An Roinn
Ealaíon, Oidhreachta agus Gaeltachta
Department of
Arts, Heritage and the Gaeltacht

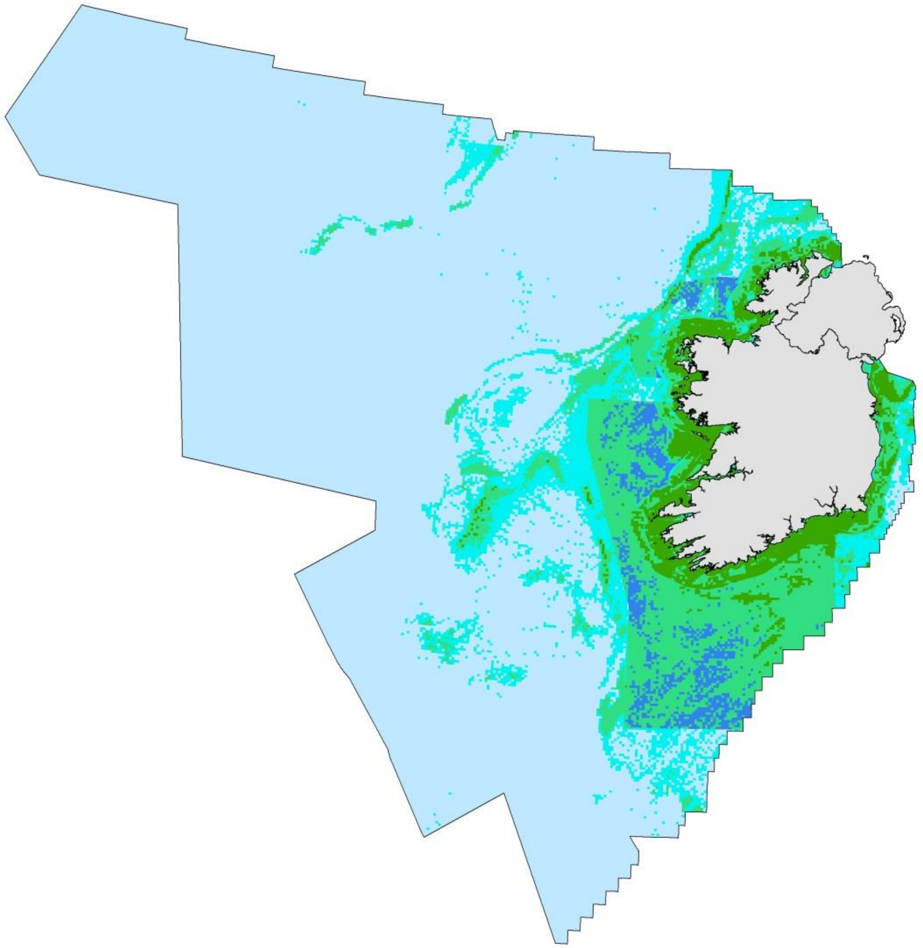
Marine areas that provide food: Indicator document - Ecosystem Service Modelling & Rule-base development

National Parks & Wildlife Service

Marine areas that provide food

Ecosystem service: **Marine food (Provision)**

29/03/2016



Legend

- ES provision hotspot
- Strong ES provision
- ES provision
- Some provision
- Neutral

How to interpret the map:
Green colours represent areas with a high contribution to marine food provision, based on data on fisheries effort; turquoise and blue areas have a lower direct contribution to marine food provision.

Ecosystem service:
Food (provision) – Marine areas that provide food

What the service is:
This service includes everything taken from the sea for human consumption. This includes fish (marine and diadromous), shellfish, crustaceans, and algae, both from wild harvest and from aquaculture.

Why it is important:
Increasing populations globally create increasing demand for food provision and are putting pressure on the marine ecosystem. Understanding current food provision, particularly in the coastal zone, is important in future marine spatial planning.

How the map was created:
The most important datasets for mapping of this service are direct measures relating to fisheries. Protected areas are included in the scoring, as they can help protect fish stock and juvenile life stages. Terrestrial habitats have been included in the mapping where they are of direct relevance, such as saltmarshes, which form nursery areas and support marine fisheries. Anthropogenic structures can impact marine food provision, if they are associated with fisheries restrictions.
This map does not consider how different substratum types support marine fisheries.

Valuation example:

Ecosystem Service Typology	Significant effects	Data used	Example attributes	Indicative scoring
Marine Food Provision	Fisheries management	Fisheries data	High intensity Low intensity	High Low
	Fisheries closures	Protected areas	None Closed for fisheries	Neutral Low
	Unharvestable areas	Dumping at sea / Windfarms	Area can be harvested Area cannot be harvested	Neutral Low

0 50 100 150 200 250
Kilometres

N

For full list of datasets used for this map, please refer to the final project report.

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Environment SYSTEMS evidence and insight

Indicator	CICES classification
MARINE FOOD PROVISION **Marine areas that provide food (Marine food (Provision)**	**Section**: Provisioning **Classes:** • Wild plants, algae and their outputs • Wild animals and their outputs • Plants and algae from in-situ aquaculture • Animals from in-situ aquaculture. **CICES IE Sub-class:** Multiple classes (see CICES for Ireland_fordb.xlsx for details)
Scale	**CICES Cascade Level** [1]
Strategic/National/~~Regional/Local~~	~~Structure/Function/~~Service/~~Benefit/Value~~

[1] Potschin, M. and R. Haines-Young (2016): Frameworks for ecosystem assessments. In: Potschin, M., Haines-Young, R., Fish, R. and Turner, R.K. (eds) Routledge Handbook of Ecosystem Services. Routledge, London and New York, pp 125-143.

What the service is

This service includes everything taken from the sea for human consumption. This includes fish (marine and diadromous), shellfish, crustaceans and algae, both from wild harvest and from aquaculture.

Function indicator(s) mapped

The most important datasets for mapping this service are direct measures relating to fisheries. Protected areas are included in the scoring as they can help protect fish stock and juvenile life stages, but scoring depends on the exact legislation of the area. The Greencastle Codling Protected Area is an example of a protected areas set up with this mechanism in mind. Data on the actual fish landings could make the spatial analysis more accurate.

Terrestrial habitats have been included in the mapping where they are of direct relevance. This mostly refers to the saltmarshes included in the terrestrial map, which have been scored highly due to their nursery function supporting marine fisheries both in coastal waters and further offshore.

Areas with anthropogenic structures can impact marine food provision, if they are associated with fisheries restrictions. Dumping at sea has been considered an influencing factor, as sites known to be used for dumping of harmful substances cannot be fished. On the other hand, dumping of fish waste can, under some circumstances, attract more fish biomass to an area and, hence, increase catches.

Datasets used	Dataset requirement [2]
Habitat Asset Register [3]	Desirable
Conservation Designations	Essential
Inshore Fisheries	Essential
Dredge Fishing Activity	Essential
Line Fishing Activity	Essential
Net Fishing Activity	Essential
Bottom Trawl Fishing Activity	Essential
Mid-water Trawl Fishing Activity	Essential
Pot Fishing Activity	Essential
Fishing Intensity by vessels >15m in length – Mobile Seine	Essential
Fishing Intensity by vessels >15m in length – All Gears	Essential
Fishing Intensity by vessels >15m in length – Mobile Bottom	Essential
Fishing Intensity by vessels >15m in length – Mobile Other	Essential
Fishing Intensity by vessels >15m in length – Other	Essential
Biologically Sensitive Area	Essential
Greencastle Codling Area	Essential
Periwinkle Access Points	Beneficial
Fishing Ports	Beneficial

[2] 'Essential' datasets are needed to map the service, whilst 'beneficial' datasets will increase model accuracy but are not necessary requirements for mapping.

[3] The Habitat Asset Register only contains habitats suitable for national scale mapping; for details, please refer to the project report.

Shellfish Waters Directive	Beneficial
Commercial Ports	Beneficial
Dumping at Sea Boundaries	Beneficial
Marinas	Beneficial
Local Ferry Ports	Beneficial
Sea Fishing Spots	Beneficial

How the map was created

The terrestrial habitat is based on a habitat conflation of several datasets; it was used for this map, to include coastal and intertidal areas that play an important role in supporting the fisheries resource by fulfilling a nursery function for many commercially harvested species. The relevant terrestrial habitats for marine food provision is are saltmarshes. Fisheries data that recorded intensity on a continuous numerical scale has been grouped using histogram statistics. The resulting classes have been scored from 'high' to 'low' and were then combined into one map layer using 'overlay analysis'.

The map should be interpreted as showing ecosystem service information based on the data currently available; when new data become available the maps can be updated. The maps are intended for use at the strategic scale, and further information should be gathered before decisions are made regarding a particular location.

Scoring

Significant Effects	Datasets used	Example attributes	Indicative scoring [4]
Some habitats included in the terrestrial habitat layer fulfil a nursery function benefitting fisheries	Habitat Asset Register	Estuaries	High
		Coastal lagoons	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Inshore Fisheries	Trawl (Pelagics); Aquaculture	High
		Line fishing (Gadoids); Dredge	Medium
		Line fishing; Gathering	Low
Higher value for more desirable/valuable species for human consumption	Dredge Fishing Activity	None	High
		[whole layer]	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Line Fishing Activity	Jigging Machines, Pollack & Mackerel	High
		Handlines, Pollack & Mackerel	Medium
		Troll Lines, Squid	Low
Higher value for more desirable/valuable species for human consumption	Net Fishing Activity	Draft Net, Salmon	High
		Gill Net, Turbot	Medium
		Trammel Net, Bait	Low
Higher value for more desirable/valuable species for human consumption	Bottom Trawl Fishing Activity	Queen Scallop Bottom Trawl, Queen Scallop	High
		Bottom Trawl, Nephrops	Medium
		None	Low
Higher value for more desirable/valuable species for human consumption	Mid-water Trawl Fishing Activity	[whole layer]	High
		None	Medium
		None	Low

[4] The indicative scoring in this table gives overview-type information on how the individual data layers were incorporated into the ES maps. For full scoring, please refer to the spreadsheet containing the full rules-base.

Higher value for more desirable/valuable species for human consumption	Pot Fishing Activity	Lobster	High
		Creel, Brown Crab	Medium
		Creel, Brown Crab	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – All Gears	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile Bottom	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile other	10	High
		5	Medium
		1	Low
Higher intensity will result in higher food provision	Fishing intensity by vessels >15m in length – Mobile Seine	None	High
		5	Medium
		1	Low
Manual periwinkle harvest unlikely to contribute strongly to food provision	Periwinkle Access Points	None	High
		None	Medium
		[whole layer]	Low
Mark point of delivery of the service, not the service itself; due to potential pollution and lack of fishing in the direct vicinity, slightly negative impact	Fishing Ports	None	High
		None	Medium
		[Whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Biologically Sensitive Area	None	High
		None	Medium
		[whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Greencastle Codling Area	None	High
		None	Medium
		[whole layer]	Low
Protected areas are considered to overall benefit fisheries by supporting stable stocks	Shellfish Waters Directive	None	High
		None	Medium
		[whole layer]	Low
Fisheries activity around port area unlikely	Commercial Ports	None	High
		None	Medium
		[whole layer]	Low

Fisheries activity around marinas unlikely	Marinas	None	High
		None	Medium
		None	Low
		Fuel facilities, no toilets	Disbenefit
Fisheries activity around port area unlikely	Local Ferry Ports	None	High
		None	Medium
		None	Low
		[Whole layer]	Disbenefit
Reduced water quality can render sea food from this region unfit for human consumption	Dumping at Sea Boundaries	None	High
		None	Medium
		None	Low
		Sludge arising from the treatment of trade effluent	Disbenefit

Data gaps associated with this map during the pilot project

The map relies heavily on fisheries data, which might not have been recorded to the same extent in all areas. It is possible that recording bias causes the model to show high food provision in coastal areas, whilst neutral values further offshore could be caused by less data being recorded and available.

To improve understanding of the fisheries resource, i.e. the supply of algae, fish, and shellfish, it would be beneficial to understand the contribution of habitats to maintaining healthy stocks. However, the relation between habitat types and individual fished species is not well enough understood. In addition, data on species-specific fishing areas was not available or does not currently exist to enable spatially explicit mapping to incorporate this concept at this time.

Scientific framework for modelling 'marine food provision'

Overview:	The oceans provide an important source of food to coastal communities and underpin economies around the world (Cochrane et al., 2009). Fishing is an important food provisioning activity providing a fundamental ecosystem service (Makino and Sakurai, 2014) through the harvesting of wild and farmed finfish, molluscs and shellfish (hereafter referred to collectively as "fish"). Fish harvesting locations range from shallow to deep water environments and are conducted by a variety of methods from small-scale artisanal fishing practices to large-scale trawling and aquaculture enterprises (Sewell and Hiscock, 2005). Fish

	stocks for food provisioning are controlled by a number of factors, which include water column properties, habitat, development opportunities, and management restrictions. Marine aquaculture (mariculture) also provides food provisioning services through the cultivation of saltwater plants/algae, most commonly macroalgae. The aquaculture industry has grown by 8.7% per year since 1970 – three times faster than agriculture (Diana et al., 2013). This makes it a fundamental contributor to the food provision service.
Water	Water properties are important considerations for marine food provision. Some of the most important supporting functions for marine food provision are nutrients/organic load, turbidity/suspensoids, sea temperature, currents, salinity, and sources of pollutants. The role of nutrients and organic compound load in the water column is accepted as fundamental in determining growth and development of algae, which underpin wild and farmed fisheries and plant/algae aquaculture (Whitney et al., 2005). Turbidity describes the optical properties of a liquid which causes light to be scattered, reducing water clarity. Suspensoids include organic or inorganic solid or colloidal particles held in suspension within a liquid. The effects of turbidity and suspensoid load in the water column can have wide ranging implications on fish stocks. In some instances, high turbidity can reduce marine fish stocks by hindering fish growth (both first maturity and maximum size), deoxygenizing the water column, clogging gills, reducing visibility of pelagic food, and by providing extra habitat for photophobic fish. Conversely, reduced visibility may increase fish survival rates by allowing concealment from predation/reducing aerial predation risk (Bruton, 1985; Kaartvedt et al., 1996). Currents provide a wealth of functions affecting fisheries and aquaculture by exchanging water. This a) changes nutrient availability (Whitney et al., 2005); b) provides a source of herbivorous food (plankton input); c) oxygenates the water column; d) provides a source of larval recruitment; e) propagates cool, nutrient rich water from poles or deep water; and f) provides an input of sediment (Crawford and Thomson, 1991). The above processes are essential supporting functions for marine food services. Water motion improves seaweed nutrient uptake and removes epiphytes and waste products (Diez et al., 2003). Salinity is essential for the spawning success of some fish species, where hyper-

	osmotic conditions are required (Westin and Nissling, 1991). Low salinity can dramatically impact the populations of shellfish (i.e. oysters) (Hofmann and Powell, 1998).
Habitat	Fisheries habitats are both complex and varied, and often species-dependent. Unlike terrestrial habitats, marine habitats tend to exist in a three dimensional setting, where the water column acts as much a part of the habitat as the substrate, geology and biology present on them. A positive relationship exists between sediment depth and the abundance of macrophytes, where macroalgae abundance increases with increases in sediment depth (Zieman et al., 1989). Roots are more readily established in fine grained sediments and may increase aquaculture success. Benthic structure may provide refuges for fish in areas where seabed relief is highly complex (Thayer and Chester, 1989), enhancing the chances of fish reaching maturity and maximum size, in turn increasing wild fish biomass. Bays, reefs and lagoons also provide areas with fish refuges and reduce damage to macroalgae by wave action. Light attenuation through the water column directly affects the photosynthetic efficiency of macroalgae, limiting cultivation, typically occurring at depths <20 m (Quartino et al., 2001). Photic zones dictate the distribution of fish (especially the distribution of photophobic/photophilic fish), which are depth dependent. Species richness for macroalgae tends to decrease at depths greater than 20m, probably due to light attenuation limiting photosynthetic efficiency (Quartino et al., 2001).
Other Effects	Primary productivity has a positive correlation with fish standing stock (Nriagu et al., 1990), particularly with phytoplankton production and the concentration of chlorophyll-α (Downing et al., 1990). These could be measured by using the Normalised Difference Vegetation Index (NDVI) in marine remote sensing imagery.
Management	Management leading to reduced biodiversity includes: • Mono-species cultivation reducing biodiversity, thus reducing natural habitat for wild faunal biomass for food provision • By-catch: fisheries waste product removed from breeding stocks but not utilised as marine food. • Environmental degradation associated with fishing techniques (i.e. bottom trawling) altering natural habitats for wild faunal biomass for

	food provision. • Unsustainable mariculture: pollution (faecal material, uneaten food, nutrients, and chemicals and drugs like pesticides, disinfectants and antibiotics) negatively impacting wild fish stocks (Cao et al., 2007); requirement of live feed for carnivorous farmed fish stocks reducing wild marine faunal stock (Benetti et al., 2006). Management, leading to increased biodiversity includes: • Sustainable fisheries practices that ensure fisheries stocks for long-term marine food provision. In 2008, 46% of fish, crustaceans and molluscs consumed by people were sourced from aquaculture projects (Jensen et al., 2014), and, as property rights strengthen for aquaculture, the aquaculture industry will invest in new technology to improve aquaculture efficiency (Anderson, 2003).

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