

# Chapter 1

## Strategies Used Throughout the World to Manage Fisheries Discards – Lessons for Implementation of the EU Landing Obligation



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**Abstract** In many countries, policies regarding reduction of unwanted catch and discards are crafted in response to concerns regarding accountability, conservation, and waste as well as scientific needs to fully account for all sources of fishing mortality. It is important to note, however, that unwanted catch is minimal and most, or all, of the catch has value in some fisheries. Utilisation rates are very high, and discarding is generally not of concern in such fisheries which occur primarily, but not entirely, in developing countries. Where unwanted catch and discards are a

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concern, legislation may be prescriptive, as can be seen in the EU Landing Obligation (LO), and programmes established in e.g. Norway, Iceland, Argentina, Chile and New Zealand. Elsewhere, legislative language is intended to minimize unwanted catch but allows for some flexibility in developing strategies and solutions, as in the USA. The effectiveness of these approaches depends on many factors and all require effective cross-sectoral collaboration. Also essential is a comprehensive monitoring and control system which insures regulatory compliance and collection of adequate data to address scientific and management information needs. In this chapter, we evaluate the effectiveness of discard and unwanted catch reduction approaches under diverse legislative systems in different parts of the world, with reference to emerging practices under the LO. We consider the importance of finding the balance between top-down and bottom-up processes and look carefully at different governance/regulatory frameworks (e.g. input controls, output controls, quota management and transferability, cooperative/collaborative management), factors which encourage or discourage innovation and collaborative problem solving, monitoring and accountability. This is accomplished through case studies from selected fisheries around the world.

**Keywords** Avoidance · Discards · Full retention · Selectivity · Unwanted catch · Utilisation

## 1.1 Introduction

Waste is associated with many contemporary food production processes, especially in developed countries. In general, producers seek to reduce waste by improving utilisation of raw materials and avoiding unwanted materials during harvesting. In wild capture fisheries, many strategies are available for reducing unwanted catch (UWC) during harvesting. However, these strategies are rarely completely effective with the result that parts of the catch are discarded at sea. Although avoidance is preferable, discarding might be perceived as an acceptable practice under certain circumstances, e.g. when discard-related mortality is low and, especially for rare, endangered or protected species caught incidentally, when animals can be released uninjured. However, for UWC where chances of survival may be small, discarding at sea is generally considered wasteful and undesirable.

Conflicting regulatory and economic drivers often create perverse incentives for fishers to discard fish. This can occur when unmarketable or undersized fish are taken, when a vessel operator is not permitted to retain marketable catch or when catch of lower value is discarded so that fishing for more valuable catch can continue (high-grading; [FAO 2016](#)). Discarding is minimal or entirely absent in some fisheries where most, if not all, of the catch has a value and is fully utilised. This typically occurs in small-scale/artisanal/traditional fisheries ([Kolding et al. 2014](#); [Damalas](#)

2015) but examples can be found elsewhere such as in industrial fisheries which produce fish meal and oil.

The 2013 reform of the Common Fisheries Policy (CFP) included an “obligation to land all catches”, referred to as the Landing Obligation (LO). The objective of the LO is to

“gradually eliminate discards, on a case-by-case basis, taking into account the best available scientific advice, by avoiding and reducing, as far as possible, unwanted catches, and by gradually ensuring that catches are landed”. An additional objective is to “make the best use of unwanted catches, without creating a market for such of those catches that are below the minimum conservation reference size” (European Union 2013).

The LO is not a fully comprehensive discard ban as it only applies to TAC (Total Allowable Catch) regulated species. In addition, it applies to species in effort-regulated fisheries in the Mediterranean for which a minimum size has been defined. Exemptions for the LO apply to species and fisheries for which high survival rates can be demonstrated for discarded fish. Furthermore, up to 5% of the total catch of species may be discarded in cases where selectivity increases are difficult to achieve or where handling of unwanted catches creates disproportionate costs. The LO requires that fish under a Minimum Conservation Reference Size (MCRS) are landed but prohibits their use for direct human consumption.

In principle, the LO involves a shift from landing quota to catch quota management as all catches must be recorded and accounted for against quotas (Mortensen et al. 2017). The LO has raised serious concerns in the fishing industry, especially where choke species issues arise in mixed fisheries regulated by TACs (Schrope 2010). Other concerns include the perception that there is insufficient knowledge to allow implementation of the LO, and that the period during which the LO is to be phased in (2015–2019) is insufficient to allow necessary preparation by those that are involved and affected (Fitzpatrick et al. 2017).

In this chapter, we compare worldwide examples of strategies for reducing discards in order to inform discussions on questions such as: “what makes a successful discard mitigation strategy?”; and “what lessons can be learned with regards to the successful implementation of the EU Landing Obligation (LO)?”. We do so by briefly reviewing approaches in several countries. The cases were selected to offer insights regarding (a) scale and drivers of discarding issues – where they exist, (b) motivation, objectives and legal status of a discard mitigation policy – if applicable, (c) technical and management approaches employed to mitigate discarding, and (d) perceived outcomes of the discard policy – or lack thereof.

## 1.2 Case Studies

### 1.2.1 Norway

Norwegian fisheries are managed through a complex system of regulations which aims to control both input (i.e., fishing licences) and output (i.e. quotas), as well as the exploitation pattern, through a multi-faceted collection of regulations and technical measures referred to as the “Discard Ban Package” (DBP: Johnsen and Eliassen 2011; Gullestad et al. 2015).

The DBP is an integrated suite of regulatory and technical measures to minimise unwanted catch including: the regulatory discard ban; gear selectivity technical measures; closed areas; and monitoring and control measures. The Norwegian Discard Ban evolved over ~30 years in response to specific fisheries problems, starting in 1987 with an *ad hoc* strategy to save the 1983 NE Arctic cod cohort from “high-grading” (Gullestad et al. 2015). Between 1987 and 2008, regulations and technical measures progressively extended this discard ban to include a further 17 commercially important species, to address bycatch issues in several fisheries, including demersal trawling for shrimp (e.g., Isaksen et al. 1992) and gadoid trawling (Larsen and Isaksen 1993). In 2009, the “Marine Resources Act” (section §15: Duty to Land Catches), in principle, extended the DBP to encompass all living marine resources with the phrase: “All catches of fish shall be landed . . .”. However, in practice, the Norwegian Seawater Fisheries Regulations (2014) (section §48: Prohibition against discarding fish), which are enforced by the Fisheries Directorate and the Coastguard, effectively limit the ban to 55 commercially important species. In addition, the regulation introduces several “pragmatic exemptions” (Gullestad et al. 2015), e.g., that surviving fish may be released, and that damaged catch (unfit for human consumption) can be discarded, “in small quantities”.

Key features of the discard package include:

- Improved Selectivity – development and regulated application of bycatch reduction devices, and other technologies and technical measures to address fishery-specific UWC issues.
- Real-Time Closures – triggered by the UWC limits being exceeded in an area and dimensions are defined by the distribution of the UWC. They are perceived by most stakeholders as a fair and effective way of addressing unpredictable distributions of UWC, although there has been discontent amongst fishers due to extended delays in re-opening some areas, primarily due to a lack of resources to survey them.
- Monitoring – using a “Reference Fleet” and targeted programmes to identify emerging UWC issues in different fisheries. However, there is no systematic at-sea monitoring by observers.
- Decriminalisation – of catching UWC for fishers who demonstrate responsible behaviour and conduct in avoiding further UWC.
- Pragmatic application of regulations – by the authorities to engage the stakeholders and ensure a “level playing field”.

- Improved dialogue – between management, fishers and scientists – to ensure the individual concerns of each have been recognised and that all stakeholders are working towards a common goal.

The greatest beneficial impact from the Norwegian Discard Ban is generally considered to have been its role in catalysing a cultural shift among all stakeholders, towards the recognition that needless waste of a living resource is no longer acceptable (Gullestad et al. 2014). The burden of proof on fishers to demonstrate acceptable behaviour and conduct is arguably resulting in increased professional responsibility (Johnsen and Eliassen 2011). This change in mindset has driven an ambition to minimise UWC and contributed to the development of a “common code of conduct” in relation to resources and compliance (Gezelius 2006). Recently, this has stimulated the development of strategies and technologies to avoid issues related to excessive catches in some fisheries, due to localised high densities of fish, e.g. high-grading of cod in the Barents Sea (Grimaldo et al. 2014; Underwood et al. 2014) and slipping of mackerel from purse seines (Breen et al. 2012). It has also promoted greater utilisation of the retained catch (Richardsen et al. 2017).

### **1.2.2 Iceland**

A ban on discarding six primary commercial species was introduced in the Icelandic fishery in 1977 (European Commission 2007). Requirements evolved as management strategies progressed from effort- to quota restrictions (Johnsen and Eliassen 2011). The ban has gradually expanded, and now applies to all species, including those with no market value. Catches that marginally exceed quotas can be landed legally since the law allows 5% of the quota to be transferred between years. Fishers can also land up to 5% of catches without deduction from quota but must then forfeit most of the value of the surplus catch (Fiskistofa 2018a). Fishers are also allowed to land catches under minimum size limits and only 50% of the weight of this portion of the catch is deducted from their quotas. This creates an incentive to land undersized catches (Fiskistofa 2018b). Larger overruns and non-target catch can be covered through the purchase or leasing of additional quota. Failure to cover excess catch with allowed overages or purchased quota can result in fines and/or revocation of licenses (Fiskistofa 2018c).

Capture of juvenile fish is discouraged through real-time area closures if catches below minimum sizes exceed prescribed limits (Johnsen and Eliassen 2011). Catches are monitored by on-board inspectors from the Directorate of Fisheries, dockside surveillance and use of electronic logbooks. The coastguard also inspects vessels to verify catch reporting. Coastguard surveillance and on-board inspector coverage levels are quite limited; inspectors from the Directorate of Fisheries are at sea for around 1200 days a year in total and the coastguard only patrols Icelandic waters for around 300 days a year using four patrol vessels, one fixed-wing aircraft and two helicopters (Fiskistofa 2018d; Landhelgisgæslan 2018).

Catch records and size composition information are matched and compared to identify possible discarding (Fiskistofa 2017). Despite a mandatory landings policy, discarding still occurs, but the level has gradually declined since the early 1990s. According to estimates from the Icelandic Marine Research Institute, haddock discard rates have, for example, fallen from 22% in 1997 to 0.12% in 2013, and cod discard rates have not exceeded 2% since 2001 and were estimated at 0.60% in 2013 (Pálsson et al. 2015; Pálsson 2003). These estimates are based on sampling by the Directorate of Fisheries and the Marine Research Institute. Some stakeholders question the validity of these estimates and believe the discard numbers are substantially underestimated while others consider them to be reliable. Limited coverage by onboard inspectors and patrol vessels is the main reason for distrust of the official discard estimates. Therefore, the Ministry of Fisheries is currently preparing a regulation which will require all commercial fishing vessels to be equipped with Electronic Monitoring (EM) equipment including video cameras to remotely and electronically monitor potential discarding (Ministry of Fisheries 2018). The regulation will also require all official dockside weighing of catches to be electronically monitored. If the regulation is passed in its current form, dockside monitoring will come into effect immediately and onboard monitoring will be in full effect by January 1, 2020.

Improved selectivity is important in reducing discards in Iceland. Selectivity increases are primarily due to advances in gear technology, regulations on gear selectivity devices, and widespread use of voluntary move-on solutions based on real-time information shared between fishers (Margeirsson et al. 2008).

The extensive consolidation that has occurred in the Icelandic fishing fleet over the past 20–30 years has contributed markedly to the overall success in reducing discards. This consolidation is one of the side-effects of the individual transferable quota (ITQ) system, as smaller and less profitable businesses merge with (or are acquired by) larger entities that benefit from economies of scale and better access to capital. Small companies operating with limited quotas have almost disappeared and large vertically integrated seafood companies that include catching, processing and marketing are now in possession of the majority of the quota (Íslandsbanki 2017). Consequently, the numbers of vessels and fishermen have been reduced significantly, such that capacity and quota allocations are now better matched, and vessels generally have enough quota to operate at full capacity throughout the year. This has eliminated many of the incentives to discard. Nevertheless, allegations of illegal discarding on larger vessels persist, despite allocation of adequate quota (RÚV 2018).

Key features to the success of the discard ban include:

- Improved selectivity.
- Real-time closures.
- Monitoring, Control and Surveillance (MCS) mechanisms that include discard monitoring (although of limited in scope).
- Regulatory incentives to land undersized catch with partial or zero deduction from quota.

- Voluntary move-on measures are used to collect and share information on where and when to avoid unwanted catch.

The discard ban is now accepted by all stakeholders and by the public such that it is generally considered unacceptable to discard catch in Icelandic fisheries. The focal point of the “discard discussion” in Iceland has shifted towards the utilisation of by-products, as full utilisation of the entire catch has been encouraged with a high degree of success (Vigfusson et al. 2013).

### 1.2.3 USA

Science-based management has been the hallmark of US national policy since enactment of the Magnuson-Stevens Fishery Conservation and Management Act (MSA) in 1976. Under the current version of this act

Conservation and management measures shall, to the extent practicable, (a) minimize bycatch and (b) to the extent bycatch cannot be avoided, minimize the mortality of such bycatch”; bycatch is defined as fish which are harvested in a fishery, but which are not sold or kept for personal use [...].

and includes economic and regulatory discards. Regionalization underpins MSA and the eight Regional Fishery Management Councils are allowed flexibility in developing Fishery Management Plans (FMPs) that comply with the MSA. Therefore, many approaches to reducing bycatch can be found in US fisheries regulations, but discarding is not banned in any US fishery.

Fisheries for walleye pollock (*Gadus chalcogrammus*), the nation’s largest single-species fishery, take place throughout Alaska but primarily in the Eastern Bering Sea and Aleutian Islands (BSAI). Since the late 1970s, catches in this region have ranged between 0.8 and 1.5 million t (Ianelli and Stram 2015). The regulations have been amended many times to reduce bycatch and discard in the pollock fishery (NPFMC 2016). The American Fisheries Act was passed in 1998 and mandated significant changes in management of the fishery. Almost the entire quota (which is reviewed annually) was permanently divided among three sectors: inshore catcher vessels delivering to shore-side plants, catcher/processors, and motherships (catcher vessels delivering to floating processors). This eliminated competition among and within sectors. Provisions for binding agreements within or among co-operatives were also established.

Bycatch challenges impacting the pollock fleet include incidental catches of Pacific salmon and other ground-fish, and undersized pollock. Through a combination of regulatory action, internal contractual arrangements, and cross-sectoral collaboration, innovative changes in fishing practice have been developed and implemented to address these challenges.

Regulations were amended in 1998 to require all ground-fish vessels to retain all pollock and Pacific cod (*Gadus macrocephalus*) and achieve defined utilisation standards (NPFMC 2016). Between 1997 and 1998, overall cod discard was reduced

from 8.6% to 2.2% of cod harvest and overall pollock discard was reduced from 8.2% to 1.6% of pollock harvest (Witherell et al. 2000). Subsequently discards have been further reduced. Pollock and cod constitute a very high proportion of the overall ground-fish harvest in this region (85.7% in 2016, 80.1% in 2017; NPFMC 2017), so overall discard rates were greatly reduced.

Bycatch of Pacific salmon cannot be retained in the walleye pollock fishery and the fishery can be penalized if salmon bycatch exceeds proscribed limits. Abundance of limiting salmon species is highly variable and influenced by multiple factors including spatial and temporal co-occurrence, and variability in the abundance of salmon year classes. Concern about salmon bycatch is exacerbated by its cultural and economic importance and long-term trends of reduced abundance of many stocks (Stram and Ianelli 2015). NPFMC has taken many actions to reduce salmon bycatch. These include time and area closures, hard caps, gear modifications, and incentive-based measures (NPFMC 2016). The most recent action, approved in 2016, constitutes a comprehensive approach including rolling hotspots (real-time, temporary closures), required use of gear modifications and contractual arrangements which obligate vessels to avoid high bycatch areas based on observer data (NPFMC 2016; Karp et al. 2005; Stram and Ianelli 2015).

The effectiveness of the increased retention requirement can be evaluated through catch and discard data obtained by observers. However, it is not possible to measure the effectiveness of the salmon bycatch reduction programme directly because bycatch rates are influenced by many factors including highly-variable patterns of salmon distribution and abundance (Stram and Ianelli 2015); furthermore, once vessels relocate, bycatch rates that would have occurred subsequently are unknown. The programme has been effective in the sense that time and area closures and hard caps have not constrained overall pollock harvests. Also, requirements for vessels to relocate to avoid high bycatch areas have been enforced effectively.

For both the increased retention and the salmon bycatch avoidance measures, elimination of the race for fish through permanent allocation of quota to cooperatives has enabled collaboration and innovation in reducing bycatch. Also, for both programmes, several best practices in bycatch management are satisfied; these include observer coverage and data collection, explicit performance standards, and adequate surveillance (Gilman 2011).

### ***1.2.4 Chile***

Chile has historically been among the 10 major fishing nations in the world, with annual landings (including aquaculture) exceeding 2.8 million t in 2016 (Sernapesca 2016). However, important fishing stocks have shown signs of overexploitation and consequently catches decreased from the maximum historical level of 7 million t in the mid-1990s (Sernapesca 2017). Consequently, management changes have been made to assure fisheries and ecosystem sustainability.

In this context the term “discard” first appeared in the Fisheries Law amendment of 2001, which also introduced an ITQ system. Before 2001, Chile had a “race for fish”, i.e. vessels would fish until the total allowable catch (TAC) was reached and the fishery closed. The 2001 amendment prohibited discards without distinguishing among species and sizes, and established penalties that would apply to offenders, such as ITQ deductions of 30% (MEFT 2011). Without a concurrent extensive enforcement system or changes in selectivity, these penalties discouraged fishers from complying with the requirements and also from reporting discards. As a result, the magnitude of discards in Chilean fisheries was unknown and the practice of discarding continued (Borges et al. 2016).

The discard problem was revisited in the 2012 revision of the Fisheries Law. The “discard ban” was re-defined and the term “incidental catch” was applied to seabirds, marine mammals and sea turtles caught during fishing operations. This revision included provisions for compulsory industry-funded electronic monitoring (EM) on-board fishing vessels (including video sensors); and strengthened the penalties for discard offences. However exemptions from the discard ban and its penalties are permitted to identify and quantify the causes of discards and incidental catch. Through this process mitigation measures could be later tailored for each fishery and binding mitigation plans put in place as of 2018. Exemptions are conditional on a minimum 2-year at-sea monitoring and research programme with observers on-board commercial vessels. Suspending penalties under these exemptions largely eliminates incentives for fishers to alter their fishing behaviour and therefore reduces bias in the information collected. Once these penalty-exempt research programmes are completed, mitigation plans are put in place where further exemptions can be applied for as long as several requirements are met, such as on-board monitoring by observers continues and a global catch quota, which accounts for discards, has been set for the target species.

By February 2018, eight binding mitigation plans had been agreed upon, covering 11 fisheries within the artisanal and industrial fleets (Subpesca 2018). Even though draft mitigation plans were proposed by the Under-Secretariat for Fisheries to the respective Management Committees, they were further developed through a participatory, bottom-up process that included skippers, vessel owners, fishers and NGOs, in addition to members of the Management Committees. Mitigation plans and compliance monitoring by EM is required for all vessels in the industrial fleets by 2018 and by 2020 for artisanal vessels over 15 m (MEFT 2017).

The impact of the Chilean discard ban is not fully understood because it is still being implemented. In some cases, these penalty-exempt programmes have enabled fishery-specific changes in regulations including changes in minimum landing size (MLS) and authorization to catch and land species which were previously prohibited for some gears or fleets. In other cases, data collected has led to increases in target species TAC, since discard mortality estimates are now included in the stock assessments. However, restrictions and uncertainty related to choke species remain in multispecies fisheries. Quota transferability under the ITQ system (a potential approach for reducing the impact of choke species) is limited. When the discard ban is fully operational, and EM is in place, discarding choke species will no longer be

possible and this may constrain fisheries for which selectivity improvements are not possible.

### 1.2.5 *Argentina*

In Argentina, fisheries resources are regulated and managed under federal law which provides a framework for the management of discards. Furthermore, each of the five provinces with maritime coasts has its own administration and applicable fishing legislation. Under article 21 of the Federal Fisheries Law “throwing discards and wastes into the sea, which is contrary to responsible fishing practices” is prohibited, while the General Environmental Law obliges the state “to promote the rational and sustainable use of natural resources”.

In 1996, regulations established minimum total length or length at sexual maturity for several demersal and coastal species, prohibiting the capture of specimens below those sizes. Further amendments restricted fishing vessels to capturing no more than 10% of sizes smaller than those fixed under this resolution. After this threshold is reached, captured specimens must be returned to the sea immediately. This regulation also details provisions for the establishment of move-on rules when catches of undersized fish are predominant, and for area closures when the presence of undersized fish in an area is predominant. These minimum size requirements were abolished in 2006 since vessels were discarding catches above the 10% threshold at sea to avoid penalties.

Control and enforcement of fishing activities in Argentina is weak, and while discarding is illegal, it occurs frequently. A recent audit of the Under-secretariat of Fisheries and Aquaculture<sup>1</sup> has identified significant weaknesses in all their areas of operation, from inspections to data reporting and recording.

Argentina has had a National On-Board Observer Programme (PNOB) for the last 30 years to monitor activities of the main fishing fleets, and to obtain high quality information to be used exclusively for scientific purposes. The data collect by the observers is confidential and cannot be used for control and enforcements purposes.

Argentinean trawl fisheries are estimated to discard between 25% and 30% of their total catch. These discards comprise ~85 fish and invertebrate species in the bottom trawl fleet, and ~60 and ~32 species, respectively, in the factory trawl and shrimp trawl fleets. In addition, there is bycatch of more than 20 species of sharks and rays, many of them considered to be highly vulnerable to exploitation<sup>2</sup>.

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<sup>1</sup><https://www.agn.gov.ar/informes-resumidos/subsecretaria-de-pesca-y-acuicultura-gestion-de-la-tecnologia-informatica>

<sup>2</sup>[https://www.researchgate.net/profile/Alicia\\_Boraso/publication/309672657\\_La\\_zona\\_costera\\_patagonica\\_Vol\\_III\\_Pesca\\_y\\_Conservacion/links/581c829808aea429b291bdaa/La-zona-costera-patagonica-Vol-III-Pesca-y-Conservacion.pdf](https://www.researchgate.net/profile/Alicia_Boraso/publication/309672657_La_zona_costera_patagonica_Vol_III_Pesca_y_Conservacion/links/581c829808aea429b291bdaa/La-zona-costera-patagonica-Vol-III-Pesca-y-Conservacion.pdf)

In summary, even though there is a legislative framework to reduce UWC and prohibit catches of undersized fish, discarding continues to occur frequently in Argentinean fisheries, especially when undersized individuals and/or non-commercial species are caught.

### ***1.2.6 Australia***

Australia's commercial fisheries are managed by eight jurisdictions that use the full range of contemporary fisheries management methods (most in combination). However, discarding is not banned in Australian commercial fisheries. Instead, the approach generally used to manage commercial discards involves: (i) targeted observer programmes to identify problematic discarding issues; (ii) research into, and the implementation of, modifications to fishing gears that reduce problematic discards – using a variety of Bycatch Reduction Devices (BRDs) such as grids, panels and escape vents; and (iii) if no such modifications can be developed, spatial and/or temporal closures may be used.

For example, in the oceanic and estuarine prawn trawl fisheries of New South Wales (NSW) focused observer data collection in 1989–1991 identified problematic discards of juvenile finfish of species that were targeted by other commercial and recreational fisheries (Kennelly and Broadhurst 2002). Experiments were conducted to develop grids and panels to reduce UWC that resulted in discarding. These were used by fishermen voluntarily for many years before they were required by regulation. It has been estimated that these BRDs are now saving over 27 million juvenile fish per year in this fishery (Kennelly 2017; Kennelly and Broadhurst 2002).

### ***1.2.7 New Zealand***

Borges et al. (2016) and Telesetsky (2016) reviewed New Zealand's management of fisheries discards and a summary is provided below. As in Australia, New Zealand's fisheries are managed through use of the full range of contemporary fisheries management methods. However, unlike Australia, discarding/dumping by commercial fishers of fish, aquatic life, or seaweed covered by the New Zealand Quota Management System is prohibited –with a few exceptions. Specifically, a commercial fisher is not permitted to “return to or abandon in the sea or any other waters any fish, aquatic life, or seaweed of legal size. . .that is subject to the quota management system”. What this means in practice is that New Zealand operates a “discard ban”, with a prohibition on the discarding of catches of quota species over their minimum legal size (i.e. to prevent high-grading) and all catches for quota species for which a minimum has not been established. A catch does not need to be brought onboard for it to be considered “abandoned”. Where quota fish are caught but left dead at sea, a harvester has a duty to prevent dumping and “make reasonable efforts to retrieve”

such fish or be subject to an offence. The NZ Fisheries Act is silent on whether it is legal or not to discard non-quota species but there is some obligation to report discards of such species.

Any quota species that is less than the minimum legal size must be “immediately” returned “whether alive or dead to the sea or waters”, where the fish or aquatic life were harvested. Generally, sub-MLS catches do not need to be reported except for certain specified stocks. However, only 11 finfish, rock lobsters, scallops, oysters, and paua (abalone) have minimum legal sizes.

New Zealand deploys an instrument to mitigate discarding of over quota catches, referred to as the “deemed value” system, by which the government puts a tax on the landing of over quota catches. The level of the tax is set through a complex set of principles to discourage discarding, without creating incentives for targeting species not covered by quota (Telesetsky 2016; Sanchirico et al. 2006).

Under Schedule 6 of the NZ Fisheries Act, a fishing operator is authorised to legally discard thirty-two stocks in New Zealand if they comply with area and practice requirements. Three scallop stocks must be returned if they are collected during a closed scallop fishery season or in an area that has been closed to scallop fishing. Other scallops and dredge oysters may be returned as long as the shellfish is likely to survive. Most of the fish and shellfish listed in Schedule 6 “may” be returned to “the waters from which it was taken” if (1) the species is “likely to survive on return” and (2) “the return takes place as soon as practicable” after the species has been taken. This introduces a degree of discretion for the skipper and his crew for the return of such species without any explicit duty spelled out in the Statute to report such decisions. In practice, the Ministry requires that all Schedule 6 species returned to the sea be reported on both catch and landing returns even though Schedule 6 returns will not be counted against TACs.

In general Schedule 6 species are those understood to have high survivability when discarded. Certain species such as cockles, scallops, oysters, mussels, lobsters, and clams are likely to have high survival, depending on how they have been caught. For finfish, even if a fish is alive when it is brought on the deck, those with swim bladders that inflate after capture because of barotrauma are less likely to survive capture and discarding.

Exemptions may protect fishers who discard fish from prosecution. For example, as long as fishers report a discard as part of his/her returns, the fisher may return any fish, aquatic life, and seaweed to the sea where a fisheries officer or observer was present, the officer or observer authorized its return, and the fisher returned it under supervision of the officer or observer. Fishers may also legally discard parts of fish if the fish were lawfully processed and the parts of the fish that are retained on board allow for the accurate calculation of greenweight (weight prior to processing). Fishers may also return catch where there are concerns for the safety of the vessel or crew but there is no explicit requirement to report quota species that were returned for safety reasons even though the Ministry has an expectation that these species will be reported under the Fisheries (Reporting) Regulations on Catch Effort Returns.

While discards below MLS are not reported, discarding increased for legally sized fish following the introduction of the ITQ system in New Zealand (MRAG

2007). This occurred despite the provisions in the regulations that enabled fishers to match their catch to fishing opportunities by leasing, borrowing, banking or purchasing quota and the deemed value system (Lock and Leslie 2007). By 2007, discarding was considered to be widespread and an increasing problem in New Zealand's fisheries (MRAG 2007). According to Condie et al. (2014), at the same time as the introduction of the discard ban, there was a small increase in selectivity, but it is difficult to assess the impact of the discarding prohibition because accurate statistics on discards are unavailable. An analysis has suggested that total catches have been about the double of reported catches since the introduction of the quota management system in 1986, indicating that discarding remains a significant problem in New Zealand's fisheries (Hersoug 2018 and references therein). In line with this perception, the New Zealand government recently commenced on an agenda of mandatory EM of fishing operations including on-board cameras<sup>3</sup>).

## 1.2.8 Asia

### 1.2.8.1 Southeast Asia

In developing countries, including those in South-East Asia, small-scale fisheries generally harvest more fish than large-scale fisheries (Mills et al. 2011) and usually have low discard because utilisation is high (World Bank et al. 2012). Trawling makes a major contribution to seafood production in Asia with about 50% of seafood produced by an estimated 100,000 trawlers, ranging in size from those towing a net behind a 5 m boat with a 2 hp engine up to vessels of 80 m length or more. In Southeast Asia, large areas of trawlable continental shelf, fed by river inflows make for some of the most productive fishing grounds in the world. There is a wide range of sizes and shapes of fishes such that it is impossible to ensure that all species are caught at sizes above their size at first maturity (especially using trawls but also for other gears).

Even though trawls have been used in the region since the early twentieth century, after World War II there was a major increase in trawl fleets as developing countries sought to increase the supply of seafood for domestic consumption, export revenue and job creation. Aid funding and technical advice from developed countries led to a rapid increase in capacity which created large discarding issues and the depletion of stocks. Concerns about the wastage of useable protein, at a time when governments were seeking to increase protein supplies supply to the rural poor generated a debate about solutions, at a time when the developed countries were also beginning to address issues concerning bycatch, discards and wastage (e.g., FAO 1996).

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<sup>3</sup><https://www.mpi.govt.nz/protection-and-response/sustainable-fisheries/strengthening-fisheries-management/future-of-our-fisheries/digital-monitoring-of-commercial-fishing/>

Thailand's discard problem was resolved in the late 1960s and early 1970s with the development of a fish meal industry which supported poultry and shrimp farming industries. In Vietnam, previously discarded fish were used as food for pigs. Concerns about feeding animals encouraged a shift of interest towards products for human consumption. As a result, the surimi industry developed in the mid-1980s and has since grown throughout the region. In the Gulf of Thailand, the amount of fish used for fish meal has declined considerably due (in part) to overfishing but also the redirection of fish to higher value products. The same has occurred in Vietnam and to a lesser degree in China. In Myanmar there is still a big focus on fish meal. Throughout South-east Asia, large quantities of small fish are also used for fish sauces and pastes or are dried. And there is increasing evidence that these 'low-value' products have disproportional high value for alleviating prevalent micro-nutrient deficiencies (Roos et al. 2003; Kawarazuka and Béné 2011).

### **1.2.8.2 India**

One of the first examples of the implementation of a discard ban in legislation occurred in India. Pramod (2010) describes Regulation 5, of the Maritime Zones of India Rules 1982: "Crews may not discard substantial surplus catch, catch exceeding authorized quantities shall be retained onboard, recorded, and surrendered as required by authorized officers". But Pramod goes on to note that mechanized vessels have never abided by this law and in any case, India keeps no formal records on quantities of discards. Nevertheless, over the last three decades, fisheries discard in India has been assumed to be low because, as in the other Asian countries mentioned above, most catches are fully utilized given the demand for protein-rich foods.

### **1.2.9 Africa**

The following information summarizes observations from three African countries as reported by Kennelly (2014).

Discarding is not prohibited in Nigeria, and its shrimp trawl fisheries make extensive use of bycatch reduction technologies. This is mostly driven by European Union requirements for shrimp imports. Virtually all trawlers in Nigeria use Turtle Exclusion Devices (TEDs) and quite well-designed square mesh panels that effectively reduce the bycatch of large quantities of juvenile fish.

However, finfish bycatch from the shrimp fishery has a well-established market where it is retained and sold from trawlers to small-scale canoe operators. These operators sell the bycatch to onshore buyers (mostly women) who, in turn, dry and smoke the fish for sale at local and regional markets. This multi-layered sector (termed the "buyemsellum" sector) provides significant seafood protein to a large number of people who are often unable to find sufficient protein to meet their dietary

needs. The use of BRD in to these fisheries is effectively reducing the bycatch available for local consumption. The current fisheries challenge in Nigeria, therefore, is to resolve this issue. Options for identifying alternative sources of seafood and new employment possibilities are now being investigated.

Madagascar currently has a very well managed shrimp trawl fishery, with no buyemsellum sector and significant use of bycatch reduction technologies, under drivers that include the shrimp import requirements of the EU and a desire to achieve Marine Stewardship Council certification. The priorities for Madagascar's trawlers are to improve the performance of the BRDs currently used so that they release more discards while increasing the retention of shrimp. Quite straightforward modifications (that have been developed elsewhere) to the gears currently used are being examined to assist with these priorities. It should also be noted that there is strong growth in the aquaculture industry in Madagascar, which brings with it the need for fish meal. As for Asian countries, increasing the utilisation of bycatch for aquaculture feed will increase its value and reduce discards.

The Cameroon trawl sector is characterized by little formal fisheries management, no implementation of sustainable fishing practices, and no pressing drive to improve fishing methods due to export requirements (most of the targeted shrimp is not exported to Europe). There is also a significant buyemsellum sector that, as in Nigeria, complicates the perceived need to reduce bycatches with the need to provide fish for undernourished people. The current challenges for this fishery therefore encompass most aspects of fisheries management, especially implementation of effective MCS, a programme to quantify and then mitigate bycatch issues, and identifying ways to manage the buyemsellum sector.

In Africa is an overarching need for an "awareness and enlightenment" campaign to educate the public and key stakeholders about the need for sustainable fisheries management, conservation of resources and effective use of fishing practices. The negative consequences of reducing access to important sources of protein and micro-nutrients for the local people must be recognized, however and the ecosystem consequences of reducing bycatch (or lack thereof) is also an important consideration (Garcia et al. 2012; Kolding and van Zwieten 2011).

### **1.3 Discussion: What Makes a Discard Mitigation Policy Work?**

The variety of the described cases highlights that there is no single or simple answer to the question of what makes a discard policy work. Thus, what works in one fishery or region may not be suitable elsewhere. For example, a policy to reduce unwanted catch through selectivity improvements in countries such as Nigeria or Cameroon may conflict with local food security needs. This situation is very different to northern European fisheries, for example, with high discard rates of undersized fish of low market value. Accordingly, we have split the discussion of the cases

we have described into two categories. The first category covers fisheries where discard rates are, or were, high and where there has been an emphasis on the reduction of UWC. The second category includes fisheries where discard rates are low, because most catches have value.

### ***1.3.1 Fisheries with a Focus on Reducing Unwanted Catches***

In this category we have included Norway, Iceland, the US, Argentina, Chile, Australia and New Zealand. Most of the discard policies in this category are highly complex. Each of these examples includes measures to reduce UWC, including selectivity improvements, various spatial measures, quota related measures and economic incentives. In addition, most the policies include monitoring and control measures and improved utilisation. A similar range of measures is being used to implement these discard policies regardless of whether the policy is defined as a discard ban (Norway, Iceland, Argentina, Chile and New Zealand) or as a policy aimed at achieving discard reduction (US and Australia).

The term “discard ban” suggests elimination of all discards. However, none of the discard bans currently in place (or under implementation) prohibit all discarding (Borges et al. 2016). Instead, they focus on specific components of the catch and exemptions apply (e.g. those with high chance of survival if released, those designated as endangered or threatened species). Moreover, there are no examples of simple discard bans, with Chile’s first and unsuccessful discard policy representing a possible exception.

In some of the cases there has been a gradual evolution from a specific discard-related issue, such as high-grading of cod in Norway, towards a more comprehensive discard policy. In Iceland and Norway, for instance, the achievement of discard rate reductions and mindset changes regarding the wastefulness of discarding required periods of 30–40 years to achieve. The US walleye pollock fishery is an exception in that regard as discard rates were reduced rapidly, perhaps due to the initial requirement for full observer coverage. This case is possibly the most demonstrably successful discard policy described here. Furthermore, some countries (e.g., Norway, Iceland, USA and Chile) stress stakeholder involvement as an essential aspect of their discard policies. This may include aspects such as: consultative processes with the regulatory authorities, modification of regulations based on stakeholder feedback and initiatives for implementing selective technical measures (i.e., increased quota/access to closed areas).

An important component of many discard reduction strategies is the use of more selective fishing gears which may also be associated with temporal and spatial closures to reduce UWC (see Bellido et al., [this volume](#); O’Neill et al., [this volume](#); Reid et al., [this volume](#)).

TAC management, often together with individual quota allocations (or allocations to groups or cooperatives) predominates in the fisheries in this category. Accordingly, policy initiatives to address discarding often feature changes

in the arrangements for implementing and allocating quotas. Quota related measures are, in most cases, a fundamental element of the overall discard policy and are generally considered to at least partially remove incentives for discarding. This issue is complex because inflexible quota management systems can cause or exacerbate choke species problems, while quota management programmes, which allocate quota to individuals and or groups of fishers and include mechanisms for transfer or leasing, can help reduce choke species effects and related discarding (Poos 2015). However, assessing the contribution of quota-based measures to the overall effectiveness of discard policies in isolation from the other policy elements is difficult. In New Zealand, the move to ITQs created an increase in discarding of legally sized fish and whether that situation has improved is difficult to ascertain due to a lack of accurate discarding data.

For a number of the cases examined, increased utilisation has occurred as a means of reducing UWC when it cannot be avoided completely. In both Iceland and Norway, the utilisation initiatives include viscera and other processing waste generated at sea (e.g., Richardsen et al. 2017).

Within fisheries focused on discard reduction, perhaps the greatest divergence in approach concerns accountability and compliance monitoring. Accountability in the context of discard restrictions or prohibitions is problematic. While it is relatively straightforward to estimate and verify the retained or landed catch, estimation and verification of discards is difficult (See Chap. 13). At-sea observers provide the data necessary for discard estimation, but observer programmes are expensive, and fishers may behave differently when observed, which can result in biased discard estimates (Benoît and Allard 2009). Technological approaches such as EM can be effective, especially for compliance purposes when discards are prohibited (and may also be an effective means of directly estimating catch and discard for certain gear types). Self-reporting of discards by vessel operators is generally considered unreliable (Kraan et al. 2013) unless verified by observers, EM or some other method (Plet-Hansen et al. 2017).

The US walleye pollock fishery stands out from the other cases described here due to its comprehensive accountability measures. This fishery requires a sufficient observer coverage to ensure that all hauls are monitored (one or two observers per vessel), which not only provides confidence that vessels are compliant, but also ensures data quality that may be lacking in other countries and fisheries (Stanley et al. 2011). The other cases have less stringent observer coverage or other forms of monitoring; although some, such as Norway and Iceland, feature significant penalties for non-compliance. It remains to be seen how the new discard regime in Chile, which requires EM on board all vessels over 15 m by 2020, will affect compliance levels and data quality. A similar question applies to the planned implementation of EM in New Zealand fisheries.

One of the striking findings of this comparative analysis is that discard data quality appears to be problematic in the majority of cases (Borges et al. 2016). This is despite the essential importance of a discard policy in many of the management frameworks described and the data collection resources available. Several issues arise from this, not least that it makes the task of determining whether a

discard policy works or not significantly more difficult. At least one of the cases, the first iteration of Chile's discard policy, provides evidence that an overly rigid and punitive discard ban can have a negative impact on data provision and compliance.

### ***1.3.2 High Utilisation Fisheries***

In many African and Asian fisheries, a local demand exists for non-targeted fish, which serves an important role by contributing to human nutrition and animal feed. In such cases, discards are low due to high utilisation levels. Accordingly, discarding becomes less of an issue than whether the fishery is sustainable. Improvements in selectivity in such fisheries would have a negative impact on important local supplies of fish protein. Of the five cases described in this category, only India has a regulatory discard ban which, however, has not been effectively implemented.

Although there is not a general management interest in improving selectivity in these fisheries, there remains concern over the capture and mortality of threatened, endangered or protected species. These may be encountered frequently in the tropical waters of Africa and Asia where, like elsewhere, retention is usually illegal. The use of bycatch reduction devices (BRDs) in these fisheries is uncommon and generally occurs where the target species is destined for export (Kennelly 2014).

## **1.4 Lessons Learned**

Reducing or eliminating discards is a public policy priority in some regions although this is not always the case. For example, very high utilisation rates can be seen in many small-scale and artisanal fisheries and some industrial fisheries, such as those for fish meal and oil. Furthermore, there is much debate in the literature regarding the factors which lead to high levels of discarding, and the costs and benefits (in economic and ecosystem contexts) of improving selectivity and avoidance compared with increasing utilisation.

In fisheries with a focus on reducing UWC, policy makers seek to implement changes through a mixture of measures which include improved utilisation as well as avoidance and improved selectivity. To some extent, we can draw from these examples and experiences to better understand and mitigate problems associated with implementation of the LO.

The LO constitutes a far-reaching change in EU fisheries policy which impacts, or will impact, fishers and stakeholders throughout Europe (Condie et al. 2014). Yet the goals and implementation process are poorly understood, and legitimacy of this policy has been questioned by many fishers, which tends to impede the implementation process (de Vos et al. 2016). Success in implementing policies to reduce discards is generally easier to achieve if fishers and other stakeholders are involved in the formulation and implementation of policies. From our case studies, we can see

examples of good and poor communication of goals, and the extent to which formulation and implementation is guided by a participatory process and how these have impeded or facilitated success. For example, under the initial Chilean discard ban a top-down regulatory approach was employed with no accountability or enforcement; this resulted in an ineffective policy. During reformulation of the Chilean discard ban, fishers and stakeholders played a substantial role in policy development and in implementation through research and drafting of discard mitigation plans together with the high mandatory monitoring levels. The new programme is better understood and accepted, and initial indications suggest a strong likelihood of success. The US programmes for increased utilisation and avoidance of salmon bycatch in the walleye pollock fishery involved a great deal of participation by fishers and stakeholders that resulted in policies which were well-understood and implemented successfully.

Effective Monitoring, Control and Surveillance (MCS) are difficult to achieve and poor MCS may render regulations ineffective. This has certainly been the case in New Zealand and Argentina and under the first iteration of the Chilean programme. MCS in Iceland and Norway has also been limited and this makes verification of programme effectiveness difficult, if not impossible. It should be noted, however, that moving towards industry and stakeholder recognition of the importance of reducing discards and developing a culture of compliance is integral to the long-term strategies employed by Iceland and Norway. In addition, poor or inadequate monitoring can make it difficult or impossible to evaluate the effectiveness of a discard reduction (or elimination) programme. In some parts of the world, MCS is entirely independent of observer coverage because observers focus entirely on scientific data collection. MCS is effective in the US walleye pollock fishery so that compliance is high, and accountability is fully documented (note that industry pays for observer coverage in this fishery). In this fishery much of the compliance monitoring is carried out by observers. In the US and elsewhere EM is beginning to be used as a compliance monitoring tool and has been shown to be effective in some instances. Regardless, an effective discard policy must have adequate MCS as well as at-sea monitoring through observers and/or EM. This is necessary to ensure the accuracy of catch and discard data.

Requirements for reducing or eliminating discards work best as part of a broader fisheries management policy that integrates regulatory measures to address an overarching goal. This can be seen in the Norwegian DBP which is comprised of a suite of regulatory and technical measures to minimise unwanted catch, including: the regulatory discard ban; gear selectivity technical measures; closed areas; and MCS measures. Elements of a more comprehensive and integrated approach can be found elsewhere such as the broad guidance to minimise discards in the US and in the Chilean and Icelandic approaches. However, the EU LO was intended to be an all-inclusive measure to eliminate unwanted catch and this will be more difficult to implement.

Integration of discard reduction policies within a broader strategy also requires a measured, adaptive approach such as occurred in Iceland and Norway, and to some extent in Chile. This facilitates alignment of the policy with industry incentives and

fostering a culture of compliance and allows for incremental improvements in the overall programme over time. The EU LO was originally conceived to be fully effective after a relatively brief phase-in period (2014–2019), which therefore could have undermined its effectiveness. However, its implementation through multi-annual plans and discard plans could enable the adaptive, incremental and case-specific approaches seen as favourable characteristics in some of the case-studies reviewed here.

Also related to the need for a broader and more comprehensive, strategic approach is the issue of governance as it relates to quota management. Quota management programmes that provide for individual or group (co-operative) ownership or leasing of quota, such as those that occur in US, Iceland and New Zealand, allow fishers to manage and trade quotas so as to avoid or minimise choke species problems which often result in discarding. In Europe, national quota management regimes can differ but how they may be adapted to cope with the challenges of the landing obligation is beyond the scope of this chapter. They may also allow for improved efficiencies in fishing operations which can facilitate change in operations and uptake of innovative technologies. Furthermore, flexibilities in these types of quota management programmes can make it easier for fishers to carry-over small amounts of quota across fishing years, or deduct overages from the next year's allocation. These types of mechanisms greatly enhance the ability of the fleet and individual fishers to adapt to regulatory change such as discard restrictions. Such opportunities are not currently available to all EU fishers working under the CFP although flexibility is allowed in some countries such as Denmark and the Netherlands.

A successful discard policy requires careful balancing of top-down factors such as legislative requirements and effective controls with bottom-up factors including participation, stakeholder acceptance and cultural attitudes towards compliance. The cases we have described have balanced these aspects differently, with some taking a long-term approach emphasising a gradual development of a low discard mindset and less restrictive and rigorous controls. Others have focussed on strong controls, while attempting to retain stakeholder support, in an effort to achieve positive results over a shorter timeframe. With the exception of India, the high utilisation fisheries described have not established discard policies and discard levels are low because utilisation, especially for human consumption, is high. Balance among the factors described above will differ within Europe due to the diversity and complexity of European fisheries and will most likely include aspects of all the approaches described in this chapter.

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## References

- Bellido, J.M., Paradinas, I., Vilela, R., Bas, G., Grazia Pennino, M. (this volume). A marine spatial planning approach to minimize discards: Challenges and opportunities of the Landing Obligation in European waters. In S.S. Uhlmann, C. Ulrich, S.J. Kennelly (Eds.), *The European Landing Obligation – Reducing discards in complex, multi-species and multi-jurisdictional fisheries*. Cham: Springer.
- Benoit H.P., & Allard J. (2009). Can the data from at-sea observer surveys be used to make general inferences about catch composition and discards? *Canadian Journal of Fisheries and Aquatic Sciences*, 66, 2025–2039. <https://doi.org/10.1139/f09-116>.
- Borges, L., Cocas, L., Nielsen, K. (2016). Discard ban and balanced harvest: A contradiction? *ICES Journal of Marine Science*, 73, 1632–1639.
- Breen, M., Isaksen, B., Ona, E., Pedersen, A.O., Pedersen, G., Saltskår, J., et al. (2012). A review of possible mitigation measures for reducing mortality caused by slipping from purse-seine fisheries. ICES CM 2012/C:12.
- Condie, H.M., Grant, A., Catchpole, T.L. (2014). Incentivising selective fishing under a policy to ban discards; lessons from European and global fisheries. *Marine Policy*, 45, 287–292.
- Damalas, D. (2015). Mission impossible: Discard management plans for the EU Mediterranean fisheries under the reformed Common Fisheries Policy. *Fisheries Research*, 165, 96–99.
- de Vos, B.I., Döring, R., Aranda, M., Buisman, F.C., Frangouides, K., Goti, L., et al. (2016). New modes of fisheries governance: Implementation of the landing obligation in four European countries. *Marine Policy*, 64, 1–8.
- European Commission. (2007). Impact assessment of discard policy for specific fisheries. European Commission, Brussels. [https://ec.europa.eu/fisheries/sites/fisheries/files/docs/publications/impact\\_assessment\\_discard\\_policy\\_2007\\_en.pdf](https://ec.europa.eu/fisheries/sites/fisheries/files/docs/publications/impact_assessment_discard_policy_2007_en.pdf)
- European Union. (2013). Regulation (EU) No 1380/2013 of the European Parliament and of the Council of 11 December 2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC. *Official Journal of the European Union*, L354, 22–61.
- FAO. (1996). Report of the technical consultation on reduction of wastage in fisheries. Tokyo, Japan, 28 October – 1 November, 1996. FAO Fisheries Report No. 547, FAO, Rome, p. 27.
- FAO. (2016). The state of world fisheries and aquaculture 2016, p. 200.
- Fiskistofa. (2017). Ársskýrsla 2016. Fiskistofa, Hafnarfjörður, Iceland.
- Fiskistofa. (2018a). Yfirlit yfir VS-afla eftir tegundum. Retrieved from [www.fiskistofa.is](http://www.fiskistofa.is): <http://www.fiskistofa.is/veidar/aflastada/vs-affli/>
- Fiskistofa. (2018b). Undirmál. Retrieved from [www.fiskistofa.is](http://www.fiskistofa.is): [http://www.fiskistofa.is/veidar/aflaupplýsingar/undirmal/undirmal\\_fiskveidiar.jsp](http://www.fiskistofa.is/veidar/aflaupplýsingar/undirmal/undirmal_fiskveidiar.jsp)
- Fiskistofa. (2018c). Um fiskveiðistjórnun. Retrieved from [www.fiskistofa.is](http://www.fiskistofa.is): <http://www.fiskistofa.is/fiskveidistjorn/stjornfiskveida/>
- Fiskistofa. (2018d). Eftirlit á sjó. Retrieved from [www.fiskistofa.is](http://www.fiskistofa.is): <http://www.fiskistofa.is/umfiskistofu/arsskyrsla-2013/efirlit-a-sjo/>
- Fitzpatrick, M., Quetglas, T., Frangouides, K., Triantaphyllidis, G., Nielsen, K.N. (2017). DiscardLess Policy Brief No 2: Year 2 of the Landing Obligation: Key Issues in Mediterranean Fisheries. <https://doi.org/10.5281/zenodo.573666>.
- Garcia, S.E., Kolding, J., Rice, J., Rochet, M.-J., Zhou, S., Arimoto, T., et al. (2012). Reconsidering the consequences of selective fisheries. *Science*, 335, 1045–1047.
- Gezelius, S.S. (2006). Monitoring fishing mortality: Compliance in Norwegian offshore fisheries. *Marine Policy*, 30, 462–469.
- Gilman, E. (2011). Bycatch governance and best practice mitigation technology in global tuna fisheries. *Marine Policy*, 35, 590–609.
- Grimaldo, E., Sistiaga, M., Larsen, R.B. (2014). Development of catch control devices in the Barents Sea cod fishery. *Fisheries Research*, 155, 122–126.

- Gullestad, P., Aglen, A., Bjordal, Å., Blom, G., Johansen, S., Krog, J., et al. (2014). Changing attitudes 1970–2012: Evolution of the Norwegian management framework to prevent overfishing and to secure long-term sustainability. *ICES Journal of Marine Science*, *71* (2), 173–182.
- Gullestad, P., Blom, G., Bakke, G., Bogstad, B. (2015). The “Discard Ban Package”: Experiences in efforts to improve the exploitation patterns in Norwegian fisheries. *Marine Policy*, *54*, 1–9. <https://doi.org/10.1016/j.marpol.2014.09.025>.
- Ianelli, J.M., & Stram, D.L. (2015). Estimating impacts of the pollock fishery bycatch on western Alaska Chinook salmon. *ICES Journal of Marine Science*, *72*, 1159–1172.
- Isaksen, B., Valdemarsen, J.W., Larsen, R., Karlsen, K. (1992). Reduction of fish by-catch in shrimp trawl using a rigid separator grid in the aft belly. *Fisheries Research*, *13*, 335–352.
- Íslandsbanki. (2017). Íslenskur Sjávarútvegur. (2017). Reykjavík: Íslandsbanki. [http://www.hafro.is/Bokasafn/Greinar/fish\\_res\\_59-437.pdf](http://www.hafro.is/Bokasafn/Greinar/fish_res_59-437.pdf)
- Johnsen, P.J., & Eliassen, S. (2011). Solving complex fisheries management problems: What the EU can learn from the Nordic experiences of reduction of discards. *Marine Policy*, *35*, 130–139.
- Karp, W.A., Haflinger, K., Karp, J.G. (2005). Intended and unintended consequences: Fisher responses to bycatch reduction requirements in the Alaska Groundfish Fisheries. CM 2005/V:03. Available online at <http://www.ices.dk/sites/pub/CM%20Documents/2005/V/V0305.pdf>
- Kawarazuka, N., & Béné, C. (2011). The potential role of small fish species in improving micronutrient deficiencies in developing countries: Building evidence. *Public Health and Nutrition*, *14*, 1927–1938.
- Kennelly, S.J. (2014). Solving by-catch problems: Successes in developed countries and challenges for protein-poor countries. *Journal of the Marine Biological Association of India*, *56*, 19–27.
- Kennelly, S.J. (2017). Developing a National Bycatch Reporting System. Final FRDC Report, ISBN 978-0-9924930-5-9, October, 2017.
- Kennelly, S.J., & Broadhurst, M.K. (2002). Bycatch begone: Changes in the philosophy of fishing technology. *Fish and Fisheries*, *3*, 340–355.
- Kolding, J., & van Zwieten, P.A.M. (2011). The tragedy of our legacy: How do global management discourses affect small-scale fisheries in the South? *Forum for Development Studies*, *38*, 267–297.
- Kolding, J., Béné, C., Bavinck, M. (2014). Chapter 22: Small-scale fisheries – Importance, vulnerability, and deficient knowledge. In S. Garcia, J. Rice, A. Charles (Eds.), *Governance for marine fisheries and biodiversity conservation* (Interaction and coevolution, pp. 317–331). Wiley-Blackwell. <https://doi.org/10.1002/9781118392607>.
- Kraan, M., Uhlmann, S., Steenbergen, J., Van Helmond, A.T.M., Van Hoof, L. (2013). The optimal process of self-sampling in fisheries: Lessons learned in the Netherlands. *Journal of Fish Biology*, *83*, 963–973. <https://doi.org/10.1111/jfb.12192>.
- Landhelgisgæslan. (2018). Arsyfirlit 2013. Retrieved from [www.lhg.is](http://www.lhg.is/media/arsskyrslur/LHG_Arsyfirlit_2013_LWR2.pdf): [http://www.lhg.is/media/arsskyrslur/LHG\\_Arsyfirlit\\_2013\\_LWR2.pdf](http://www.lhg.is/media/arsskyrslur/LHG_Arsyfirlit_2013_LWR2.pdf)
- Larsen, R.B., & Isaksen, B. (1993). Size selectivity of rigid sorting grids in bottom trawls for Atlantic cod (*Gadus morhua*) and haddock (*Melanogrammus aeglefinus*). *ICES Marine Science Symposia*, *196*, 178–182.
- Lock, K., & Leslie, S. (2007). *New Zealand's quota management system: A history of the first 20 years* (Motu Working Paper 07–02). Motu Economic and Public Policy Research, p. 75
- Margeirsson, S., Jónsson, G.R., Hrafinkelsson, B., Jensson, P., Arason, S. (2008). Processing forecast of cod. Decision making in the cod industry based on recording and analysis of value chain data. University of Iceland. Reykjavík, Iceland. <http://www.matis.is/media/utgafa/krokur/PhDThesisSveinnMarg.pdf>
- MEFT. (2011). Ley 19713/2001 de 18 de enero de 2001 del Ministerio de Economía, Fomento y Reconstrucción; Subsecretaría de Pesca. Establece como medida de administración el límite máximo de captura por armador a las principales pesquerías industriales nacionales y la

- regularización del registro pesquero artesanal. Diario Oficial de la República de Chile el 25 de enero de 2001. 16 p. <http://www.leychile.cl/Navegar?idNorma=180659>
- MEFT. (2017). Decreto Supremo N°76 de 2015. Aprueba Reglamento del Dispositivo de Registro de Imágenes para Detectar y Registrar el Descarte. <https://www.leychile.cl/Navegar?idNorma=1100026>
- Mills, D.J., Westlund, L., de Graaf, G., Kura, Y., Willmann, R., Kelleher, K. (2011). Under-reported and undervalued: Small-scale fisheries in the developing world. In N.L. Andrew, & R. Pomeroy (Eds.), *Small-scale fisheries management: Frameworks and approaches for the developing world* (pp. 1–15). Wallingford: CABI.
- Ministry of Fisheries. (2018). Frumvarp til laga um breyting á lögum lögum nr. 57/1996, um umgengni um nytjastofna sjávar og lögum nr. 116/2006, um stjórn fiskveiða (rafræn vöktun, eftirlit með vigtun, fjarstýrð loftför o.fl.) og um breyting á lögum nr. 36/1992 um Fiskistofu. Retrieved from <https://www.stjornarradid.is/lisalib/getfile.aspx?itemid=2a0680ae-8056-11e8-942c-005056bc530c>
- Mortensen, L.O., Ulrich, C., Eliassen, S., Olesen, H.J. (2017). Reducing discards without reducing profit: Free gear choice in a Danish result-based management trial. *ICES Journal of Marine Science*, 74, 1469–1479.
- MRAG. (2007). Impact assessment of discard policy for specific fisheries. Studies and Pilot Projects for Carrying Out the Common Fisheries Policy No FISH/2006/17.
- Norwegian Seawater Fisheries Regulations. (2014). Regulations relating to sea-water fisheries. Norwegian Ministry of Fisheries and Coastal Affairs. Amended 7th April 2014. <https://www.fiskeridir.no/.../20140407-regulations-relating-to-sea-water-fisheries.pdf>
- NPFMC. (2016). Bering Sea/Aleutian Islands groundfish fishery management plan amendment action summaries. North Pacific Fishery Management Council. Anchorage, Alaska, p. 23.
- NPFMC. (2017). Stock assessment and fishery evaluation report for the groundfish resources of the Bering Sea/Aleutian Islands regions. North Pacific Fishery Management Council. Anchorage, Alaska.
- O'Neill, F.G., Feekings, J., Fryer, R.J., Fauconnet, L., Afonso, P. (this volume). Discard avoidance by improving fishing gear selectivity: Helping the fishing industry help itself. In S.S. Uhlmann, C. Ulrich, S.J. Kennelly (Eds.), *The European Landing Obligation – Reducing discards in complex, multi-species and multi-jurisdictional fisheries*. Cham: Springer.
- Pálsson, Ó.K. (2003). A length-based analysis of haddock discards in Icelandic fisheries. *Fisheries Research*, 59 437–446. [http://www.hafro.is/Bokasafn/Greinar/fish\\_res\\_59-437.pdf](http://www.hafro.is/Bokasafn/Greinar/fish_res_59-437.pdf).
- Pálsson, Ó.K., Björnsson, H., Gudmundsson, S., Ottesen, Þ. (2015). Mælingar á brottkasti þorsks og ýsu. (2013). Reykjavík: Marine Research Institute. <http://www.hafro.is/Bokasafn/Timarit/fjolrit-183.pdf>
- Plet-Hansen, K.S., Eliassen, S.Q., Mortensen, L.O., Bergsson, H., Olesen, H.J., Ulrich, C. (2017). Remote electronic monitoring and the landing obligation – Some insights into fishers' and fishery inspectors' opinions. *Marine Policy*, 76, 98–106.
- Poos, J.J. (2015). Update of “Delineating catch quotas for Dutch demersal fisheries: A theoretical pilot study.” IMARES Wageningen Research Report number C139/15. Ijmuiden, The Netherlands, p. 19.
- Pramod, G. (2010). Illegal, unreported and unregulated marine fish catches in the Indian exclusive economic zone. Field report, policy and ecosystem restoration in fisheries, Fisheries Centre, University of British Columbia, BC, Vancouver, Canada, p. 30.
- Reid, D.G., Calderwood, J., Afonso, P., Fauconnet, L., Pawlowski, L., Plet-Hansen, K.S., et al. (this volume). The best way to reduce discards is by not catching them! In S.S. Uhlmann, C. Ulrich, S.J. Kennelly (Eds.), *The European Landing Obligation – Reducing discards in complex, multi-species and multi-jurisdictional fisheries*. Cham: Springer.
- Richardsen, R., Nystøyl, R., Strandheim, G., Marthinussen, A. (2017). Analyse marint restråstoff, 2016. SINTEF Report OC2017A-095. ISBN 978-82-7174-286-7. <https://brage.bibsys.no/xmliui/handle/11250/2446152>

- Roos, N., Islam, M.M., Thilsted, S.H. (2003). Small indigenous fish species in Bangladesh: Contribution to vitamin A, calcium and iron intakes. *Journal of Nutrition*, 133, 4021S–4026S.
- RÚV. (2018). Brottkast, ís-svindl og uppgjöf Fiskistofu. Retrieved from <http://www.ruv.is/frett/brottkast-is-svindl-og-uppgjof-fiskistofu>
- Sanchirico, J.N., Holland, D., Quigley, K., Finad, M. (2006). Catch-quota balancing in multispecies individual fishing quotas. *Marine Policy*, 30, 767–785.
- Schrope, M. (2010). What's the catch? *Nature*, 465, 540–542.
- Sernapesca. (2016). Anuarios Estadísticos del Servicio Nacional de Pesca y Acuicultura. [http://sernapesca.cl/index.php?option=com\\_remository&Itemid=246&func=startdown&id=261](http://sernapesca.cl/index.php?option=com_remository&Itemid=246&func=startdown&id=261)
- Sernapesca. (2017). Anuarios Estadísticos del Servicio Nacional de Pesca y Acuicultura. [http://sernapesca.cl/index.php?option=com\\_remository&Itemid=246&func=select&id=2](http://sernapesca.cl/index.php?option=com_remository&Itemid=246&func=select&id=2)
- Stanley, R.D., McElderry, H., Mawani, T., Koolman, J. (2011). The advantages of an audit over a census approach to the review of video imagery in fishery monitoring. *ICES Journal of Marine Science*, 68, 1621–1627. <https://doi.org/10.1093/icesjms/fsr058>.
- Stram, D.L., & Ianelli, J.N. (2015). Evaluating the efficacy of salmon bycatch measures using fishery-dependent data. *ICES Journal of Marine Science*, 72, 1173–1180.
- Subpesca. (2018). Planes de Reducción del descarte y la pesca incidental. <http://www.subpesca.cl/portal/615/w3-propertyvalue-62973.html>
- Telesetsky, A. (2016). *Fishing for the future: Addressing fisheries discards and increasing export value for New Zealand's sustainable fisheries*. Fulbright New Zealand, ISBN 978-0-473-36903-3, p. 128.
- Underwood, M., Engås, A., Rosen, S., Aasen, A. (2014). Excess Fish Exclusion Device (ExFED): How to passively release fish at depth during trawling. In Escape slots in front of a demersal seine codend combined with a new “Fish lock”. In ICES. 2014. First Interim Report of the ICES-FAO Working Group on Fishing Technology and Fish Behaviour (WGFTFB), 5–9 May 2014, New Bedford, USA. ICES CM 2014/SSGESST:08.
- Vigfusson, B., Sandholt, G., Gestsson, H.M., Sigfusson, Þ. (2013). Tveir fyrir einn. Reykjavík: Íslenski sjávarklasinn. [https://issuu.com/sjavarklasinn/docs/tveir\\_fyrir\\_einn\\_fullvinnsla\\_aukaaf](https://issuu.com/sjavarklasinn/docs/tveir_fyrir_einn_fullvinnsla_aukaaf)
- Witherell, D., Pautzke, C., Fluharty, D. (2000). An ecosystem-based approach for Alaska ground-fish fisheries. *ICES Journal of Marine Science*, 57, 771–777.
- World Bank, FAO & World Fish Center. (2012). Hidden harvest: The global contribution of capture fisheries. Report No. 66469-GLB. Washington, DC: World Bank.

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