Life on the Edge
Seabirds and fisheries in Irish waters

BirdWatch Ireland
2016

Hannah Keogh

About the Report

A BirdWatch Ireland Report by the Policy, Communications & People Engagement Team (PCPE). Written and compiled by Sinéad Cummins, Siobhán Egan and Lesley Lewis. Thanks to Stephen Newton and Niall Tierney for their contributions to the case studies.

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Cover photo: Skelligs, Co. Kerry, Mark Carmody.

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Gannet
(M.O'Clery)

Overview

Seabirds are adapted to life on the ocean waves, searching for food, often resting and sleeping and for many, travelling large distances across this maritime landscape is part of their annual life cycle. Generally long-lived and amongst the top predators in marine food webs, they act as good indicators of environmental changes as they rely upon healthy seas to support themselves. All seabirds return to land to breed, where many gather in large numbers to form breeding colonies. Observations at these colonies form the foundation of what we know about seabird biology, answering questions such as how many seabirds attempt breeding each year and how many chicks do pairs rear successfully and how hard must they work to raise those chicks? Research has shown the availability and distribution of fish and other marine organisms are known to be important factors driving seabird distribution and abundance; with seabird survival, breeding success and chick growth all linked to food availability [(1) (2) (3)]. The life history of seabirds is inextricably linked with the seas around us and like coastal communities across the world, many seabirds depend on fish for their survival. Without adequate food, seabirds cannot raise chicks and in some cases, sustain their own life.

This report describes why the seas around Ireland's coast and out beyond the shelf edge are so important for seabirds and their survival. Case studies highlight some of the key challenges and threats to seabird survival. A review of the interactions between fisheries and seabirds is provided and the challenges in ensuring that fisheries management and policy will allow marine systems to recover and provide for the multiple needs of fish, fisheries and marine wildlife into the future.

Finian's Bay, County Kerry (M.O'Clery)

Gannet colony, Little Skellig, County Kerry, (M. O'Clery)

Introduction

As an island nation, we have only recently come to realise the potential value of our ocean resources. Improved technology and market pressures such as the demand for seafood and exploration of energy sources offshore have also produced new and additional ambitions for our seas with social, economic as well as ecological implications. This ambition is reflected in national policies including Harnessing Our Ocean Wealth – An Integrated Marine Plan for Ireland [(4)]. Ireland has a significant marine responsibility in the context of the EU considering its large sea to land ratio (10:1) [(5)]. This presents a significant challenge and responsibility to understanding ocean systems, monitoring activities and managing resources at sea.

The Marine Strategy Framework Directive (2008/56/EC) aims to protect more effectively the marine environment in Europe, providing a basis for an ecosystem-based approach to the management of our seas and human activities which impact on the marine environment, incorporating the concepts of environmental protection and sustainable use. Likewise, global commitments under the United Nations Sustainable Development Goal 14 [(6) (7)] aim to 'conserve and sustainably use the oceans, seas and marine resources for sustainable development'. The Common Fisheries Policy (CFP) [(66)] enshrines an ambition for healthy fish stocks. Despite the ambitions displayed in both national and EU policy-making, our seas are no longer pristine and along with the worrying status of many fish stocks, decision-makers are struggling to live up to these ambitions.

Seabirds and trawler
(Hannah Keogh)


Rockabill Island, Co. Dublin - holds the largest and most important colony of Roseate Tern in Europe, with more than 1,500 pairs (Sinéad Cummins).

Watching over our seas

Seabirds can provide vital clues as to what is happening beyond our horizons, beneath the seas surface, and can act as sentinels of change highlighting a pressure or threat that may otherwise go undetected. Ireland supports a rich maritime biodiversity and heritage located on the Atlantic edge of Europe, with an extensive coastline, many offshore islands and vast marine waters, fed by the Gulf Stream [5]. Supporting some of the most iconic seabird colonies in Europe, seabirds can be found along Ireland's coastline, inshore waters and right out beyond the shelf edge, with many species occurring in numbers of international importance [8] (see Annex 1). Huge seabird cities form on our islands and mainland cliffs in summer, one of nature's great spectacles, with the sights and smells once experienced, never forgotten.

One of the most dramatic seabird colonies in the world – The Skelligs, Co. Kerry (A.Walsh).

Yet many seabirds frequenting our waters are classified as 'vulnerable' or endangered at global or European level [9]. Ireland has 24 breeding species, but obtaining reliable estimates of breeding pairs or attempts for all species is challenging. Information on annual productivity (that is the number of chicks fledged per pair) for some species (i.e. Roseate Tern) is comprehensive (see Case Study 1), but there are large gaps in information for most species e.g. burrow-nesting seabirds.

The degree of flexibility in migratory behaviour of seabirds can affect their ability to adapt to environmental change [10]. Most seabirds undertake long migrations post breeding which is thought to be an adaptation to avoid seasonal deterioration in weather and or scarcity of food resources near colonies post breeding [11]. Given less is known about the non-breeding distribution of Irish seabirds, it is harder to predict what the likely implications of environmental changes such as excessive fishing pressure will have on an ecosystem and on the long-term survival of adult seabirds.

Great Black-backed Gull (Jamie Durrant).

There are nonetheless patterns emerging from recent monitoring of Irish seabird populations [12] that reflect global trends [13]. Seabirds are more threatened globally [14] than any other comparable group of birds with over one quarter of species threatened and five percent of species critically endangered. More local evidence of changes in seabird populations includes declines in numbers of breeding pairs and breeding productivity in species such as Black-legged Kittiwake, Northern Fulmar and Atlantic Puffin at colonies in Ireland and Britain [15] [16] [17] [18] [3] [19] [20]. While the cold waters of the North East Atlantic have been considered amongst the most productive in the world, particularly for cold-loving fish species such as Herring [21], the changes in the availability of preferred forage fish species, particularly in inshore waters, has likely affected both seabird distribution and has had knock-on effects on seabird breeding productivity [22] [23]. Changes in the availability of fish species eaten by seabirds has probably been the biggest driver of these changes [24] [25] [1] [26] [27].

Our naturally biodiverse marine environment supplied by deep water and surface currents, supports high levels of primary productivity [(8)] (i.e. phytoplankton) the building blocks of the marine food web upon which fish, seabirds and many other marine organisms depend. Phytoplankton, and its transition through zooplankton and fish, fuels the second key necessity for seabirds after a safe nesting site – which is an abundant and dependable food supply. In the North Atlantic, Copepod abundance has declined over the past 40 years [(28)].

Ireland's seabirds need healthy seas

Ireland's rugged and diverse coastline, some 7,500km long, and vast marine waters support hundreds of thousands of seabirds (Table 1) with globally important numbers of breeding Manx Shearwater, European Storm-petrel [(8)]. Some seabirds form spectacular breeding colonies (e.g. Northern Gannet, Northern Fulmar, Black-legged Kittiwake) in summer, forming 'high rise' settlements as on Little Skellig (Co. Kerry), with other species preferring to stay underground, literally, in breeding burrows (e.g. Atlantic Puffin) or in crevices (Black Guillemot). Arctic Terns choose to come to our waters to breed and feed in often very localised areas, travelling massive distances across the globe as part of their annual breeding and foraging cycle.

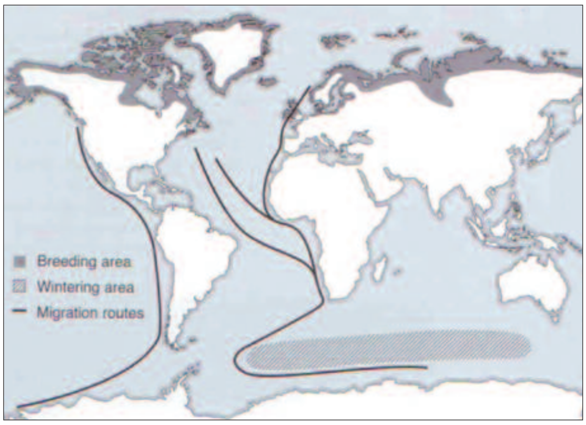

Figure 1. The migration routes of the Arctic Tern which largely breeds in the Arctic circle, and winters in the Antarctic, clocking up a staggering 35,000km round-trip [(29) (30)].

Arctic Tern
(M.O'Clery)

Sooty Shearwater (Anthony McGeehan).

Several specialist seabirds never set foot on mainland Ireland (e.g. Storm Petrel and Leach's Petrel breed on offshore islands mainly along the west and southwest) while others, such as Sooty Shearwater and Cory's Shearwater are passage migrants, yet our seas provide vital food resources that support them through critical parts of their annual globe-trotting journeys.

An abundant food supply is most important during the breeding season, when seabirds need access to a healthy food resource (i.e. fish) within a 'reasonable' commuting distance of their colony to provision their chicks.

Our seabird populations have a wide range of biological needs and each species has a unique association with the marine environment on which it depends for foraging and/or navigation to wintering grounds or breeding colonies. Fish are integral to the life cycle of most seabirds making up a large component of their diet, with some species also feeding on non-fish prey such as squid, copepods (small crustaceans) and plankton. In summer, shimmering shoals of sandeels lie beneath the surface of the sea, with seabirds such as Black-legged Kittiwakes and terns hovering above the waves before diving to consume their silvery prey. The energetic requirements of our seabirds during summer and winter are largely known, and as one would expect, species like Northern Gannet having much larger energetic requirements than Arctic Terns, for example, requiring over a kilo (1359g) of food a day in summer compared to 83g for the Arctic Tern [31]. Gulls are considered generalist omnivores, also feeding on marine invertebrates and terrestrial prey [32]. Species such as Black-headed Gull (Red-listed in Ireland) [33] highlight that despite their dietary preferences, these birds are vulnerable to negative environmental changes.

Table 1. Regularly-occurring breeding seabirds in Irish waters. Included information on their abundance[1], nesting and dietary preferences and biogeographical importance (maximum % of the relevant biogeographical population that the Irish population represents) (largely based on Seabird 2000 data [(2)]). Note it is difficult to sample diet of seabirds at sea, with the majority of studies on seabird feeding ecology limited to studies at or near breeding colonies [(34)].

Species	Nesting Habitat Preference	Fish mainly eaten	Number of breeding pairs (max.)	Biogeo-graphical Importance %
Northern Fulmar *Fulmarus glacialis* 	Cliff nesting	Sandeels, offal	39,000	1.4
Manx Shearwater *Puffinus puffinus* 	Burrow-nesting	Herring, sardines, sprats	37,000	17.9
European Storm Petrel *Hydrobates pelagicus* 	Burrow-nesting	Small fish e.g. lantern fish, occasionally offal	128,00	42.7
Leach's Storm Petrel *Oceanodroma leucorhoa* 	Burrow-nesting	Small fish e.g. lantern fish	310	0
Northern Gannet *Morus bassanus* 	Cliff nesting	Includes mackerel, horse mackerel, herring, haddock, Atlantic cod & offal	50,000*	8.5
Great Cormorant *Phalacrocorax carbo* 	Cliff nesting, rocky crevices & trees	Capelin, flounder, eels, wrasse	5,200	10
European Shag *Phalacrocorax aristotelis* 	Cliff nesting & rocky crevices	Sandeels, whiting, cod, sprat	3,700	5.6
Atlantic Puffin *Fratercula arctica* 	Burrow-nesting	Sandeels, herring, hake, sprats, capelin	21,000	0.4
Black Guillemot *Cepphus grylle* 	Rocky crevices	Sandeels, flatfish, Gadoids	4,500 ind.	1.7

[1]Number of breeding pairs.
* based on recent Gannet Census 2014 (Unpublished BWI Report to NPWS)

Species	Nesting Habitat Preference	Fish mainly eaten	Number of breeding pairs (max.)	Biogeo-graphical Importance %
Razorbill *Alca torda* 	Cliff nesting	Sandeels, sprats, herring	35,000	6.6
Common Guillemot *Uria aalge* 	Cliff nesting	Sandeels, sprats	236,000 ind.	5.7
Little Tern *Sterna albifrons* 	Ground-nesting	Sandeels, sprats	210	1.2
Sandwich Tern *Sterna sandvicencis* 	Ground-nesting	Sandeels, sprats	3,700	5.4
Common Tern *Sterna hirundo* 	Ground-nesting	Sandeels, sprats	4,200	1.9
Roseate Tern *Sterna dougallii* 	Ground-nesting	Sandeels, sprats, herring	1,500*	38.8
Arctic Tern *Sterna paradisaea* 	Ground-nesting	Sandeels, sprats	3,500	0.7
Kittiwake *Rissa tridactyla* 	Cliff nesting	Sandeels, herring	49,000	2
Black-headed Gull *Chroicocephalus ridibundus* 	Ground-nesting	Discards, Clupeidae	14,000	0.7
Mediterranean Gull *Larus melanocephalus* 	Ground-nesting	Discards, sandeels, sprats	5	0.1
Common Gull *Larus canus* 	Ground-nesting	Discards, sandeels, sprats	1,600	0.4
Lesser Black-backed Gull *Larus fuscus* 	Ground-nesting	Discards, cod (W. of Scotland), herring	4,800	2.7
Herring Gull *Larus argentatus* 	Ground-nesting	Discards, cod (W. of Scotland)	6,500	0.9
Great Black-backed Gull *Larus marinus* 	Ground-nesting	Discards, herring (W. of Scotland/ Ireland)	2,300	2.2

* Burke *et al.* 2016 [74].

Most seabirds feed upon small, shoaling, lipid-rich pelagic fish that occur in the upper to mid water column [34]. Seabirds employ different strategies to catch fish [34], from the plunge-diving of the Northern Gannet from a height of tens of metres above the water, to shallow plunges used by terns and gulls, the pursuit-plunging of shearwaters and Northern Fulmars and the pursuit-diving of the auks [21]. Some, such as Black-legged Kittiwakes, gulls, terns and European Storm-petrels dip and patter across the ocean surface while in flight feeding on items such as zooplankton, small fish and squid. The scavenging of kleptoparasitic (i.e. pirate) species, such as skuas and large gulls, target the freshly-fished or regurgitated offerings of harassed Northern Gannets, Black-legged Kittiwakes, terns, auks, shearwaters and, in some cases, other kleptoparasites [35]. Certain offshore and inshore seabird species, such as Northern Fulmars, Northern Gannet, Great Skuas and gulls, also scavenge fishing discards [36] [37] [38] [39].

Food availability has been shown to be a good indication for the at-sea distribution of seabirds [3] [11]. Seabird research has tended to focus on colony-based studies in the past; particularly given they can be easily accessed during the breeding season [16]. The arrival of individual-based tracking technology (initially deployed on larger seabird species) has provided valuable information on the movements and foraging behaviour of seabirds away from their breeding colonies [11] [40] [41]. Seabird distribution and abundance are also indirectly influenced by factors that cause variation in prey abundance such as environmental and oceanic conditions, sea temperature [42], regional climate variability (e.g. North Atlantic oscillations), climate change [5] [43] and fishing pressure [15] [44]. The seabird community in our waters is largely made up breeding species at the southern edge of their range [8].

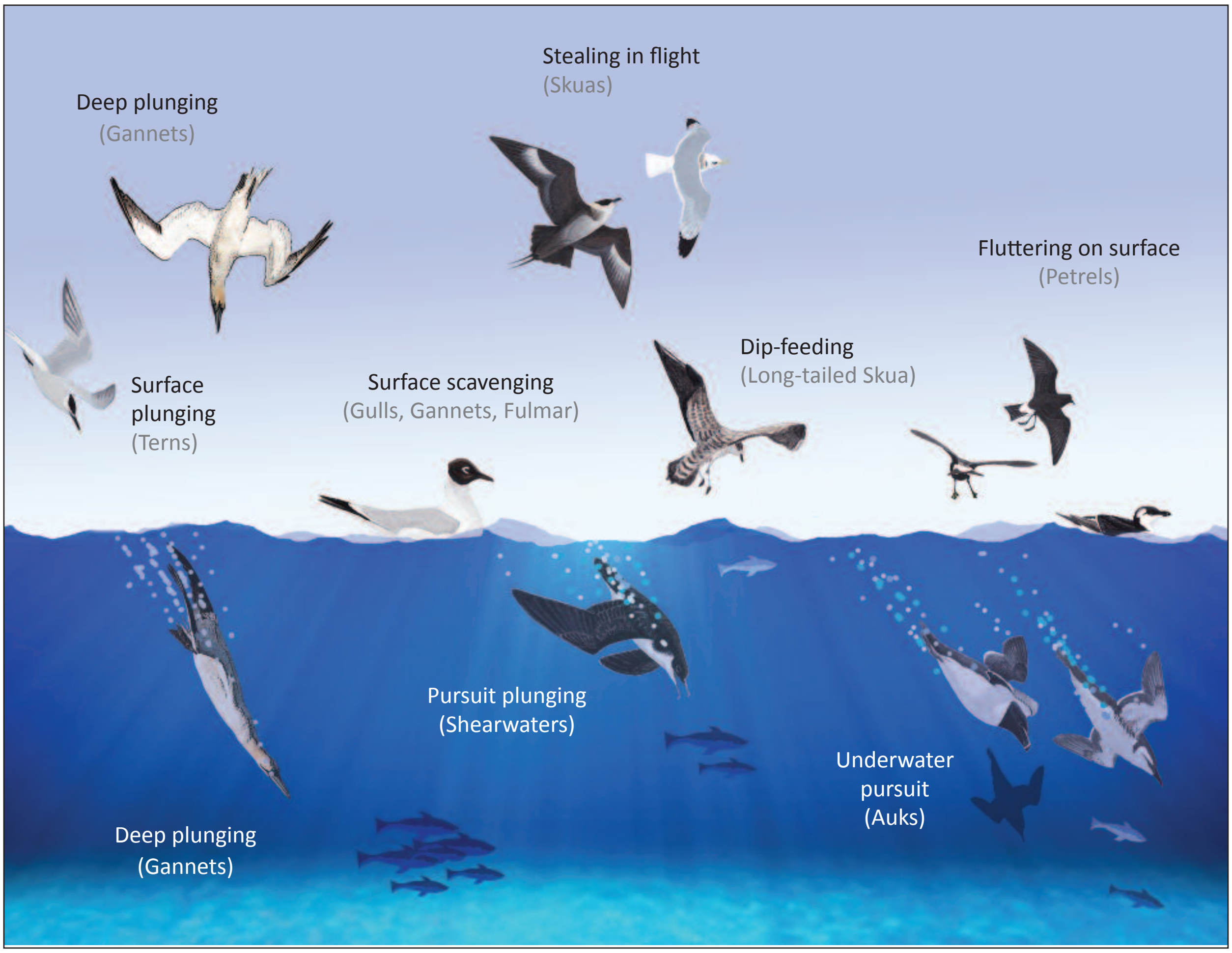

Figure 2. Feeding methods of Irish seabirds.

Seabirds are often divided into two groupings according to their feeding ecology: inshore feeders (e.g. gulls, terns, cormorants) and offshore feeders (e.g. shearwaters and petrels). Inshore feeders breed mainly on land or on islands close to land and tend to have more than one chick that can be provisioned by multiple foraging trips away from the breeding colony. In contrast, the single chick produced by offshore (pelagic) species such as the European Storm-petrel, grows slowly and has a low metabolic rate related to the intermittent feeds it receives [44].

Seabirds are generally long-lived species, usually with delayed breeding and low reproductive output (typically less than 0.5 chicks reared per pair per year) and so, factors which influence adult survival will strongly influence population dynamics [45]. Environmental changes which affect breeding productivity may initially have a lesser impact, only becoming evident after a considerable time lag [45].

Trawler (Hannah Keogh).

A closer look at Irish fisheries

Making up almost 16% of the total extent of EU waters, Ireland's natural marine habitats and fish communities dictate that fisheries are 'mixed', with multiple species sharing the same areas, and are comprised of deep water, demersal, pelagic and shellfish species. Fish and shellfish are mainly landed at five ports (Killybegs, Castletownbere, Howth, Rossaveal and Dunmore East) and at an additional 40 secondary ports and 80 or so piers [46].

On any given day, more than 1,000 fishing vessels are actively catching fish in the seas around Ireland with most of the seabed around our coasts trawled at least once per year, and in some regions more than 10 times a year [47]. Fisheries in Irish waters are diverse, with many different techniques employed (eight main groups which include demersal otter trawls, beam trawls, demersal seines, gill and trammel-nets, longlines, dredges, pots and pelagic trawls) depending on the target species with most fish landed by Irish Vessels at least, being horse mackerel and mackerel, along with blue whiting, hake and herring [48]. The range of species caught in the waters of the continental shelf (up to 200m depth) include *Nephrops* (prawns), cod, haddock, whiting, megrim, plaice, black sole, herring and boarfish. Shelf edge species include anglerfish and hake with mackerel and horse mackerel caught on migration to the shelf edge to spawn [48].

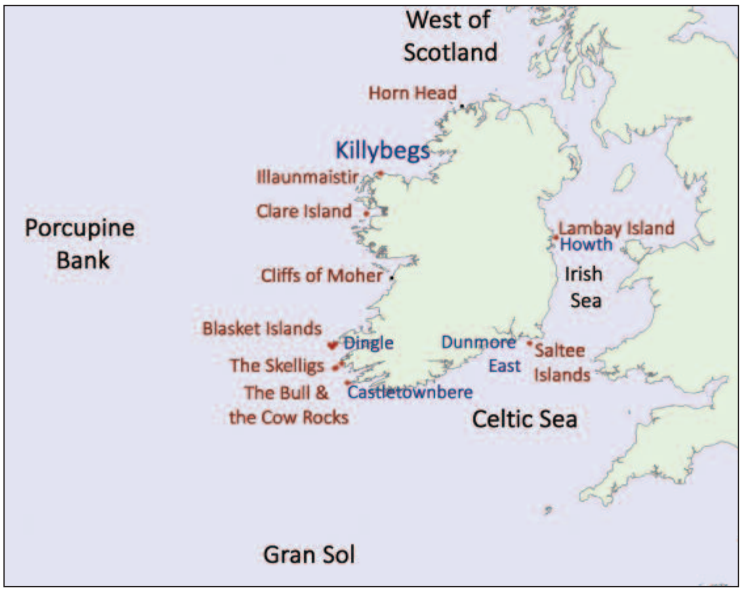

Figure 3. Location of main fishing ports (blue), fishing grounds (black) and major seabird colonies (red) in Irish waters

Trawler landing a catch (Hannah Keogh).

In 2015, the contribution of the seafood industry in Ireland to national income was estimated by BIM at almost €1 billion and the industry employs 11,000 people mainly in coastal counties with over 2,000 registered fishing vessels [49]. The latest published information from the Sea Fisheries Protection Agency in Ireland [50] (based on the 2014 figures as the 2015 report is not yet available) indicates the total value of landings to Irish ports is approximately €346 million, with Irish vessels accounting for 88% of landings to Irish Ports (an estimated value of €241 million). Pelagic species accounted for 71% of all fish landed and 35% of their value, with demersal species representing 38% of the total value of species landed into Irish Ports. Historically, the most important species contributing to total marine fish landings by weight in Ireland have been pelagic species such as Atlantic mackerel, Atlantic herring and more recently, Atlantic horse mackerel and blue whiting [51]. Atlantic mackerel is the most important pelagic species caught, accounting for 88,708 tonnes (for >10m vessels) with an estimated landed value of €49 million [49]. Demersal species including *Nephrops*, whiting, cod, haddock and plaice have also contributed significantly to landings with *Nephrops* by far the most lucrative with an estimated landed value of €49 million for 8,282 tonnes in landings.

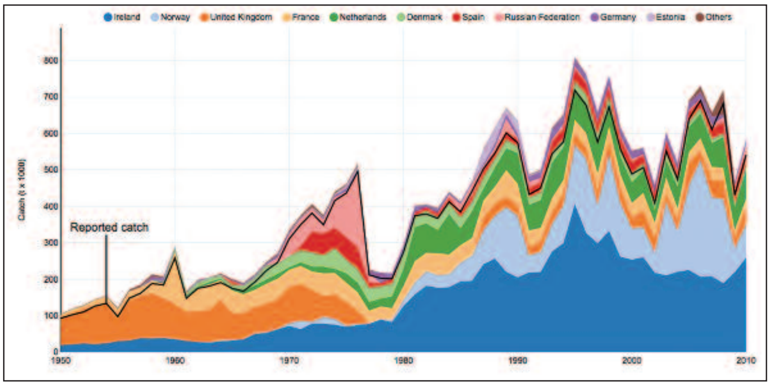

Figure 4. Total catches in the Irish EEZ by all vessels
(Sea Around us Project http://www.seaaroundus.org/).

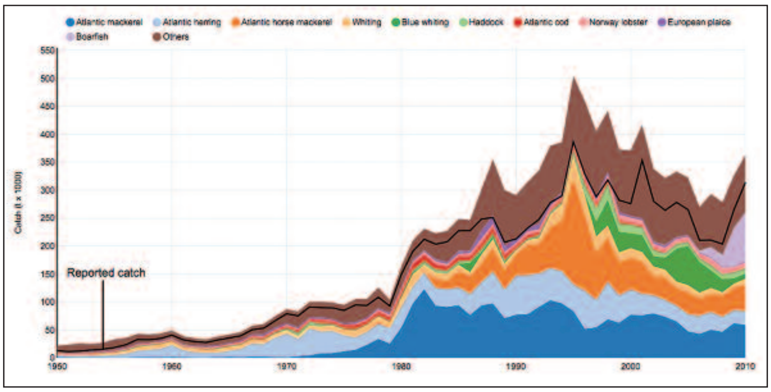

Figure 5. Catches by Taxon by the fleets of Ireland
(Sea Around us Project http://www.seaaroundus.org/).

Note: The data presented here ('reconstructed data') combine official reported data and reconstructed estimates of unreported data (including major discards), with reference to individual EEZs. Official reported data are mainly extracted from the Food and Agriculture Organization of the United Nations (FAO) FishStat database. The "Reported catch" line overlaid on the catch graph represent all catches deemed reported (including foreign) and allocated to this spatial entity. For background information on the reconstruction data, download the .pdf file for the specific EEZ(s) from 'http://www.seaaroundus.org/.

Irish Landings include the following fish species

Deepwater (Orange roughy; Siki)

Demersal (Brill; Cod; Dogfish; Dover sole; Haddock; Hake; John Dory; Lemon sole; Ling; Megrim; Monk/angler; Plaice; Ray/skate; Saithe; Turbot; White pollock; Whiting; Witch; other demersal);

Pelagic (Blue whiting; Pilchard; Herring; Horse mackerel; Mackerel; Sprat; Tuna; other pelagic);

Shellfish (Blue mussel; Crab; Crawfish; Dublin Bay prawns; Escallop; Lobster; Periwinkle; Prawn tails; Shrimp; Squid; Whelk; other shellfish).

The Stock Book

The North East Atlantic and adjacent waters include the Irish Sea, Celtic Sea, North Sea, Baltic Sea, Skagerrak, Kattegat, West of Scotland Sea. Here, catches of fish are largely determined through total allowable catches (TACs) or landings that are negotiated as national quotas. These set limits on the amount of fish that can be caught and landed. Th Irish Stock Book [(52)] provides the evidence of overfishing along with government documents (e.g. the Irish Government's response [(53)] to the Commission's Green Paper [(54)] on the reform of the Common Fisheries Policy (Department of Agriculture, Fisheries and Food), reports from European institutions as well as the Non-government Organisations (NGO) sector [(55)]. Scientific information on the state of most stocks is largely provided by the International Council for the Exploration of the Sea (ICES) who recommend maximum catch levels. However, fisheries ministers have a long history of not listening to the advice given [(56)]. Of the 72 fish stocks covered by the Irish Stock Book i.e. the fishing opportunities published for 2016, Ireland allowed fishing for 19 stocks (26% in terms of total tonnage) above sustainable levels (FMSY) [(57)] with a further 27 (37.5%) stocks with no or limited data on sustainability in the longer term. Ireland was top of the league table in setting excess TAC followed by Spain (24%), Sweden (23%) and the UK (18%).

Overfishing continues despite examples of declines in stocks such as Irish Sea cod [(58)], which by 1999 were so low that ICES (the International Council for the Exploration of the Sea) advised that the stock was in danger of collapse, and recommended that a recovery plan be put in place [(59)]. This and other whitefish stocks (e.g. whiting, sole) in the Irish Sea remain with zero catch advice from ICES, the international body giving advice on fishing limits [(52)]. Stocks of cod in the Irish Sea have declined by ten-fold in terms of spawning stock biomass (SSB) over the last 30 years with below average recruitment for over two decades [(58)]. Studies have shown the SSB of Irish Sea Cod has a negative relationship with recruitment success in times of high and low SSB [(58) (60)].

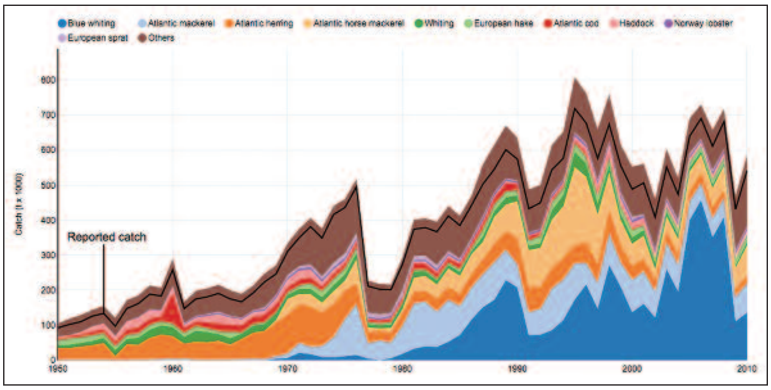

Figure 6. Catches by Taxon in the waters of Ireland
(Sea Around us Project http://www.seaaroundus.org/).

Note: The data presented here ('reconstructed data') combine official reported data and reconstructed estimates of unreported data (including major discards), with reference to individual EEZs. Official reported data are mainly extracted from the Food and Agriculture Organization of the United Nations (FAO) FishStat database. The "Reported catch" line overlaid on the catch graph represent all catches deemed reported (including foreign) and allocated to this spatial entity. For background information on the reconstruction data, download the .pdf file for the specific EEZ(s) from 'http://www.seaaroundus.org/'

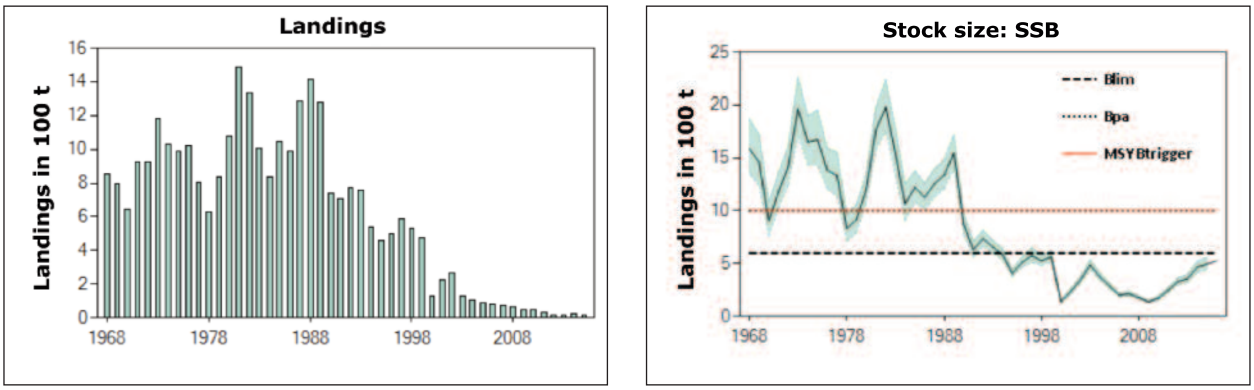

Figure 7. Latest ICES data [(61)] on landings and spawning stock biomass (SSB) of cod in the Irish Sea.

Note: SSB is currently below MSY $B_{trigger}$ and B_{pa} , the precautionary reference point for SSB.

Since 2000, a closed area has been established as part of the Irish Sea cod recovery plan [58]. The crash in cod populations has allowed the growth of a lucrative fishery for *Nephrops* i.e. prawns (cod prey on *Nephrops*). Less is known about the impact of the collapse of the cod fishery on sandeels which are not a species included in Council negotiations. However, cod and haddock are the main choke species for both *Nephrops* and mixed demersal whitefish vessels in the Irish Sea. In determining the allocating of fishing opportunities in Irish waters the increased quotas for Nephrops in the Irish Sea come at the expense of whitefish 'choke' species where quota has been negotiated upwards despite scientific advice from ICES for a reduced or zero TAC for cod as recommended for 2017 [62]. Despite concerns over the ecological status of these whitefish species in the Irish Sea, Ireland has ignored the scientific advice so as not to curtail the lucrative *Nephrops* (prawn) fishery.

Looking back at the 2016 Council of Ministers, Ireland increased the TAC for Irish Sea haddock by almost three times the advised landings, and added an additional quota to take account of the Landing Obligation (LO) [63] despite scientific advice to cut the TAC by half. By 2019 the reformed CFP requires EU fishermen to retain virtually all commercial catches. The fish must be kept on board, landed and counted against their total quota. This regulation will be phased in gradually between 2015 and 2019 to give fishermen time to adjust to it. The landing obligation poses several challenges to the Irish fleet particularly in the demersal mixed fisheries fleet segment including the requirements to land undersize quota species and cessation of fishing activity once the quota for the first individual TAC species is exhausted (choking) [64].

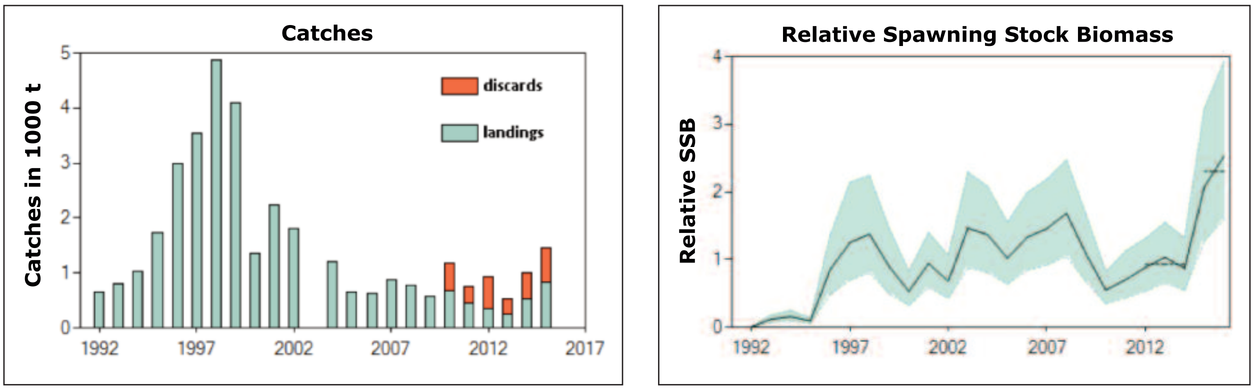

Figure 8. Latest ICES data [61] on catches and relative SSB of haddock in the Irish Sea.

Quota for southern Celtic Seas haddock has been consistently set more than advice [52] [62] despite the lack of evidence to show that selectivity measures are effective for haddock [65]. Such actions come at the expense of the health and recovery of other depleted stocks in the Celtic Seas including cod and blue whiting for which higher quotas continue to be set despite the scientific advice from ICES [62].

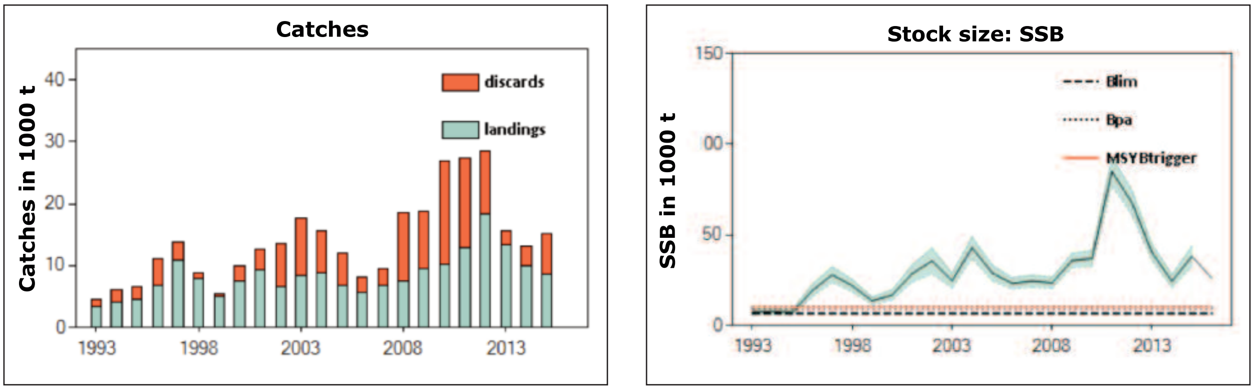

Figure 9. Latest ICES data on SSB and catches of haddock in the Celtic Sea.

Note: Bpa is the precautionary reference point for SSB. Stock currently above MSY $B_{trigger}$.

Benefits of sustainable fisheries

The reformed CFP aims to restore and maintain the health of fish stocks [66] [67]. The reform (carried out in part under the 2013 Irish EU Presidency) followed decades of fisheries mismanagement. The current challenge however is to ensure the effective implementation of the new reform. Despite having agreed to, and made some progress towards, phasing out overfishing by 2015 where possible and by 2020 at the latest, EU fisheries ministers have recently again increased the level of overfishing [67]. A recent report by the New Economics Foundation (NEF), *Landing the blame: Overfishing in EU waters 2001–2015,* [57] concluded that seven out of every ten TACs were above the limits advised.

EU fisheries ministers have the opportunity to end overfishing on an annual basis when they agree on a Total Allowable Catch (TAC) for each commercial fish stock.

An analysis of fishing effort in the EU carried out by the STECF [68] shows that the ten-year period to 2013 saw fishing pressure (F/FMSY) for all MSY assessed stocks combined in EU waters decline but with an upward trend detected in 2014. Based on the Scientific, Technical and Economic Committee for Fisheries (STECF) Report, in 2014 in the North-East Atlantic and adjacent waters, 28 out of 59 stocks which were assessed were outside safe biological limits i.e. F exceeds FMSY in about 50% of the total number of stocks for which this indicator can be computed. Progress towards ending overfishing has slowed down, making additional and urgent efforts necessary to restore stocks to healthy levels.

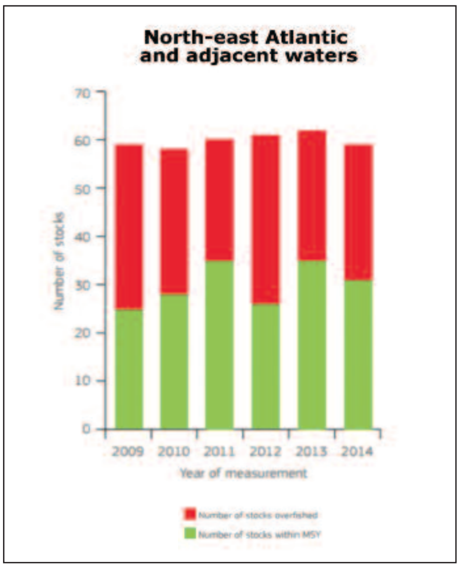

Figure 10. Number of stocks subject to overfishing (fishing > FMSY) in the North-East Atlantic and adjacent waters.

Source: Scientific, Technical and Economic Committee for Fisheries (STECF), Monitoring the performance of the Common Fisheries Policy (STECF-16-03), Luxembourg, Publications Office of the European Union, 2016.

Fulmar
(Dick Coombes)

However, if all Northeast Atlantic fish stocks were exploited at FMSY, an additional €4.6 billion per year in profits could potentially be generated compared to current exploitation rates [69]. Setting correct fishing limits is fundamental to achieving the objectives of the CFP, namely to end overfishing and to restore and maintain fish stocks above levels capable of producing the maximum sustainable yield (MSY). The precautionary approach to fisheries management should be applied to ensure populations of harvestable species are not over-exploited to levels that cannot be sustained in the longer term. In mixed fisheries, this may mean setting quotas (TAC) according to the most vulnerable stock. Multi-Annual Plans (MAPs) are at the heart of the EU's reformed CFP, the vehicle to deliver its objectives through adoption of an ecosystem-based approach to fisheries management, to restore and maintain populations of harvested fish species above levels which can produce MSY. They are designed to ensure the long-term sustainable management of fisheries and to end the focus on short-term gains that has long plagued EU fisheries. MAPs lock stakeholders into taking and following measures for years to come to reverse the effects of decades of overfishing. To achieve this outcome, they must include robust objectives and safeguards that deliver on the CFP's requirement to restore and maintain populations of fish stocks.

The slippery slope of overfishing is changing the composition of our seas. By fishing down the food web and removing predatory fish from marine systems, fisheries have been transitioning to smaller plankton feeding fish. This progression leaves our wildlife and fishing communities vulnerable and the diversity of our fisheries compromised.

Inishtooskert, Blasket Islands, Co. Kerry
(M.O'Clery)

Marine food webs risk collapse

The problem is two-fold. Longer-lived fish-eating (piscivorous) fish have been depleted significantly, in many cases to the point of no longer being able to provide a commercial fishery. Then, having exhausted catches of larger, longer-lived species (e.g., tuna, cod), fishing fleets are increasingly concentrating on catching smaller, shorter-lived, plankton-eating species such as mackerel, sardine and sandeel, mostly known as 'forage fish' and invertebrates such as mussels, prawn and shrimp, which are nearer the bottom of the food chain [(70)].

The practice of fishing down food webs i.e. removing top predators, leads at first to increasing catches, then to stagnating or declining catches and is most pronounced in the Northern Hemisphere fisheries where landings have shifted from larger piscivorous fish to smaller planktivorous fish and invertebrates. This has major implications for marine food webs [(56)] and occurs when the balance of the ecosystem is altered by overfishing with declines of large predatory species seeing further targeting towards smaller fish impairing the long-term viability of other ecologically important species [(71) (72)]. Ecosystem-based fishery management of fisheries is especially important because of the position of smaller fish and invertebrates in marine food webs.

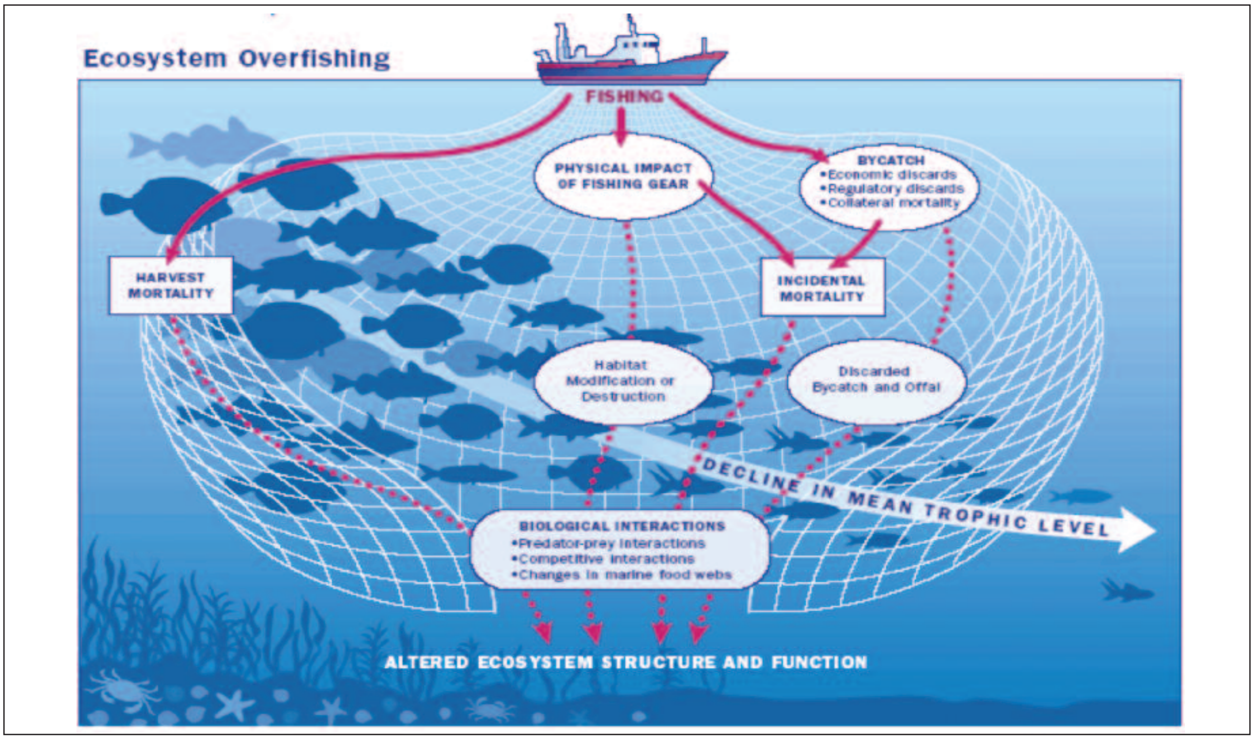

Figure 11. Ocean energy transfers and the importance of forage fish [(56)] .

Forage fish can experience rapid population expansion because of their relatively small body size, fast growth, early maturity, and relatively high fecundity. However, their short life span can also lead to sudden population collapse when adult mortality rates are high. As such, forage fish have unstable population dynamics and may exhibit large annual, inter-annual, or decadal-scale fluctuations and these booms or bust years can have huge implications for the species that depend upon them. When fisheries target these smaller fish species, it not only puts pressure on seabirds that depend upon them, but alters the food abundance of the larger predatory fish species with the overall effect of hindering their recovery and unbalancing the entire marine ecosystem. Therefore, depleted abundance of forage fish can negatively affect the ecosystem [(70)] and the marine wildlife that depend on them. Forage fish play a crucial role in supporting top predators in marine food webs, such as seabirds [(15) (73)].

Case study 1

Terns in the Irish Sea

Terns are almost exclusively dependent on forage fish (sandeels and sprats) which can make them more vulnerable to changes in their preferred food supply than other, more generalist feeding seabirds (34) (89) (6). Fisheries which target or alter the availability of these forage fish, can impair the breeding success of seabirds that rely on these small fish for their existence.

Annual monitoring of tern colonies along the east coast of Ireland for nearly three decades, has provided a unique insight into how changes in our seas are affecting these long-distance travellers. Tied to colonies in summer, terns forage in shallower seas with sandbanks such as the Kish Bank and Codling sandbanks along the East Coast, important habitats for spawning sandeels which are exploited by terns and other seabirds.

Common Tern (John Fox).

The east coast of Ireland, supports the breeding grounds of five species of terns (Roseate, Common, Sandwich, Arctic and Little). The tern colonies range in locations from offshore islands (Rockabill Island, Dalkey Island, Co Dublin), to brackish lagoons (Lady's Island Lake, Co. Wexford), to coastal shingle beaches (e.g. Kilcoole, Co. Wicklow) and port infrastructure (mooring dolphins and pontoons) in Dublin Bay. Rockabill Island holds the largest concentration of breeding Roseate Terns in Europe (approx. 1,500 pairs) along with almost 2,000 pairs of Common Tern and circa 65 pairs of Arctic Tern (74). With a large Common Tern colony at Dublin Port (circa 500 pairs) and smaller Arctic Tern colony (up to 50 pairs) (75), Dublin Bay itself supports a breeding population of upwards of 4,000 tern pairs (76) in summer and close to 17,000 terns (including young successfully fledged) post-breeding (Niall Tierney, BirdWatch Ireland, 2016).

Common Terns and Manx Shearwater (John Fox).

Intensive monitoring of the Roseate Tern breeding colony at Rockabill Island indicates that almost 82% of their diet is made up of Clupeids (mostly sprats), with sandeels (almost 13%) and Gadoids (5%), making up the remainder (74). Snake pipefish, known to cause mortality in some seabird chicks, were brought in by adult Common Terns in early July in 2015 having not been recorded at the colony between 2007-2014 (74). Snake pipefish are a sub-optimal prey item for seabirds, they are less nutritious and can cause mortality of chicks through choking (77) (78). Given terns breeding on Rockabill have been monitored annually since the mid-1990s, the data collected provide a good opportunity to assess longer-term trends in overall site productivity. In five of the last six years, most pairs have fledged at least one chick (1.12 fledged young/nest) which has been supporting a positive upward trend in the overall population (74). Data on the availability of their preferred fish (e.g. sprat*) in the Irish Sea is lacking but annual provisioning studies of tern chicks on Rockabill Island indicate that there is some degree of annual variability in the quantities of sprats and sandeels taken by Roseate and Common Terns, but most of their diet consists of sprat.

Case study 1 (continued)

Post-breeding (late July-September) even larger concentrations of birds occur in Dublin Bay and the nearby sandbanks (e.g. Kish Bank) attracting terns, not only from local colonies, but from further afield in Ireland (e.g. Lady's Island Lake in Wexford) and overseas (North Sea, Baltic Sea) (79) (80) with recent counts indicating up 4,000 terns feeding in the Bay immediately post-breeding (5 species including Black Tern, Roseate Tern, Common Tern, Arctic Tern & Sandwich Tern) feeding in the bay post breeding (76). The concentration of terns, particularly on the Kish Bank, is likely due to a supply of forage fish such as sandeels and sprats in late summer (79). While the main east coast tern colonies are in Special Protection Areas (SPAs), in the Irish Sea, there is little data on available prey species sandeels and sprats, which terns depend on for chick provisioning (74). If these resources become limited, then ultimately the long-term viability of these colonies will be tested.

Using protected areas as a fisheries management tool is not a new concept for fisheries management, yet Ireland lags behind others in the scope of their use. A range of protected areas would provide safeguards for nursery beds and spawning areas of important forage fish including sprats and sandeels, benefiting breeding seabirds, and predatory fish such as Irish Sea cod. Management plans for such areas could facilitate both human activities and ecosystem values.

*Note for sprat fisheries. Irish vessels are not subject to any quota for sprat, but certain licence provisions regulate access to coastal waters for certain sizes of vessels, with mesh sizes of 16mm and above are permitted when sprat is the target species. Preliminary research suggests at there are at least two discrete populations in Ireland, one along the south, west and northwest coasts of Ireland and another in the Irish Sea. Although there is currently no TAC for this species in Irish Waters, they are an important forage fish species and a management plan for them is required (81).

Sandeel stocks in the North East Atlantic are changing due to both fisheries and climate change (16). Sandeels are not free to move into deeper waters in response to warming sea temperatures because they are tightly associated with sandy sediments leaving them susceptible to increased pressure from fisheries (82). Common Guillemot productivity is directly influenced by sandeel availability, and in years when fewer sandeels are available, chick growth and survival rates are lower (83).

Sandeels are a keystone species, linking zooplankton on which they feed and predator species at higher trophic levels such as cod, herring and seabirds.

As predatory fish have been selectively removed from the ocean by commercial fisheries, they in turn have relied increasingly on smaller fish species, which reproduce faster but are more seasonally abundant and thus any remaining larger fish are exposed to greater variability in their food supply. Commercial fisheries for forage fish are now amongst the largest in the world and the demand for products derived from forage fish is increasing [70]. However, small shoaling fish species (i.e. forage fish) favoured by seabirds are targeted by commercial fisheries for production of fish meal and oils which has increased in recent years due to the demand to supply the aquaculture sector. Many of these forage fisheries are supplying fish meal to fish farms and intensive livestock systems elsewhere in Europe [84]. The global demand for fish meal is expected to nearly double by 2025 [85]. Ireland currently has one fish meal plant (Killybegs, Co. Donegal) processing 60% trimmings (industrial fisheries) and 40% feed fish (other fisheries) with blue whiting (65%), horse mackerel (20%) and herring (15%), the most common catches for feed fish. In addition, the many catches from boats registered in Russia, Norway and Faroe Islands are landed in Ireland for processing [84]. The removal of large quantities of these 'feed-fish' pelagic fish species, could reduce supply of preferred fish of breeding seabirds [45] in Ireland which are known to feed on herring and mackerel [86].

Given the foraging ranges of many seabirds are extensive, detecting whether changes in the availability of fish in our oceans is influencing adult survival of seabirds is difficult. However, during the breeding season, seabirds are effectively 'tied' to their breeding colonies (most foraging ranges around colonies being in the order of 10s of kilometres), so local fluctuations in fish recruitment and availability can have more significant effects on the reproductive output of seabirds (number of eggs laid/chicks hatched) and their chicks' survival.

In the worst-case scenario, if fish populations are reduced below the level needed for seabirds to support themselves and their young, or if the fish species and prey sizes needed to feed chicks are unavailable, then nests fail (i.e. no young are fledged due to starvation or depredation) or indeed, seabirds fail to reproduce at all if the shortfall occurs early in the season [87].

Arctic Tern
(M.O'Clery)

Seabirds are long-lived, allowing for many breeding attempts on average in their lifetime. However, successive annual breeding failures will eventually lead to population declines in affected species, which, due to seabird life-history characteristics, may not become apparent until it is too late.

Case study 2

Atlantic Puffins in the Celtic Sea

Ireland is home to 20,000 breeding pairs [8] of Atlantic Puffins in summer where they seek out suitable fish in the seas around our coast. Lipid-rich sandeels are perfect for adults to fatten up young chicks in burrows, but decreasing abundance of fish loved by Atlantic Puffins has resulted in adults often choosing sub-optimal prey i.e. Snake Pipefish, which are a choking risk and far less nutritious. Atlantic Puffins are perfectly adapted to capturing fish in their serrated bills, which along with their raspy tongues and spiny palates allowing them to hold many sandeels at one time (record of 83 in total). Given national monitoring of these well-known and loved seabirds includes decadal surveys at best [8], detecting subtle changes in food availability and its likely impact on their fecundity will be problematic. Newly added to the European Red List [9], the Atlantic Puffin is perhaps one of the most iconic seabirds, yet until recently we were largely ignorant of how they spend their time away from breeding colonies [8]. Often dubbed the 'Sea Parrot' with its distinctive colourful bill and appearance, this member of the auk family spends most of its life at sea but is a summer visitor to sea stacks and cliffs along Irish coasts from March to September. Atlantic Puffins are truly international travellers, with recent tracking studies of birds indicating they commute post-breeding between Ireland and Newfoundland-Labrador Shelf, with the furthest distance travelled in just 20 days [41]. They usually mate for life, choosing a partner at between 3 and 5 years old, spending their formative years at sea learning about feeding places.

Atlantic Puffin (John Fox).

The west coast is the best place to see and hear them, with the Cliffs of Moher in Co. Clare, as well as Horn Head in Co. Donegal accessible sites, though there is a scattering of smaller colonies at east-coast sites, including Ireland's Eye and Lambay Island and Great Saltee Island. Skellig Michael in Co. Kerry, with its world-renowned 6th-8th Century monastic settlements, a UNESCO World Heritage Site, is perhaps the most spectacular home to Atlantic Puffins. Nearby Puffin Island, closer to mainland Kerry, also holds important populations of Manx Shearwaters and European Storm-petrels.

Case study 2 (continued)

In Ireland, monitoring of Puffins is irregular, as colonial burrow-nesters (nest underground), they are a difficult species to census at colonies. The most recent national census of Atlantic Puffins in Ireland (Seabird 2000) indicated the population had declined since the 1960s from just under 28,000 pairs to 21,000 pairs (a decline of 24%) [8]. Atlantic Puffins are known to switch from feeding on mainly fish during the breeding season and post breeding periods to zoo-plankton over the remaining winter period (Nov-Jan) [41]. Atlantic Puffins more generalised feeding strategy of switching between prey types allows them to cope with fluctuations in forage fish during breeding [88]. Sprat and sandeels are key prey items for Puffins. Changes in availability of these forage fish due to fishing down the food webs in North-Western Europe, which holds the majority of the global population, has had negative implications for overall numbers of Atlantic Puffins in the biogeographic region with indications from colonies in the UK, Norway, Faroe Islands and Iceland, that breeding productivity at colonies has declined markedly since the 1980s [88] [14] [20] [1] [19] [23]. In the North Sea, sandeels have been the target of a major industrial fishery and declines in sandeel availability has both ecological and financial implications [89]. Alongside declines in their breeding success, noted significant declines in the volume of eggs laid (i.e. egg sizes) by Atlantic Puffins at two Norwegian colonies situated in different marine ecoregions were driven by changes in availability of forage fish (capelin and early life stages herring and haddock) (90).

Puffin Island, Co. Kerry (M.O'Clery).

Since 2003, numbers of snake pipefish in the North East Atlantic have been increasing [77], including in areas such as the Barents Sea and Spitzbergen in Norway with changes most likely due to warming ocean temperatures [91]. These noted increases in abundance are replicated in dietary studies of seabirds at breeding colonies in the UK, Iceland, Norway and the Faroe Islands where there have been numerous reports of Atlantic Puffins and other seabirds feeding their young snake pipefish, which can be a significant choking hazard [77] [78] [83] and being of lower nutritional value (due to lower lipid content), can impact negatively on chick growth, fledgling weights and ultimately survival.

In Ireland, records of Snake Pipefish being fed to Atlantic Puffin chicks were first noted in 2007 at Skellig Michael which had disastrous consequences for the productivity of the colony that year. Since then, new prey species have been recorded including garfish (or skipper), possibly an indication that the birds are switching prey types due to availability or lack thereof preferred food types (Dr. Stephen Newton, Senior Conservation Officer, Seabirds, BirdWatch Ireland). At Irish colonies, more in-depth monitoring of the feeding ecology of Atlantic Puffins is needed to understand whether local fluctuations in availability of their preferred fish is having a negative impact on the breeding success of these seabirds.

Seabirds and fisheries in Ireland

The picture of how fishing affects seabirds is a complex one, not helped by existing research gaps on Irish seabird populations. It is nonetheless clear that depleting the food resource by 'fishing down the food web' (56), or with boats that are too numerous (or too powerful) chasing too few fish, is a significant additional pressure on our seas. Seabird populations are therefore faced with cumulative pressures at both their colonies (from invasive species and disturbance) and at sea (fishing, pollution, marine renewables) (14) (92) (93) (94).

Seabirds are long-lived, and thus, their populations can only increase slowly, even if environmental conditions are favourable and any additional pressure increasing adult mortality will have a particularly strong negative influence on overall population dynamics (45). The impacts of commercial fishing upon seabirds are variable (95) depending on whether species
• expend a lot of energy to find food
• need to forage close to the colony
• are limited to using a specialised and inflexible foraging method
• unable to dive below the sea surface, and
• lack 'spare' time in their activity budget that could be allocated to prolonged foraging if food is scarce.


Seabird bycatch (Nuno Barros).

Fisheries can also impact seabirds through direct mortality caused by entanglement and trapping in fishing gears (96) (97) and more subtle changes, such as increased effort to find prey (18) (98) (99), or changes in the fish species composition available to seabirds feeding in the same waters as fishing vessels (70) (100). While some seabirds are able to adapt to fluctuations in food availability (27), many studies have shown that seabird survival, breeding success and chick growth are closely correlated to food availability (3) (101) (102). During the breeding season, seabirds are effectively affiliated to their breeding colonies meaning that local fluctuations in fish recruitment and availability can have a large effect on seabird reproduction. This low level of seabird breeding productivity, compounded over several years, often makes the problem difficult to detect before there is an impact at a population level when it is often too late to act. Breeding colonies are particularly vulnerable, with all birds reliant on the same area, and while some seabirds are generalists (Northern Gannets) other specialists show declines earlier (Black-legged Kittiwake). The lack of data for offshore species put this group of seabirds in an even more precarious position (Manx Shearwater and European Storm Petrel).

Given the dependence of seabirds upon fish, it follows that where seabirds and fisheries utilise the same fish stock, this inevitably leads to seabird – fishery interactions.

Short-term changes in the abundance of small pelagic fish (with shorter lifespans) do affect seabirds, including smaller surface-feeding species such as Black-legged Kittiwakes (3) and Arctic Terns (23). Of course, other keystone predators such as mackerel can affect availability of smaller fish species too (103). In Ireland, as in many parts of North Western Europe, the Black-legged Kittiwake has seen a decline in its productivity overall, largely thought to be due to reduced availability of sandeels (see Case Study 3).

Case study 3

Black-legged Kittiwakes declines

Black-legged Kittiwakes are good indicators of food availability in surrounding seas and in some cases (fishing effort) as numerous studies have shown that breeding success and productivity at colonies suffers when there are shortages of their preferred prey.

With a tern-like wingbeat, the Black-legged Kittiwake is highly manoeuvrable in the air, and can land on narrow ledges on the steep sided rocky cliffs on which they nest, even in strong winds. An opportunistic feeder, it feeds on small surface fish and invertebrates. Black-legged Kittiwakes prefer live fish over discards, and the species consumed most often are capelin (Barents Sea), young herring (Norwegian Sea), and sandeels (North Sea).

Globally, the most numerous of the gull species, the Black-legged Kittiwake is also probably the most oceanic in its preferences with tracking studies indicating most (80%) of the 4.5 million Atlantic adult population winter west of the Mid-Atlantic Ridge, with only birds from Ireland and the west coast of Britain remaining on the European side of the ridge (104). Similar to the Atlantic Puffin, Black-legged Kittiwakes at breeding colonies have been shown to be susceptible to changes in the abundance of their preferred prey, sandeels, with adult survival and breeding success negatively impacted when sandeel fisheries operate locally (15) (105) (77). A study comparing their foraging behaviour in years of varying food availability showed that trip length and duration increased in years of low food availability resulting in decreased breeding success (25). On Shetland, Kittiwake numbers fell dramatically in the late 1980s and have remained lower ever since (83), (15) (106). The North Sea has been severely impacted by overfishing and coupled with rising sea temperatures associated with climate change, significant changes to trophic food webs are happening (107). The UK population has shown a decline of 72% between 1983 and 2013 (108). Along the Bering Sea Shelf, food-shortages may have contributed to declines in Black-legged Kittiwake populations due to increased adult mortality and/or breeding desertion due to high foraging effort and nutritional stress (109).

Black-legged Kittiwake (Dick Coombes).

In Ireland, annual colony monitoring at all colonies is not carried out, but analyses of trends from colonies monitored indicates the species is declining. In two colonies monitored in 2014; Wicklow Head (Co. Wicklow) and Great Skellig (Co. Kerry), which together held a total of 1,170 Apparently Occupied Nests (AON) compared to 1,650 AON during Seabird 2000, a decline of 29% in Black-legged Kittiwake nests was noted. Similarly, in 2013, only two colonies were surveyed; 845 AON were recorded on Great Saltee (Co. Wexford) with 439 AON at Downpatrick Head (Co. Mayo), a total of 1,284 compared to 3,143 AON during Seabird 2000 representing a decline of 60%. These colonies held 13% of the national population during Seabird 2000. At Rockabill Island located on the Irish Sea, just off the north coast of Co. Dublin, Black-legged Kittiwake productivity has been monitored there since 1999 with approximately 1.2 chicks

Case study 3 (continued)

per AON (based on data collected from 1999 to 2007) higher than most other Irish and UK colonies [110]. However, in the last ten years, annual productivity of Kittiwakes at Rockabill has fallen to approximately 0.86 chicks per AON (74). In Northern Ireland, the fortunes of Black-legged Kittiwakes have been mixed with recent declines at Rathlin Island (20%), the loss of a colony at Strangford Lough and recovery at 'The Gobbins'. With no clear pattern overall with the most recent assessment indicates the population in Northern Ireland is relatively stable [108].

Studies from GPS tagged Black-legged Kittiwakes in the North Sea have shown that during incubation (April–May), birds foraged substantially further from the colony and fed on larger sandeels than when feeding chicks, and there was significant inter-annual variation in foraging areas used during the chick-rearing period (June–July) [111]. A recent study of breeding Black-legged Kittiwake at two colonies (Rathlin Island, Co. Antrim and Lambay Island, Co. Dublin) in Ireland [112], showed that this species can be vulnerable to local food shortages with contrasting fortunes in terms of breeding success across consecutive breeding seasons (2009 & 2010). In the latter season, breeding success suffered most likely due to shortages in food resources near the colonies with pairs responding by extending their foraging range. Unfortunately, this resulted in greater losses of clutches and higher numbers of starving chicks (15%). Foraging range data from these two colonies did indicate most pairs remain within 40km of land and within 30km of the colony feeding in productive waters of 25-175m deep [113].

In Ireland, Clupeids (include herring) are also known to be an important component of their diet [25]. With a herring fishery in the Irish Sea already in existence [52], future concerns relate to plans announced by the Irish Fisheries Minister in 2015, to establish a small commercial fishery for herring off the west and north-west coast. Such fisheries may have implications for the breeding success of Kittiwake colonies along these coasts if they were to negatively impact on availability of young herring sprat.

Most seabirds show varying degrees of prey selectivity while the prey selected may also vary by season. Many species (e.g. gulls) are opportunistic, taking whatever mix of prey species is available, but in multispecies communities, it has been shown that seabird species show distinct, consistent preferences for prey (Table 1). However, prey preferences may be constrained by foraging behaviour and energy requirements, with energetic demands being greatest during the chick provisioning period of the breeding season [87].

Some of the most dramatic examples of seabird declines due to collapsing fish stocks have come from Norway which holds 10% of the world's biogeographical population of seabirds [114]. Here, the largest Puffin colony on the Lofoton islands, historically supported an estimated 700,000 pairs in 1964 [115]. Subsequently, the collapse of herring stocks in Norway because of overfishing resulted in an almost complete breeding failure of Puffins, and between the years 1969 and 1990 they bred successfully in only five seasons [115]. The closure of the herring fishery in 1988 saw an immediate improvement in Puffin breeding success at the colony [116].

In northern latitudes, most seabirds feed upon a preferred range of fish that include species such as mackerel, herring, pollock, sprats and sandeels [82]. Many of these are referred to as 'forage fish' and are small, schooling species that eat the microscopic plants (phyto-plankton) and animals (zoo-plankton) drifting in the seas.

The major development of a commercial sandeel fishery in the 1980's coupled with a decline in sandeels due to poor recruitment, led to dramatic seabird declines on Shetland, an internationally-important concentration of seabird colonies [1]. Overfishing of cod, mackerel and herring caused an increase in sandeel populations in the 1950's, as predation pressure from cod was lowered [15] [87] [1]. The new fishery and environmentally induced fluctuations in sandeel recruitment [117], and a lack of understanding of the ecological interactions between sandeels, their predators and the impacts of the fishery on the diet of some seabirds than others [3] resulted in dramatic declines because of not being sufficiently understood. This had important implications for fishery management [118].

Some seabirds have adapted their foraging behaviour due to fisheries and fisheries-related activities

Commercial fishing has likely benefited some bird species that learnt to associate fishing boats with food (fishing discards) [119]. However, this is an imbalance in the marine food web with these birds becoming un-naturally dependent on fishing discards. Furthermore, by becoming more familiar with fishing vessels, the birds have become more vulnerable to being caught in fishing gear, a process known as bycatch. The practice of discarding led to scavenging seabirds exploiting opportunities to feed on more benthic fish species they could not naturally obtain themselves although unforeseen impacts include a higher risk of accumulating contaminants such as mercury than if they were feeding on more pelagic fish [120]. The impacts of having access to this supplementary food supply by scavenging seabirds on breeding success and overall population trends can vary [119].

Fishing practices in the recent past included discarding non-target fish/offal from boats at sea which did change the feeding behaviours of certain seabird species [119] [11]. Current research hopes to better understand how new fisheries legislation [121], including the ending of discarding, will affect seabirds, particularly those that have been more closely tied to fishing vessels. The Northern Gannet, for example, is capable of switching its behaviour when in close proximity to fishing vessels with individual birds able to differentiate between whether vessels are fishing or drifting and can adjust their behaviour from commuting to feeding accordingly [86] [40]. While scavenging can be an important aspect of an individual's diet, as a population, Northern Gannets continue to rely on natural foraging [86].

Fulmars and Gannets scavenging bycatch (Hannah Keogh).

Case study 4

Northern Gannet in the Celtic Sea

The introduction of the landing obligation (LO) under the new CFP reform [66] means that the practice of discarding large catches of unwanted fish will end by 2019. The Northern Gannet is a seabird whose feeding behaviour has included feeding on discarded fish from vessels off our coast. This case study focusses on the foraging strategies of these birds and how they might be affected by the LO.

One of the most striking of all seabirds, the Northern Gannet is a bird of the open sea, foraging even beyond the outer limits of the continental shelf, on occasion, and yet can be seen regularly from headlands all year round. Ireland supports upwards of 50,000 breeding pairs of Northern Gannet, almost 10% of the biogeographic population worldwide. Over the past 40 years, populations in Ireland have grown, replicating trends in neighbouring Britain [8]. Our largest colonies or gannetries can be found on islands off the south coast (Celtic Seas region) with colony sizes based on numbers of apparently occupied nests (AONs), the equivalent to numbers of breeding pairs, given below: Little Skellig, Co. Kerry (35,000), the Bull Rock, Co. Cork (6,400) and the Great Saltee, Co. Wexford (4,700) with smaller colonies on east and west coast (Ireland's Eye 550, Lambay Island 730 (up to 900 in 2015) Co. Dublin, Clare Island, Co. Mayo 270) [12].

As an apex predator, the Northern Gannet has been the focus of previous studies examining the links between seabirds and fisheries as they are known to avail of offal and fish discarded from trawlers for at least part of their diet, possibly artificially elevating numbers at some colonies [122]. Previous colony-based studies have demonstrated that the larger the gannetry, the further birds will travel [123]. The predicted foraging range for larger colonies such as Bass Rock (North Sea) is 115 km (maximum of 368 km) whereas from Lambay Island (in the Irish Sea), the predicted foraging range is 47 km (maximum of 159 km). [124]

Ireland's Eye seabird colony, Co. Dublin (Alyn Walsh).

Northern Gannets spend most their time 'natural foraging' on mesotrophic shoaling fish such as herring, sandeels and mackerel [119]. Therefore, while reforms to eliminate discarding (includes unwanted and undersized catch) may have consequences for the Northern Gannet, who can benefit from the practice through scavenging, ongoing declines in global catches of fish will most likely have longer-term impacts on this long-lived seabird [101] [14] [125]. Northern Gannets adjust their foraging behaviour according to the resources available and use cues to find fish and learn from previous experience, following each other [86]. With the advent of individual-based tracking using satellite and GPS tags, Northern Gannets tagged from neighbouring colonies have been shown to partition resources at sea, with little overlap in areas in which they forage [126]. There are also strong links between their foraging behaviour and productive/mixing zones [39].

Charting the changes in the fish populations on which the Northern Gannet depends, along with associated food web interactions between their preferred prey, including forage fish such as sandeels and herring, is vital to understanding the potential implications such changes may have on a top predator like the Northern Gannet. Ideally, a more ecosystem-based approach to fisheries management will address these concerns regarding food availability for these and other seabirds.

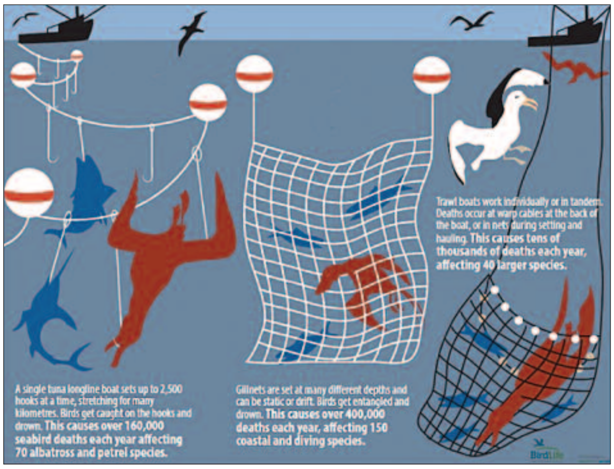

Figure 12. How seabirds get caught (BirdLife International).

Northern Gannet carrying baited hook from long-line fishery. (Mairead O'Donovan, Celtic Explorer At Sea Survey 2015).

Some fishing techniques adversely affect seabirds through increased risk of incidental drowning in fishing gear (nets or long-line hooks) or collision with gear cables (96) (97) (125) or where adults carry materials from discarded gears to nests where young chicks can become entangled (127). Ideally seabird monitoring programmes should include measures of adult survival as well as breeding productivity, in order ascertain the level of impact pressures such as overfishing will have on populations in the longer term. Teasing out the potential impacts of industrial fisheries, coupled with potential climate change effects on the marine ecosystem in the North Atlantic and associated shifts in zooplankton distribution and associated fish availability is not straightforward (128) (129) and requires detailed information on the biology of seabirds and fish populations which are not always available.

One less understood impact of fisheries, with indirect impact upon seabirds, is the habitat damage caused by fishing gear with subsequent effects on benthic community structure and changes to marine food webs.

Fishing gears that make contact with the seafloor disturb geological and biological structures, planing off structures on soft areas of the ocean bottom, displacing boulders, and harming bottom-dwelling organisms by crushing them, burying them, or exposing them to predators (130). The benthic animals most sensitive to fishing gears are those that are sedentary, erect and fragile, long-lived and slow-growing (131). A review of studies on beam trawl fisheries in the North Sea and focusing on direct impacts of the trawling on benthic communities, found that direct impacts on these bottom-dwelling species could have indirect effects on other species in the food chain. These effects can be 'bottom-up' (e.g. effects on benthic communities leading to changes in fish communities and/or birds) or 'top-down' (e.g. removal of predatory fish species, causing shifts in prey species) (132).

Very little information is known about levels of seabird bycatch in waters around Ireland. Fishing gears which are known to be problematic for seabirds (BirdLife International Seabird Programme) include gill nets (133). The Irish fleet has about 300 vessels (<10m) which use gill nets and about 20 larger vessels (information from the EU fishing vessel register), with most active off the west and southern coasts. Globally, an estimated that 400,000 seabirds die in gill nets each year although the true magnitude of the problem is poorly known in all regions (96) (97). Less than 10 vessels from the Irish fleet use demersal longlines which are also known to be problematic for seabird bycatch. There has been an assessment of the global problem in longline fisheries with petrels and shearwaters particularly vulnerable along with other largely Southern Ocean seabirds such as albatrosses (133).

Species such as the Balearic Shearwater, Cory's Shearwater, and Great Shearwater are being killed at an alarming rate. The Balearic Shearwater is listed as Critically Endangered on the International Union for Conservation of Nature (IUCN) Red List [134], the highest threat category possible [135].

An estimated 320,000 seabirds die annually world-wide from being caught on the hooks of longline fishing. In Europe, the worst known hotspots are the Gran Sol hake fishery off the southwest of Ireland and the Mediterranean Sea [133]

Case study 5

Great Shearwaters and seabird bycatch in the Gran Sol

For those seabirds, which spend only part of their annual life cycle in our waters, never coming ashore, it is challenging to identify and quantify the impact of pressures from fishing and the example of the Great Shearwater, is a species which represents the difficulties in monitoring seabirds in the deep sea and safeguarding them.

Great Shearwater, is a truly pelagic seabird, performing a trans equatorial migration in April and is a regular visitor to Irish waters where during August records of thousands of Great Shearwaters have been seen by observers on headlands along the south coast (*Cape Clear Bird Observatory Log, Co. Cork*). Great Shearwater breeding grounds are in the Southern Hemisphere oceans and it travels to the Northern Hemisphere oceans post breeding in April following a circular route up the eastern seaboard of the Americas before crossing the Atlantic in August where they can be seen off the South-Western coasts of Ireland and the UK before they head back south in November along what is known as the Eastern littoral of the Atlantic to the southern Hemisphere once more [44].

Great Shearwaters are subject to one of the highest levels of bycatch in the Atlantic Ocean [136]. Bycatch concerns relating to largely the Spanish demersal longline fishery (Gran Sol grounds off South West Ireland,), where the estimated average annual mortality of seabirds is ca 56,000 birds per year based on data collected between 2006 and 2007 [133]. This fleet targets hake, using the traditional piedra-bola system (a line with hooks hanging off it weighted along points to hang near the sea bottom). Great Shearwaters were found to make up most the bycatch (included Northern Fulmar, Black-legged Kittiwake and Northern Gannet) and although their current status globally is not threatened, the sheer volume of birds being lost to this fishery (largely hake), is a concern.

A comprehensive study is needed to throw light on what impact longline and gill net fisheries [137] in the North Atlantic may have had on this species. Fishermen are often reluctant to have on-board observer on vessels, but with the new regulations under CFP, observers on fishing vessels should be more commonplace. Ireland (18%) and the UK (91%), together hold much of the world population of Manx Shearwaters [8]. Studies using tagged birds from one of the largest colonies on Skokholm and Skomer Islands (Pembrokeshire, in Wales) have shown that birds at the colonies (breeders and non-breeders) utilise much of the Irish Sea (Mull of Galloway to the Saltees) on foraging trips [138]. Covering distances of up to 330km each way, such studies highlight the wide-ranging nature of some seabirds even though they are tied to breeding colonies. The interactions between fisheries and these shearwaters in Irish waters is also a knowledge gap that needs to be addressed.

Case study 5 (continued)

There is currently no dedicated bycatch monitoring programme for seabirds in Irish marine waters. Seabird bycatch is recorded on:

- the fisheries observer programme which formed part of the Data Collection Framework Directive (DCF) No. 665/2008 of the 14 July 2008 (run by the Marine Institute);
- the cetacean bycatch observer programme run by Bord Iascaigh Mhara in support of requirements under Council Regulation (EC) No 812/2004, and
- any fisheries surveys on chartered commercial vessels.

A Seabird Action Plan [139] was adopted by the EC in November 2012, and under current reform of the Common Fisheries Policy (CFP), and new legislation, proposed on 11th March 2016 by the European Commission, will make it mandatory for all fishing vessels in the EU that accidentally catch seabirds to put in place measures to prevent this. The legislation still needs to be negotiated between the Council (i.e. Member States) and the European Parliament before it becomes enforceable law. There are also discussions whether such an observer programme should have increased sampling effort in high risk fisheries such as the hake fishery in the Gran Sol.


Great Shearwater (John Fox).

The Birds Directive (79/409/EEC) requires Member States to set up Special Protection Areas (SPAs) to protect seabirds, such as the Manx Shearwater, which have two basic requirements, safe nesting sites and safe feeding sites, ideally with a plentiful supply of food. Providing safe feeding sites at sea is much harder task, in particular for wide-ranging species such as shearwaters where Marine Protected Areas (MPAs) or marine reserves tend to be located near colonies which is probably beneficial to species that do not travel such great distances from colonies, but for shearwaters, which have more wide-ranging diffuse patterns of foraging, such protected areas do not afford any protection.

Climate change is now being linked to changes in marine food webs which in combination with fisheries and other pressures, can impact upon seabird populations.

Ocean surface temperatures are increasing, causing surface waters to expand and sea-levels to rise. Warming surface waters also reduce the degree of vertical mixing, which diminish the upward transfer of deep, cool, nutrient-rich waters that encourage the growth of phytoplankton [140], also affecting the abundance, size composition, diversity, and trophic efficiency of zooplankton [141]. This decline in plankton biomass, the very foundation of primary production in the oceans, has many implications that resonate up the marine food web through fish and to marine mammals and seabirds [142]. Even small changes in this part of the ecosystem could have a large-scale effect on fish and influence seabird reproductive success and population change [143]. The pressures brought about by climate change, marine pollution and the increasing demands on our oceans for energy, transport and pollution (oil spills) emphasise the importance of building resilient ecosystems that can adapt to environmental changes.

Restoring fish stocks and resilient seas

European, along with global fish stocks have been overfished for decades and the fishing fleets continue to have capacity to catch a volume of fish that far exceeds sustainable catch limits [144]. Political decision-makers come under pressure from sections of the fishing industry to allow overfishing to continue. Ministers with responsibility for fisheries in European waters continue to set fishing limits exceeding the available resource [55]. Coupled with poor public awareness of this phenomenon, Ministers are in a difficult position.

The outcome is that too many and too powerful boats chase too few fish, which is economically unviable as well as worryingly unsustainable [56].

The reform of the CFP was progressed during the Irish EU presidency when Ministers, members of the European parliament and the European Commission made commitments to ending overfishing. The has the potential to transform fisheries management in the EU by safeguarding fish stocks. To achieve these ambitions, the reformed policy commits Member States to:

- ensuring catches (TACs) are sustainable in the long-term
- managing boat capacity, including restrictions on overcapacity of some fleets
- regulating fishing effort by licensing and through provision of closed areas or seasons and integrating an ecosystem-based approach to fisheries management
- designing and use fishing gears that catch target species, with minimum fish and mesh sizes and to ensure gears used minimise negative environmental impacts on other marine wildlife and marine habitats
- prohibiting the wasteful practice of discarding unwanted fish through the landing obligation (to be fully enforced by 2019) particularly in fisheries where percentage of reported discarding is high (>40% in the Celtic Seas in 2014 [63]) through improved selectivity in fishing methods including technical adaption of nets and gears.

A better future for fisheries, fishing communities and marine wildlife including seabirds requires delivery of the ambitions of the CFP along with delivery of the provisions outlined in the Habitats and Birds Directives and the Marine Strategy Framework Directive which aims to take measures to achieve or maintain good environmental status and supports a broad ecosystem-based approach to management of human activities with spatial protection measures and protected areas recognised as one potential mechanism (Article 13 (4)).

Whether the CFP will be successful in achieving its ambitions to reform fishing by EU fleets will depend on the commitment of Ministers and the fishing industry across Europe to take on board scientific advice and harvest fish at levels that will ensure the long-term survival and recovery of fish stocks. There is also a significant role for civil society to ensure the ambition for fisheries management is achieved.

Fishing at levels up to FMSY would create the prospect of stock recovery to levels that have the potential to deliver high yields and would comply with Article 2.2 of the CFP (which requires exploitation rates that restore and maintain populations of harvested species above levels which can produce MSY). If all North East Atlantic fish stocks (includes the Irish Sea & Celtic Seas) were exploited below FMSY, an additional €4.6 billion per year in profits could potentially be generated compared to current exploitation rates (69).

Protection measures for fish, fisheries and seabirds

Member States must act without delay and recover all fish stocks above healthy levels as the positive consequences of sustainable exploiting fish resources are clear: better management can increase catches and hence deliver greater socio-economic benefit to the fishing sector (145). Fish stocks are biological resources that undergo natural fluctuations e.g. varied cycles of recruitment and therefore careful management of catch efforts is necessary to ensure their long-term future.

European, along with global fish stocks have been overfished for decades and the fishing fleets continue to have capacity to catch a volume of fish that far exceeds sustainable catch limits (144). Political decision-makers come under pressure from sections of the fishing industry to allow overfishing to continue. Ministers with responsibility for fisheries in European waters continue to set fishing limits exceeding the available resource (55) and with only the outcomes of negotiations public, the lack of transparency means it is difficult to identify those ministers who ignore the scientific advice (146). Arguments such as lack of scientific data or the economic and social well-being of fisheries have been used in the past by Ministers for delaying meeting CFP objectives but proper implementation could replenish depleted stocks and better support and sustain the communities that depend on fish (57).

There is a growing body of evidence from examples in the EU where fisheries management has worked to end overfishing, including haddock and herring in the North Sea (147). Bringing stocks to sustainable levels has made fleets more profitable as greater catching efficiency reduces operating costs and with improved fleet profitability comes knock-on social benefits for those coastal communities dependent on fishing. Ireland has committed itself to rebuilding fish stocks and to ending the wasteful practice of discarding fish at sea and agreed to legislation that will end EU overfishing by 2020 at the latest. If Ireland is to live up to its promise, it will need to ensure there are no delays in reaching the FMSY objectives of the CFP.

In Ireland, there is an urgent need to delineate and manage a network of Marine Protected Areas (MPAs) that effectively protects our marine biodiversity and helps to maintain sustainable fisheries. This network would include the protection of spawning and nursery grounds for key fish species including groundfish such as mackerel and pollock. An ecosystem-based and precautionary approach to fisheries management will provide more benefits in the long-term both in terms of conserving fish stocks, supporting marine biodiversity and makes the most economic sense. Also needed is monitoring and better protection of forage fish species (e.g. sprat, sandeels), which are such an important food source for other larger predatory fish and seabirds.

Seabirds are characterised as being late to mature and slow to reproduce but they are long-lived, with natural adult mortality typically very low. Detecting changes in seabird populations over time, requires more comprehensive monitoring of productivity at breeding colonies, annual survival rates and detection and estimation of losses through both natural (predators, weather events) and man-made causes (bycatch, oil spills etc.). Annual monitoring of seabirds in Ireland is largely restricted to a few species at colonies along Ireland's east coast. Detecting changes in seabird populations nationally, requires a more national-based monitoring scheme that will encompass key breeding colonies around the Irish coast. Thus far, the frequency of monitoring for most species (8) is such, that detecting changes in populations is hampered by lack of up-to-date information on colony sizes and overall breeding success.

Other challenges for commercial fishing include the elimination of seabird bycatch through application of simple, inexpensive technical measures or adaptations in fishing practices, yet such mitigation has so far had negligible integration and implementation in EU fisheries policy (133). Where possible seabird bycatch should be eliminated in fisheries operating in the EU and by EU fishing vessels. In EU waters, this is in keeping with the Birds Directive which prohibits killing of birds whenever this is a possibility. Furthermore, the CFP reform includes an obligation to collect and report data on seabird bycatch under the Multi-Annual Programme for Data Collection. National at-sea observer schemes, working to an effective protocol, need to play a key role. Without the requirement for such data collection there will be no basis for evaluating the delivery and effectiveness of the plan and its objectives. While SPAs designated under the Birds Directive represent some of the key sites for the protection of seabirds in Europe, special attention is needed towards fishery management measures that will prevent seabird bycatch in these areas.

The European Maritime and Fisheries Fund (EMFF) package is the financial instrument to support the CFP, with an allocation of €6,400 million (2014-2020). Ultimately, the success of the CFP reform will be judged on whether it delivers on promises to regulate fisheries, enforce strict catch limits and supports more environmentally friendly fishing practices. Fisheries management must be based on sound scientific advice and must follow the ecosystem and precautionary approach. Failure will not only risk the livelihoods of fishermen but ultimately the long-term survival of the marine wildlife that depend on healthy seas and oceans to provide them with plenty of fish.

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Annex 1
Regularly occurring breeding seabirds in Ireland

Current status and trends as per EU Bird's Directive, Article 12 reporting[1] and status as per European Red List (Birdlife International, 2015[2]) and current global Red-list (Cr critically endangered; EN endangered; Vu vulnerable; Nr near threatened; LC least concern). Species highlighted in red, are those which are 'Red-listed' in Ireland i.e. of highest conservation concern, those highlighted in amber, are 'Amber-listed' (of medium conservation concern) and those highlighted in green (current status is secure) are 'Green-listed'[3].

Species	EU Bird's Directive Annex 1	Short-term trend[1] (2002–2012)	Long term trend[1] (c. since 1980)	IUCN Red List Category (Europe)	IUCN Red List Category (EU 27)	Current Global Red List Status
Northern Fulmar *Fulmarus glacialis*		Stable	Increase	EN	VU	LC
Manx Shearwater *Puffinus puffinus*		Unknown	Unknown	LC	LC	LC
European Storm Petrel *Hydrobates pelagicus*	Yes	Unknown	Unknown	LC	LC	LC
Leach's Storm Petrel *Oceanodroma leucorhoa*	Yes	Unknown	Unknown	LC	VU	LC
Northern Gannet *Morus bassanus*		Increase	Increase	LC	LC	LC
Great Cormorant *Phalacrocorax carbo*		Stable	Increase	LC	LC	LC
European Shag *Phalacrocorax aristotelis*		Increase	Decrease	LC	NT	LC
Atlantic Puffin *Fratercula arctica*		Increase	Increase	EN	NT	LC
Black Guillemot *Cepphus grylle*		Unknown	Unknown	LC	VU	LC
Razorbill *Alca torda*		Decrease	Increase	NT	LC	LC
Common Guillemot *Uria aalge*		Stable	Increase	NT	LC	LC
Little Tern *Sterna albifrons*	Yes	Increase	Increase	LC	LC	LC
Sandwich Tern *Sterna sandvicencis*	Yes	Increase	Increase	LC	LC	LC
Common Tern *Sterna hirundo*	Yes	Increase	Increase	LC	LC	LC
Roseate Tern *Sterna dougallii*	Yes	Increase	Increase	LC	LC	LC
Arctic Tern *Sterna paradisaea*	Yes	Increase	Increase	LC	LC	LC
Kittiwake *Rissa tridactyla*		Decrease	Increase	VU	EN	LC
Black-headed Gull *Chroicocephalus ridibundus*		Increase	Increase	LC	LC	LC
Mediterranean Gull *Larus melanocephalus*	Yes	Increase	-	LC	LC	LC
Common Gull *Larus canus*		Increase	Decrease	LC	LC	LC
Lesser Black-backed Gull *Larus fuscus*		Increase	Increase	LC	LC	LC
Herring Gull *Larus argentatus*		Decrease	Decrease	NT	VU	LC
Great Black-backed Gull *Larus marinus*		Increase	Decrease	LC	LC	LC

[1]http://bd.eionet.europa.eu/activities/Reporting/Article_12/Reports_2013/Member_State_Deliveries.
[2]BirdLife International 2015. *European Red List of Birds.* Luxembourg: Office for Official Publications of the European Communities.
[3]Colhoun, K. & Cummins, S. 2013. Birds of Conservation Concern in Ireland 2014-19. *Irish Birds* 9:523-544.

Glossary of acronyms and terms

AON Apparently Occupied Nest.

Auks Family Alcidae in the order Charadriiformes and includes Common Guillemot, Black Guillemot, Razorbill and Atlantic Puffin.

Beam trawl A net which is held open by a horizontal beam and dragged along the bottom. Often used to target flatfish.

Blim Limit reference point for spawning stock biomass (SSB). Below this value recruitment is expected to be 'impaired' or the stock dynamics are unknown. Below Blim there is a higher risk that the stock could "collapse". The meaning of "collapse" is that the stock has reached a level where it suffers from severely reduced productivity.

BMSY is the biomass that enables a fish stock to deliver the maximum sustainable yield. In theory, BMSY is the population size at the point of maximum growth rate. The surplus biomass that is produced by the population at BMSY is the maximum sustainable yield that can be harvested without reducing the population.

Btrigger ICES defines an additional MSY trigger level for biomass (MSY Btrigger); if this level is not reached ICES advises lower fishing limits to safeguard the stock.

Bycatch Fish or other species that are caught unintentionally during fishing operations.

Celtic Sea The sea area between southern Ireland and southwest England.

Choke species a term used to describe a species with a low quota that can cause a vessel to stop fishing even if they still have quota for other species.

Clupeids Fish family which includes herring, sprat, menhadens and sardines. Small, mostly silvery fish, with a complete series of scutes (external horny plates) present along the abdomen.

CFP Common Fisheries Policy Regulation (EU) No 1380/2013.

Continental Shelf The part of the seabed that gently slopes down from the shore, typically ending around 200m depth (the shelf edge) after which the seabed forms a steep slope down to the ocean floor.

Demersal Associated with the seabed. Demersal fish live near the bottom of the sea and demersal fishing gear is deployed on or near the seabed.

Demersal otter trawl A net which is held open by otter boards or trawl doors and dragged along the bottom. Mainly used to target demersal fish species and Nephrops.

Demersal seine A net which surrounds fish, it is usually set from a vessel. Long lines on either side of the net are used to herd the fish and haul the net. Mainly used to target demersal fish species.

Discards The part of the catch that is discarded (thrown back to sea).

Dredge A frame with a holding bag which is dragged along the bottom. Mainly used to target shellfish.

EEZ Exclusive Economic Zone The sea area around a nation in which it has special rights over the use of marine resources. It extends up to 200nm offshore.

FMSY is the maximum rate of fishing mortality (the proportion of a fish stock caught and removed by fishing) resulting eventually, usually a very long time frame, in a population size of BMSY. FMSY is a constant and can be applied to any stock that is not impaired in its reproductive capacity.

Fishing down the food web refers to systematic removal of the largest and usually most valuable fish species in a system (explicitly top-level predators). As a result, smaller, less-valuable species (typically prey or forage species) are caught.

Fishing effort The time spent engaged in fishing operations or time spent at sea, this time may be multiplied by a measure of fishing capacity, e.g. engine power.

Forage fish Also known as prey fish, are small pelagic fish species which are preyed upon by larger marine predators and typically include species such as herring, sardines, anchovies and sprats. Traditionally their superabundance makes them present in schools or shoals which are exploited by predators (including fishermen).

Gadoid Family of bony fish, including cod, haddock, whiting and pollock.

Ghost fishing is the mortality of fish caused by lost or discarded fishing gear.

Gill net A single wall of netting hung vertically. Fish generally get trapped by their gills. Mainly used to target demersal fish species.

ICES International Council for the Exploration of the Sea.

Keystone species is a species that has a disproportionately large effect on its environment relative to its abundance.

Landings The part of the catch that is retained (not discarded) and landed.

Landing Obligation By 2019 the reformed CFP requires EU fishermen to retain virtually all commercial catches. The fish must be kept on board, landed and counted against their total quota. This regulation will be phased in gradually between 2015 and 2019 to give fishermen time to adjust to it.

Longline A mainline with hooked and baited branch lines. Very few Irish vessels use longlines, Spanish and UK vessels use longlines in the waters around Ireland, mainly to target hake.

MSFD (2008/56/EC) Marine Strategy Framework Directive European Legislation to protect more effectively the marine environment across Europe.

MSY is the largest average yield (catch) that can theoretically be taken from a species' stock over an indefinite period under constant environmental conditions. It is usually measured in tonnes. The Marine Strategy Framework Directive aims to achieve Good Environmental Status (GES) of the EU's marine waters by 2020 and to protect the resource base upon which marine-related economic and social activities depend.

Overfishing Put simply, catching too many fish for the ecosystem to support. If there are too many adult fish harvested, there are not enough remaining to breed and replenish the population. To allow an overfished stock to rebuild to BMSY, the fishing rate F should be set at FMSY or below. The lower F, the faster a stock can recover and the sooner it will be possible to take the maximum sustainable yield.

Pelagic Associated with open water. Pelagic species live in the water column and pelagic fishing gear is deployed in mid-water.

Pelagic trawl A net which is held open by otter boards or trawl doors and deployed in midwater.

Pot A trap usually baited. Mainly used to target crab, lobster and whelk.

Sea Fisheries Protection Agency (SFPA) the independent regulator in Ireland responsible for the enforcement of EU and national sea fisheries and food safety legislation.

Sustainable Development Goal (SDG) United Nations' 193 Member States framework which includes 17 sustainable development goals (SDGs). Most significantly, they include a stand-alone goal for the ocean and seas—SDG 14—further acknowledging that protecting marine ecosystems is a critical component of sustainable development.

Seine Nets Hang vertically in the water, generally weighted at the bottom and with floats at the top. In pelagic fisheries, they are often used to encircle schools of fish and are 'pursed' tight at the bottom before the catch is hauled in.

Shelf edge The beginning of a steep slope from the continental shelf towards oceanic depths, typically around 200m depth.

STECF The Scientific, Technical and Economic Committee for Fisheries established by the European Commission to provide them with independent, evidence-based scientific and technical support throughout the whole CFP lifecycle.

TAC Total Allowable Catch, the amount of each fish species that EU fishing member states may catch each year.

Trammel net A wall of several layers of netting hung vertically. Fish get entangled between the layers of netting. Mainly used to target demersal species.

Trophic level The trophic level is a position an organism occupies in the food web. 'Low Trophic level' fish are general plankton eaters such as herring; 'high trophic level' fish are predators such as cod.

Whitefish Finned demersal fish such as cod, whiting, hake and haddock.

Razorbill
(John Fox)