 and total catch data for U.S. federally-managed fisheries were available for 2005 and
193 2010 in the two National Bycatch Reports [40,47]. The LOF was used to designate each
194 fishery into MMPA Categories describing their potential level of interaction with marine
195 mammals (described in detail in section 2.2.1). The marine mammal stock assessment
196 reports provided estimated mortality for each stock in each fishery 2002-2010. Observer
197 coverage by year was also compiled from the LOF and the marine mammal stock
198 assessment reports.

199 Bycatch was evaluated separately in two time periods: 2002-2005 and 2006-2010.
200 Only Alaska salmon was certified before 2005, and the two Alaska pollock fisheries were
201 certified in 2005. By 2010, 17 fisheries in the U.S. were certified. The four that have been
202 certified since then were undergoing certification at this time. The most recent marine
203 mammal bycatch data from federal observer programs available to certifiers includes
204 records through 2010. As such, we define the period 2002-2005 as a “pre-certification”
205 period and 2006-2010 as a period during which certification was occurring. The two time
206 periods were compared to examine temporal changes in bycatch rates. Similarly, discard

data from 2005 and 2010 were compared to evaluate changes during these two time periods.

Both the discard and the marine mammal bycatch data define fisheries based on region and gear type and/or target species. This means that one certified fishery may be comprised of several NMFS fisheries, each of which may have different MMPA Category designations. In the NMFS northeast region many fisheries are multispecies, and thus defined without reference to a target species. This primarily affected the classification of the spiny dogfish fishery. Fisheries which landed spiny dogfish in 2010 using gears defined as eligible in the MSC unit of certification [52] were considered part of the certified fishery.

2.1.2 Gear Impacts

For the gear analysis, uncertified stocks were isolated to those in the Ram Legacy Stock Assessment Database (RAM) [53]. Because fisheries in the RAM database have the data available to evaluate target stock performance, they represent an ideal set of non-certified fisheries that meet the minimum information requirements to pursue certification from a single-stock perspective, but that may or may not meet standards for environmental impacts. However, they likely represent an optimistic measure of the performance of fisheries without formal stock assessments [54].

The definition of a fishery differs between MSC and RAM. The RAM database contains information at the stock level, which is generally defined as a reproductively isolated population, except when the scale of that population extends beyond the jurisdiction of management agencies (e.g., across international borders). MSC, however,

operates at the scale of fisheries, which can be defined in a multitude of ways, but is generally much smaller than the stock level. As such, a single stock can be targeted by multiple fisheries, each of which may or may not be certified. “Non-certified” stocks were defined as those within RAM that have never been targeted by a certified fishery, and the percent of total landings by gear type in these stocks was compared to that of MSC-certified fisheries.

Landings by gear type for MSC-certified fisheries were provided by the MSC (A. Stern-Pirilot, *personal communication*; Table A.1). Information on gear type is not currently available in the RAM database. When possible, data on landings by gear type were collected for the most recent year available from stock assessment reports for stocks already included in the RAM database.

2.2 Analyses

2.2.1 Bycatch

Marine mammal bycatch rates in certified and non-certified fisheries in the U.S. were evaluated relative to the target and limit reference points defined nationally for each species relative to its population size and productivity. The limit reference point for total incidental mortality has been termed the Potential Biological Removal (PBR), which is defined by MMPA as the maximum number of individuals that may be removed from a marine mammal stock while allowing that stock to reach or maintain its optimum sustainable population. The target reference point for marine mammal bycatch is the Zero Mortality Rate Goal (ZMRG). Established by Congress as an amendment to the MMPA in 1994, the ZMRG requires that the level of incidental mortality and serious injury of

each fishery be reduced to insignificant levels approaching zero. The ZMRG was defined as 10% PBR by NMFS in 2004 [55]. NMFS is required to establish a Take Reduction Plan for fisheries for which bycatch of a marine mammal stock exceeds ZMRG. Bycatch rates in certified and non-certified fisheries were evaluated relative to both the limit reference point of PBR and target reference point of ZMRG.

Fisheries were analyzed separately within the categories assigned by NMFS to describe the level of interaction each fishery has on marine mammals [48] (referred to as MMPA Categories henceforth). Category I fisheries have the highest levels of bycatch, causing annual mortality and serious injury of at least one stock with which it is known to interact at a rate greater than or equal to 50% of the PBR level. Category II fisheries cause mortality and serious injury of at least one stock at rates between 1% and 50% of PBR. Category III fisheries cause mortality and serious injury at rates less than 1% of PBR. Only fisheries with observer coverage were included in the analysis.

The mean take relative to their PBR was evaluated relative to the target and limit reference points and compared with non-certified fisheries within the same category using Wilcoxon rank sum tests. The proportion of stocks exceeding the target was compared using chi-squared tests.

2.2.2 Discard Rate

The discard ratio (discard/total catch) in each time period was calculated for each fishery for both those species identified as key stocks and those without this designation. Key stocks are defined by NMFS as those that have high discard levels, are of special importance to management, or for which there are stock status concerns [40].

Discard ratios were compared between certified and non-certified U.S. fisheries, and examined relative to the 15% target discard rate. Fisheries in the Southwest NMFS region were excluded from the analysis due to the absence of 2005 data on finfish discards. For fisheries where catch was reported as the number of individuals, catch weights were calculated by multiplying the number of individuals caught by their weight at 50% of the maximum weight as determined from von Bertalanffy growth parameters and length-weight relationships extracted from FishBase [56]. The sensitivity of the ratios to the percent maximum weight used in the calculation was explored and found to have a negligible effect.

2.2.3 Observer Coverage

Observer coverage by year for U.S. fisheries was recorded from Marine Mammal Stock Assessment Reports [49–51] or from the description of the fisheries in the 2012 List of Fisheries [48]. Observer coverage for each fishery was compared between certified and non-certified fisheries in the two time periods, as well as evaluated relative to the target 20% minimum level established by Babcock et al. [41] and Lawson et al. [42].

2.2.4 Gear Impacts

Landings at both the MSC “fishery” and the RAM “stock” level can be caught using multiple kinds of gear. A total gear impact score was calculated for each stock by weighting the severity score [43] for each gear type used by the percentage of landings captured by that gear. A second gear impact score was calculated by weighting the

severity score for each gear type by the number of fisheries using that gear type. Gear distributions and overall gear scores of MSC-certified fisheries were compared to the non-certified RAM stocks for which landings by gear type was available. Certified fisheries were expected to use less destructive gear on average than those used globally. Significant differences in mean gear scores were evaluated using t-tests.

3. Results

3.1 Marine Mammal Bycatch

The annual designation of U.S. fisheries into MMPA Categories for marine mammal bycatch represents the relative potential that the fishery will cause adverse impacts on bycatch species. More than half of all U.S. certified fisheries were classified as those with high potential levels of marine mammal bycatch (Category I and II) (Table 1).

In terms of the median bycatch rate, certified fisheries did not outperform non-certified fisheries, and the certified Category II fisheries actually had a significantly higher median bycatch rate ($p=0.006$ for 2002-2005 and $p=0.03$ 2006-2010). Bycatch rates for all stocks were lower than the limit reference point for both certified and non-certified fisheries, and on average they were also lower than the target reference point. Despite the good performance on average, the mean bycatch rate of 17% of certified fisheries exceeded the target reference point for at least one marine mammal stock in both time periods.

[Figure 1 about here]

3.2 Discard Rate

On average, both certified and non-certified fisheries met the target discard rate of 15% (Fig. 2) in both time periods. However, a large proportion of certified and non-certified fisheries exceeded this target level in both 2005 (64% of certified and 44% of non-certified fisheries) and 2010 (40% of certified and 56% of non-certified fisheries). Discards of key stocks were low, and certified fisheries had significantly lower discard rates of key stocks (0.002 in certified fisheries and 0.05 in non-certified fisheries, $p=0.002$).

[Figure 2 about here]

3.3 Observer Coverage

Despite certification requirements for adequate bycatch information, certified and non-certified fisheries did not differ in their observer coverage in both time periods ($p=0.37$ for 2002-2005, $p=0.22$ for 2006-2010), with a median rate of 0% OC, significantly less than the 20% target level (Fig. 3). More than half (13/23) of the fisheries with the greatest potential interactions with marine mammals (Category I and II) have no observer programs (Table 1), including Maine lobster, Atlantic deep-sea red crab, Oregon Dungeness crab, and the various certified units of Alaska salmon. Of those with observer programs, observer coverage in Category I fisheries was actually lower in certified fisheries ($p < 0.001$ in both time periods), and no different between certified and non-certified Category II fisheries ($p=0.27$; Figure S1).

[Figure 3 about here]

3.4 Gear Impacts

Certified fisheries utilized a wide range of gear types (Fig. 4A), with many gear types used in similar proportions to the non-certified stocks included in the RAM

database. 23% of certified landings were obtained using bottom trawl, which had the highest gear score, and is therefore considered the most destructive. By contrast, the fraction of landings by bottom trawl was higher for non-certified fisheries (50%). In addition, a higher percentage of landings by certified fisheries were landed by pelagic trawl (35% vs. 19%), which is one of the least destructive fishing methods. As a result, when weighted by landings, the mean gear score for certified fisheries (31.3) was significantly less than for non-certified stocks in the RAM database (52.8, $p < 0.001$), indicating that on average the gears used by certified fisheries have lower ecological impact.

Likewise, a smaller fraction of certified fisheries used bottom trawl (33% vs 48%) and a higher fraction used pelagic trawls (11% vs 6%). However, certified and non-certified RAM fisheries did not have significantly different gear scores (49.2 vs. 56.5) when weighted by the number of fisheries (Figure 4B).

[Figure 4 about here]

4. Discussion

Eco-labeling schemes have been posited as a mechanism that links consumer preference to fishing behavior through market-based incentives [57]. As such, while management agencies remain rooted in assessing the impacts of fisheries on target species, eco-labeling provides an opportunity for the recognition of fishing behavior that also minimizes its collateral impacts on non-target species and habitats. However, EBFM-related certification requirements are highly subjective, making comparisons between fisheries and fishing practices difficult. The performance of MSC-certified fisheries was quantitatively evaluated against non-certified fisheries for metrics of

collateral impacts of fishing, beyond removal of target stock biomass. Specifically, performance was evaluated with respect to marine mammal bycatch, finfish discards, and gear destructiveness. Bycatch and discards are an indication of the trophic impact of fisheries [35], and gear destructiveness indicates potential habitat degradation [43]. Together these three quantitative criteria provide a valuable metric with which to assess the incidental impacts of fishing practices on marine ecosystems.

Overall certified and non-certified fisheries did not differ in either their bycatch or discard rates. With regard to habitat impacts, the results were equivocal. When weighted by landings, MSC fisheries used less destructive gear but this difference was not significant when examining the proportion of fisheries using each gear type. While the results of this study show MSC-certified fisheries did not consistently represent a *better* environmental choice than non-certified fisheries, they on average met the literature-derived metrics of ecosystem-based sustainability. Despite adequate performance on average, further improvement is necessary for all certified fisheries to meet these targets.

While the observed levels of bycatch in both certified and non-certified fisheries was far below the limit reference point of PBR at which bycatch has been deemed to negatively impact marine mammal populations, conclusions about the impact of these fisheries on all of the marine mammal populations with which they are known to interact are undermined by inadequate levels of observer coverage. MSC has continued to certify U.S. fisheries with high levels of historical interactions with marine mammals, and these fisheries did not have higher levels of observer coverage than their non-certified counterparts. A large fraction of these certified fisheries actually had zero observer coverage. As bycatch of marine mammals is typically a rare event, low observer coverage

can result in inaccurate estimates of bycatch for the fleet, and lead to either under- or over-estimates of impacts on marine mammal stocks [58]. Developing standards for a certain level of observer coverage would increase consumer confidence that eco-labels like MSC are a reliable indicator of the collateral impact of fisheries on non-target species.

For those fisheries with observer programs, the lack of observed differences in bycatch performance between certified and non-certified fisheries may be explained by the fact that fisheries can be certified with conditions requiring improvements in the status of bycatch species, their bycatch management plan, and/or the level of information available to assess bycatch. The ability of certification conditions to catalyze change, however, is compromised by inconsistent application. For example, the U.S. North Atlantic Swordfish fishery's certification was conditional upon improvements to the status, management, and information available for ETP bycatch, specifically sea turtles. The fishery has pledged to increase observer coverage from 7% to 100% in five years [59], a demonstrable improvement in bycatch performance if achieved. In contrast, the Maine lobster fishery has <1% observer coverage, a level that, while only 25% of the minimum standard established by NMFS for this fishery [60], was considered by the assessment team "to provide an adequate understanding of the impact of the fishery on all bycatch species" [61]. No conditions on bycatch or observer coverage were established [61], despite documented interactions with five endangered species. Furthermore, the two certified fisheries for spiny dogfish are required to develop and implement a plan to increase the data on interactions with ETP species, including potentially increasing observer coverage (currently at <6%), but no targets were established [52]. Although this

fishery exceeded the target bycatch rate and had inadequate observer coverage in order to meet the precision goal for many of its marine mammal stocks, no additional conditions were required with respect to ETP species.

The inconsistency in the interpretation of the requirements by certifiers highlights the potential improvement that could be gained by including specific reference points for observer coverage. While the MSC includes explicit recommendations for sufficient observer coverage to adequately observe shark finning (20% as “good”; [30]), no comparable reference points are established by the MSC for observer coverage to adequately quantify catch of other retained, bycatch and ETP species caught incidentally by the fishery. In the U.S. target reference points for observer coverage have already been established by NMFS [62], and many regional fisheries management plans have made this their official standard [60]. Including reference points for minimum observer coverage levels for bycatch and/or a framework for linking levels of observer coverage to catch of protected species would demonstrate a clearer commitment to monitoring bycatch and could improve the quality of information for numerous other ecosystem metrics.

On average, discard rates in both certified and non-certified U.S. fisheries met the 15% target in both time periods, but many certified fisheries still require improvement to meet this goal. As part of the standards review, MSC is considering adding language requiring fisheries to review “the effectiveness and practicality” of available measures to minimize bycatch and that these strategies be “incorporated as appropriate” to receive unconditional passing scores [63]. However, “incorporated as appropriate” is defined with the caveat that such measures must be comparably efficient at harvesting the target

catch in order to require them to be incorporated [63]. While intended to incentivize a reduction in the discard rate, the caveat in combination with the lack of reference to a specific discard rate may limit its ability to catalyze measurable change.

The metric in which certified fisheries outperformed non-certified fisheries most clearly was in gear impacts. When weighted by landings, certified fisheries do have an overall lower destructive gear score than non-certified fisheries, due to lower relative landings from bottom trawls and higher landings in pelagic trawls, one of the least destructive gear types. However, being certified in no way precludes fisheries from using some of the more destructive gear methods such as bottom trawling [43], an omission criticized by Greenpeace [67] and some scientists [25]. Indeed bottom trawl is the gear most frequently used by certified fisheries when examining the numbers of fisheries employing each gear type. The only gears explicitly prohibited from being used in certified fisheries are explosives and poisons [30]. As such, eco-labeling by MSC will likely not incentivize a move away from gears like bottom trawl, and other management measures may be necessary to minimize damage to sensitive habitats, such as spatial restrictions on gear usage.

This study represents a first step in the evaluation of quantitative metrics to assess the extent to which eco-labels effectively reduce the collateral impact of fishing on non-target species and habitats. Because few target reference points for ecosystem impacts exist, we have explored the extent to which MSC-certified fisheries, which are supposed to represent a more sustainable seafood choice for consumers, actually reflect a more sustainable choice based on metrics of marine mammal bycatch, discard rates, and gear destructiveness. MSC-certified fisheries outperformed non-certified fisheries on some of

these metrics (i.e. gear destructiveness, discards of key stocks), but displayed no significant improvement in others (i.e. marine mammal bycatch, overall discards). With respect to quantitative targets, MSC-certified fisheries met the target reference point for discards on average, and the limit reference point for marine mammal bycatch, but more improvement is required for all certified fisheries to meet targets for bycatch, observer coverage, and discard rates.

Minimizing the collateral impacts of modern fishing practices is critical to the stability and sustainability of fisheries under ever increasing demand. EBFM seeks to incorporate a range of environmental and behavioral characteristics that preserve intact marine ecosystems, thereby preserving both single-stock health and ensuring future productivity. Yet, because EBFM practices are often vague and difficult to implement, fisheries, managers, and certification schemes continue to rely heavily on single-stock health as a proxy for trophic and environmental impacts of fishing. We isolated three widely available and easily comparable metrics from the EBFM literature that extend beyond single species management, and compared outcomes for MSC certified and non-certified fisheries. While these metrics are certainly not all-encompassing, this study illustrates the great potential for using simple quantitative metrics to standardize evaluation of the collateral impacts of fishing on non-target species and habitat.

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Tables

Table 1. Number of certified (C) and non-certified (NC) U.S. fisheries in each MMPA Category. Category I fisheries have marine mammal bycatch rates of at least one stock >50% Potential Biological Removal (PBR), Category II have bycatch rates 1-50% of PBR, and Category III have bycatch rates <1% of PBR. The number of fisheries in each Category with observer coverage estimates, bycatch estimates, and the number of stock-years in which bycatch was estimated in 2002-2005, and 2006-2010 is also listed.

MMPA Category	Status	# Fisheries	Observer Coverage (OC) Estimates	Fisheries with reported bycatch estimates / Fisheries with non-zero OC	Stocks (Stock-years) with bycatch estimates 2002-2005	Stocks (Stock-years) with bycatch estimates 2006-2010
I	NC	1	1	1/1	9 (22)	9 (37)
	C	4	4	3/3	15 (52)	14 (60)
II	NC	31	31	9/14	50 (116)	48 (170)
	C	19	19	7/7	24 (76)	28 (127)
III	NC	149	10	6/8	10 (21)	8 (27)
	C	20	6	5/6	19 (60)	19 (58)

Figure Captions

Figure 1. The ratio of mean estimated mortality to Potential Biological Removal (PBR) for each period for each marine mammal stock caught by non-certified (NC; white bars) and certified (C; gray bars) U.S. fisheries within each MMPA Category for 2002-2005 and 2006-2010. The dashed horizontal line at 10% PBR represents the Zero Mortality Rate Goal (ZMRG) established in 2004 by NMFS to comply with the 1994 Amendment to MMPA. Fisheries for which take of a particular marine mammal stock exceed ZMRG are required to establish a Take Reduction Plan in order to reach this level within 5 years. Horizontal lines represent the median with the box representing the Interquartile Range (IQR) between the 25th and 75th percentiles of the data. The whiskers extend to the maxima in the data within 1.5 times the IQR.

Figure 2. Discard Ratio (Discard/Total Catch) for non-certified (NC; white bars,) and certified U.S. fisheries (C, gray bars) for 2005 (NC=37, C=28) and 2010 (NC=43, C=33). Discard ratios are shown for all finfish discards, and stocks which have been established as “Key” by NMFS in the National Bycatch Report [40]. The dashed horizontal line shows a discard rate of 15%, which we have deemed a potential target reference point. See Figure 1 for details of quantiles shown with the boxplot.

Figure 3. Observer coverage for non-certified (NC; white bars; n=42) and certified (C; gray bars; n=29) U.S. fisheries. The dashed horizontal line represents the minimum level to adequately observe common bycatch species suggested by Babcock et al. [41]. See Figure 1 for details of quantiles shown with the boxplot.

Figure 4. Landings by gear type for non-certified RAM stocks (gray bars, n=275), and certified fisheries (white bars, n=165). Gear severity scores are indicated in parentheses, and gears are ordered by these severity scores. The composite gear severity score when weighted by landings was lower for MSC fisheries than for certified RAM stocks (A) but was not different when weighted by the number of fisheries (B).