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MAPPING THE BIOECONOMY: BIOLOGICAL RESOURCES AND PRODUCTION IN FORESTRY, AGRICULTURE, FISHERIES AND AQUACULTURE ACROSS NORWAY

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TITLE: Mapping the bioeconomy: Biological resources and production in forestry, agriculture, fisheries and aquaculture across Norway.

Summary: Terrestrial and marine resources is the primary basis for the bioeconomy. This report gives an overview of the status and development of biological resources and production across forestry, agriculture, fisheries and aquaculture in Norway. Resources and output in the sectors vary both geographically and over time. Forestry is mostly inland in the Southeast, fisheries and aquaculture is along the Southwestern and Northern coasts, while agriculture is more spread across the country. The annual increment in the productive forests, at around 25 million m^3 for many years, has been bigger than the annual logging at 7-10 million m^3, leading to increased standing volume. The share of agricultural land in Norway is small at 3 per cent, but a high proportion of this is arable. The use of agricultural land has decreased slightly over the last decade, but the production of food from agriculture has been quite stable at 10 000-12 000 Terajoule/year. In fisheries, spawning stock of different species fluctuates markedly over time with corresponding variations in catches. However, the total harvest of wild seafood has been around 2.5 million tons annually since the mid-1990s. Aquaculture has had continuous growth since the birth of this sector in the 1970s, except for two years, and was at 1.3 million tonnes in 2014. The potential for increased production differs between the sectors, depending on the biological resource base, but also various techno-economic and environmental challenges. In *forestry*, there is potential for utilising the increased standing forest volume. In *agriculture*, production can be increased through better agronomic practices, such as crop rotation, and use of outfield grazing areas for livestock. In *fisheries*, traditionally harvested fish species are practically fully exploited, but expansion can be achieved through exploiting other species, for example plankton and seaweed. The *aquaculture* sector has an ambition of a five-fold production increase. The realization of this requires among other things control with diseases, securing sufficient feed with the right quality and handling of negative impacts on the environment.

Keywords: Bioeconomy; primary productions; resources; developments; Norway; Biosmart project

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Foreword

The purpose of this report is to give an overview of the biological resources (biomass) and production (output) in Norway across the primary sectors, on land (forestry and agriculture) and in the marine environment (fisheries and aquaculture). The report lists relevant data sources and what type of information is available on the topic, including at what geographical resolution and the notation. In the conclusion, we provide some thoughts on the potential for future development in the sectors.

The report is connected to Work Package 6, Task 1 in the Biosmart project, which investigates: *What is the status for biological biomass resources in Norway from forestry, agriculture and the marine environment in terms of annual availability, fluctuations and use? Do the resources meet 2030's needs foresighted in Work Package 2 (scenarios for the bioeconomy)?*[1]

More specifically, in this report, we 1) identify and quantify basic biomass resources in the different sectors, 2) net annual growth and fluctuations in the resources, and 3) output based on the resources in terms of harvesting of forests and fish and production in agriculture and aquaculture and development in output in recent decades. "Use", including exploitation of this output (e.g. in the processing industry) and if the resources meet future needs (cf. foresights for 2030) will be specifically explored in a later report.

[1] For more information, see: www.biosmart.no

1 GLOSSARY AND DEFINITIONS

Before we go on, it is necessary to define some frequently used terms in the discussion of bioeconomy.

Bio-economy: "The Bioeconomy encompasses the sustainable production of renewable biological resources and their conversion and that of waste streams into food, feed, bio-based products such as bio plastics, biofuels and bioenergy. It includes agriculture, forestry, fisheries, food and pulp and paper production, as well as parts of chemical, biotechnological and energy industries" (SCAR 2014).

Statistical group: Biological resources and products are often grouped in statistics. For example resources are often reported at a lower resolution than species. In fisheries statistics "groups" refer to the following: pelagic fish, cod – and cod species, benthic fish, deep water fish, shellfish and molluscs.

Species: "In sexually reproducing organisms, a group of interbreeding individuals not normally able to interbreed with other such groups" (Henderson and Lawrence 2000).

Taxonomic category: Is "used in the classification of living organisms, e.g. phylum, class, order, family, genus or species" (Henderson and Lawrence 2000).

Taxonomic resolution: Is in this report used to describe statistics on biomass production and utilization is available at different resolutions with respect to identification of the organisms produced/ utilized. Some data is given at the level of species, while other data is grouped.

Raw material, main product, rest product, by-product and waste: There are no ultimately unified definitions of these terms. However, there exist some recent opinions and general guidelines (EU-kommisjonen 2007, Kemistsamfunnets nomenklaturutskott 2010). *Raw material* (also called raw product) can be defined as any object or material for further processing. *Main product* is an object or material that is the purpose of a production process, also called primary product, e.g. fish and shellfish harvested in fisheries or timber logged in forestry. (NB! A certain production process may be aimed at more than one main product.) *Rest product* is a product that does not constitute the main product of a production process. There are gliding transitions from raw material to product through the value chain, such that in fisheries one uses the word rest raw material rather than rest product. Moreover, there are two categories of rest products. An applicable rest product is a *by-product*. A rest product that is not applicable (has no value and is scrapped), is called *waste*. With connection to this nomenclature, EU (and Norway as part of EEA) has established regulations for *specific* categories of rest products, such as animal by-products (Mattilsynet 2007). These are defined as products that cannot be used for human consumption and divided into various categories according to risk (Richardsen, Nystøyl et al. 2015).

Measures of biological resources (units): Biological resources (biomass) have different purposes and are measured in various ways. Biomass is commonly used, for example in fisheries, aquaculture and agriculture, but in some contexts and for some sectors it may be relevant to use other measures, for example volume in forestry. Energy content can be relevant for food, feed and fuels (measured in joule, eventually kg or tons), while fibre (e.g. timber, wool) can be measured in volume (e.g. m3) or mass (e.g. kg). Energy flow through ecosystems is given per unit area, where the bodies of living organisms within this unit area constitute a standing crop of biomass. This is normally expressed in units of energy (e.g. kilojoule per m^2), or dry organic matter (e.g. tons per m^2). The biomass includes the living parts of the organism, as well as dead parts attached to the organism (necromass, not capable of generating new growth) (Begon, Harper et al. 1996).

Growth: Stock change is a function of recruitment, individual growth, natural mortality and harvest (Flaaten 2011). The growth of a stock determines the potential for sustainable harvesting within a given time period, which in the context of natural resource extraction normally is a year.

Output: Biological matter (biomass) extracted from harvesting of fish and forest, and resulting from agricultural and aquaculture production. Note that input and output are relative entities, as output from one production or sector may represent input in a later stage in the value chain.

Standing crop vs standing stock: Standing crop is the bodies of living organisms within a given unit area at any specified time (Begon, Harper et al. 1996, Henderson and Lawrence 2000). Standing stock is the weight (or number) of a group of individuals of a species that can be regarded as an entity for management or assessment purposes (a separate breeding population of species) (source: glossary, www.fishbase.org). Standing stock is often used for marine populations and for forests. In agriculture, the term stock is applied to animal production (livestock), while standing crop is relevant for plant production.

2 BRIEF CHARACTERISTICS OF FORESTRY, AGRICULTURE, FISHERIES AND AQUACULTURE IN NORWAY

Mainland Norway consists of 323 781 km^2 land area. If you include Svalbard, Bjørnøya and Jan-Mayen, Norway is 385 180 km^2. In terms of sea area, Norway's Exclusive Economic Zone, where Norway has sovereign rights over the marine resources, is 10.3 million km^2. In addition, Norway has fisheries jurisdiction around Svalbard and Jan Mayen, the "Fisheries Protected Zone" which makes up 10 km^2 (kartverket.no). The coastline of mainland Norway is 102 373 km long (Statistics-Norway 2016). In addition there are fresh-water resources that are not included in this overview. These land and sea areas are the basis for the Norwegian bio-economy from forestry, agriculture, fisheries and aquaculture in Norway.

2.1 FORESTRY

There is about 75 000 km^2 of productive forest in Norway, which makes up about 20 per cent of the land area. It is unprofitable to log about 10 per cent of this forest. Much of the afforestation happened at a time with manual labour, using horses. That is why much of the forest is planted in terrain that is very difficult to access with today's technology. Today logging is conducted with the use of logging machines and forwarders. There are about 120 000 land owners in Norway with forest. 40 000 of these organize harvesting in their forest for industrial purpose. Land owner structure is fragmented in the way that the 20 per cent biggest land owners stand for 80 per cent of all cuttings. Normally these land owners are harvesting the growth from forest. Current regulations have a strong focus on climate and environment, which has affected the logging operations and costs to the processing industry. In combination with reduced prices of wood after WWII, the profitable area of forest has been reduced. In addition, there has been an increased focus on protection of land areas, including coniferous forests (Vennesland, Hohle et al. 2013, Granhus Aksel 2014).

2.2 AGRICULTURE

Along with labor, technology and knowledge, cultivated land, crops and livestock are the basic resources for agricultural production. Cultivated land is characterized in that it is land affected by culture (exposed to human activity). Agricultural land may have plants in the form of permanent vegetation (meadows, pastures or other perennial crops) or periodic vegetation (arable land) (Skog og landskap 2010). Unlike fisheries, but similar to aquaculture, organisms used in agriculture (crops and livestock) are domesticated, nurtured by humans and often bred through selective breeding. Due to the northern latitude and a limited growing season (5 months in average) and rough topography, agriculture in Norway is a challenging business. Milk and grain production are the two most important productions in terms of energy output. Most of the grain production is located in the low lands of Eastern and Mid Norway, while in other areas grass based animal productions dominate. This regional differentiation has been strengthened through the so-called "canalization policy" pursued since the 1950s. Through

market and price instruments, this policy facilitates grain production in the most favored areas (lowlands in Eastern and Mid Norway) thereby indirectly securing "room" for grass based animal productions in areas with less production options (Almås 2002, Forbord 2015). Since the 1990s, animal productions based on feed concentrates, especially chicken, has been the fastest growing agricultural productions. Most of the produce is processed in the food industries into various products, of which most are distributed and sold by the retail chains. Nearly all production is consumed domestically.

2.3 FISHERIES AND AQUACULTURE

Wild fish harvest[2] was about twice as large as aquaculture production in 2014 (2.3 mill tons vs 1.3 million tons), but in terms of value, the first hand value of aquaculture production was 44.334 billion NOK in 2014, while for wild fish the number was 14.427 billion NOK (Statistics-Norway 2016). Aquaculture production has shown a steep increase the past 20 years, with salmon being the most important species for aquaculture, followed by trout (Statistics-Norway 2016). The Norwegian government aim to increase aquaculture production. However, there are some environmental challenges to securing sustainable growth in this industry. This includes solving the problem of escapees and salmon lice (Svådesand, Boxaspen et al. 2015).

Cod and herring are the most important wild caught species in terms of quantity and value (Statistics-Norway 2016). About 80 per cent of the stocks the Norwegian fishers harvest are shared stocks with other nations, mainly Russia and the EU. This is because the stocks migrate between the exclusive economic zones (EEZs) of the different countries (FKD 2002). The amount of fish Norway can harvest is determined through annual negotiations where the quotas on different species are set. The negotiations are based on recommendations on sustainable harvest levels given by fisheries scientists, via ICES[3] which is an independent scientific institution for giving advice on sustainable use of the oceans. The Institute of Marine Research is responsible for research and stock assessments in Norway. Once the Total Allowable Catch (TAC) is determined, the Norwegian quotas are allocated the different vessel groups (trawl and conventional vessel groups) down to the level of vessels (FKD 2002).

Traditionally, marine harvesting was governed by the migration pattern of the fish, seals and whales to the coast. Technological advancements lead to development of larger, motorised vessels that could go further out at sea (snl.no). The number of fishing vessels have decreased steadily from its peak in the 1960s of about 40 000 vessels to about 5900 vessels in 2014. At the same time, the amount of fish being harvested per vessel has increased from 818 671 tons in 1945, to 2 436 744 tons in 2008. This is due to increased efficiency of the vessels. Also the number of fishers have been reduced from 112 000 in 1945, to 11 300 in 2014 (Storbråten 2010, Statistics-Norway 2016).

[2] The amount of salmon, trout and char caught in rivers is small (321 tons in 2014) and is not included in this analysis.

[3] The International Council for the Exploration of the Sea (www.ices.dk).

3 METHOD AND DATA

3.1 METHOD

The method we applied was to gather relevant publicly available secondary statistics on the Internet. We arranged and systematized the various statistical information for the actual sectors aimed at facilitating comparisons across sectors and between geographical spaces. Concerning the *time dimension*, we show data on development on national level over the last 2-4 decades, and then present detailed data for the most recent contemporary year with complete data, year 2014, or if not available, the most "nearby" year. Regarding *spatial resolution*, we present contemporary data on county level, where Oslo (with little primary bioeconomy) is grouped together with the neighbouring county Akershus, altogether 18 county "units".[4]

Concerning the *theme of* the report (biological resources and production) we applied the standard categories in the statistics, or eventually merged them into larger categories. In the statistics, partly different *measures* are used in the different sectors to account for the various resources and outputs. In forestry, cubic measures (m3) dominate, both for resources and output. In aquaculture and fisheries, measures for mass (typically tons) are used. Mass measures are also commonly used for agricultural output (e.g. tons of grain, tons of wool). However, for agricultural resources, surface measures (e.g. hectares of land) and numbers (of animals) are used. It is though possible to convert from some of these measures to more unified measures, such as mass (e.g. in terms of tons) and nutritional value (e.g. in terms of Joule). At the end of the report, we attempt to "totalize" and compare the biomass production in the various sectors. Most of the data are presented as numbers in tables. Some information is also presented graphically.[5]

3.2 DATA SOURCES

Table 1 in Appendix 1 gives an overview of sources of data for biological biomass resources in Norway for the sectors forestry, agriculture and the marine environment (fisheries and aquaculture). Among other things, the table shows on what spatial level (resolution) and time dimension (time series) the various data can be presented.

[4] In terms of primary productions, the 19 counties could have been grouped into five larger and relatively homogeneous regions, such as: 1) Eastern Norway (Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold), 2) Southern Norway (Telemark, Aust-Agder, Vest-Agder), Western Norway (Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal), Mid Norway (Sør-Trøndelag, Nord-Trøndelag), and Northern Norway (Nordland, Troms, Finnmark).

[5] Note that in some tables the original figures from the public statistics have been rounded to the nearest 1000, for example from decare to 1000 decare. When doing this, we have chosen to preserve the original total amount, which may then not correspond exactly to the sum of rounded figures for the counties in the table.

3.2.1 FORESTRY

Basic statistics on forestry resources and logging in Norway can be found in Statistics Norway under the topic "Agriculture, forestry, hunting and fishing" (Statistics Norway 2015), subtopic "Forestry". Data on logging is given at municipality level and are normally split between spruce, pine and broadleaves. The data for growing stock and annual volume increment presented here is made available through the National Forest Inventory ("Landsskogtakseringen") (Norsk institutt for bioøkonomi 2015). Statistics on volume of forest are normally divided in conifer and broadleaves. Often we split conifer between spruce and pine. The National Forest Inventory is measuring volume of single trees in specific areas in Norway every five years. These micro areas are assumed to represent all of forest land and by that we sum up to total volume of forest (Vennesland, Hohle et al. 2013, Granhus Aksel 2014). The forestry data are provided for resources in terms of volume of growing stock (m3) and output in terms of harvested volume (m3).

3.2.2 AGRICULTURE

The general statistics on agricultural resources in Norway (land, plants and animals) are collected and presented by Statistics Norway (SSB). Basic statistics on land is presented under the statistical topic "Nature and the environment" (Statistics Norway 2015). The rest of the statistics on agricultural resources can be found under the statistical topic "Agriculture, forestry, hunting and fishing" (Statistics Norway 2015), subtopic "Agriculture". As the table in Appendix 1 shows, in addition to national level, statistics are also available on county level and to some extent municipal level. Moreover, the statistics exist to various degree in time series. In this paper, we present data on agriculture in Norway for *resources* in terms of land and livestock, and *output* (from production) in terms of crops and livestock products. Data are provided on county and national level.

3.2.3 FISHERIES AND AQUACULTURE

Statistics on marine biomass can be found in Statistics Norway under the topic "Agriculture, forestry, hunting and fishing", subtopics "Fishing and catches", and "Aquaculture", (Statistics Norway 2015), in data-bases of the Institute of Marine Research, ICES and the Directorate of Fisheries. Multi species- and ecosystem- models, as well as publications on biomass production of individual organisms or groups, also hold information on marine biomass, including non-commercial species. Marine *resources* discussed in this report include wild harvest of fish stocks, mammals, algae and zooplankton, and aquaculture species produced. *Outputs* are harvest landed and aquaculture species sold.

For wild stocks, there are longer time series and higher resolutions on commercial stocks, compared to non-commercial stocks. The total landings in Norway can be found by species from 1977 until today, and stock size estimates for the main commercial stocks are available from 1950. Landings of fish on the resolution of municipality can be found for groups of fish, but not by species. Ecosystem models can give information on the biomass and production of

both commercial and non-commercial species, and thereby the potential for harvesting the whole ecosystem. See for example Dommasnes, Christensen et al. (1997) of the Norwegian-Barents Sea and Pedersen, Nilsen et al. (2008) for a fjord in northern Norway. The latter model converted wet weight and dry weight into carbon (g C m^{-2}). The 1997 Norwegian-Barents Sea Ecopath model covering 2 115 000 km^2 suggest that the krill biomass in the area is 52 tons per km^2, while the large zooplankton and small zooplankton biomass is 16.9 t ton per km^2 and 33 tons per km^2 respectively (Dommasnes, Christensen et al. 1997).

4 BIOLOGICAL RESOURCE BASES AND CHANGES

Time series reflecting standing stocks of biomasses and fluctuations in standing stock can say something about the potential for bioeconomic production and value creation. For forestry and fishery the changes in the available stock biomass determines the harvest potential of the resource, while for agriculture and aquaculture production factors such as agricultural land, water and nutrition are basic factors. Current uses of land areas and marine environments can say something about the potential for future biomass production. However, there are significant types and amounts of biomass, e.g. in the waters off Norway, that are not utilized for the time being. Moreover, the report will show that the resources are unevenly distributed across regions.[6]

4.1 FORESTRY

The National Forest Inventory has monitored the development in Norwegian forests since 1919. The development has been recorded in terms of growing stock and annual increment. As mentioned, the total terrestrial area in Norway is 323 771 km2 (Kartverket 2015). Of this 83 337 km^2 (25 %) is classified as productive area of forest (Statistics Norway 2015). The total growing stock is estimated to 929 million m^3. The growing stock on the productive forest area has increased three-fold since 1925 and is currently 831 million m^3; 385 million m^3 (46 %) of spruce, 246 million m^3 (30 %) of pine and 199 million m^3 (24 %) of broadleaf wood.

The annual increment on the productive forest area amounts to 23.9 million m^3, of which spruce accounts for 13.4 million m^3, pine 5.4 million m^3, and broadleaves 5.2 million m^3. The total annual logging for sales in 2014 was 9.8 million m3, which is around 40 per cent of the annual growth on the productive forest area. 75 per cent of this logging was spruce, 24 per cent was pine and 1 per cent was broadleaf wood. The National Forest Inventory covers all areas with forest in Norway and is organized in seven regions.[7] The distribution of the various types of wood differs considerably between regions, with a high share of coniferous wood in Eastern and Southern Norway and Trøndelag, and a high share of broadleaf wood in Northern Norway. Nearly half of the annual growth on the productive forest area is in Eastern Norway.

[6] Note that there also are other basic factors for biological production, such as CO_2 and light. Since these factors exist as freely available resources, we do not analyze them in this report.

A warmer climate, in combination with fewer grazing animals, results in the total forested area in Norway growing (Granhus Aksel 2014). Total volume of growing stock does not mean that all of this is available for harvesting. We divide the trees in a forest into five different age classes. Age class number one is the youngest stand (new-planted) whereas age class number five tells that the trees are ready to be harvested. In Norway normally it takes 80 years from planting a tree to harvesting. There was a national afforestation action in Norway from 1950 – 1975. This means that in Norway we still have relatively high share of younger stands that is not ready for harvesting. Within the next 10 – 30 years a larger share of total volume of forest will be matured and ready to be harvested.

The National Forest Inventory in Norway measures the volume of growing stock and annual increment. An overview of these numbers is given at county level in Table 1 and Table 2.

Table 1: Volume of growing stock in Norway (2014) at county level (1000 m^3)

County	**Spruce**	**Pine**	**Broadleave**	***Total***
Østfold	18 812	13 763	4 461	*37 036*
Akershus and Oslo	30 808	11 435	9 133	*51 376*
Hedmark	70 035	55 314	16 221	*141 570*
Oppland	54 813	16 749	14 311	*85 873*
Buskerud	31 653	25 144	10 689	*67 486*
Vestfold	8 134	2 787	5 498	*16 419*
Telemark	29 932	22 226	14 562	*66 720*
Aust-Agder	11 923	20 639	8 139	*40 701*
Vest-Agder	10 691	16 459	10 640	*37 790*
Rogaland	5 332	7 202	7 382	*19 916*
Hordaland	13 907	11 354	10 148	*35 409*
Sogn og Fjordane	9 815	9 915	12 325	*32 055*
Møre og Romsdal	11 217	9 304	12 551	*33 072*
Sør-Trøndelag	21 137	10 393	8 575	*40 105*
Nord-Trøndelag	38 099	6 061	11 043	*55 203*
Nordland	16 739	2 822	19 677	*39 238*
Troms	1 769	2 261	16 309	*20 339*
Finnmark	0	1 918	7 147	*9 065*
Total	***384 816***	***245 746***	***198 811***	***829 373***

Source: National Forest Resource Assessment («Landsskogtakseringen»)

Table 2: Annual increment of growing stock in Norway (2014) at County level (1000 m3)

County	Spruce	Pine	Broadleave	*Total*
Østfold	745	356	179	*1280*
Akershus and Oslo	1086	304	291	*1681*
Hedmark	2382	1316	428	*4126*
Oppland	1640	379	369	*2388*
Buskerud	1117	545	336	*1998*
Vestfold	392	57	193	*642*
Telemark	921	526	421	*1868*
Aust-Agder	440	464	198	*1102*
Vest-Agder	465	320	210	*995*
Rogaland	222	135	141	*498*
Hordaland	540	185	241	*966*
Sogn og Fjordane	383	155	289	*827*
Møre og Romsdal	524	163	386	*1073*
Sør-Trøndelag	619	187	220	*1026*
Nord-Trøndelag	1204	111	393	*1708*
Nordland	608	59	468	*1135*
Troms	96	48	289	*433*
Finnmark	0	64	127	*191*
Total	***13 384***	***5 374***	***7 079***	***23 937***

Source: National Forest Resource Assessment («Landsskogtakseringen»)

4.2 AGRICULTURE

4.2.1 LAND RESOURCES

All land in Norway is mapped and presented in the so-called AR5 classification (Skog og landskap 2010). AR5 means land resource map in the scale of 1:5000. The AR5 classification describes land resources, with emphasis on suitability for crop production and natural plant production. Figure 1 illustrates the proportion of agricultural land (also called cultivated area) in mainland Norway in relation to the total land area. In international comparison, the share is low, around 3 per cent.

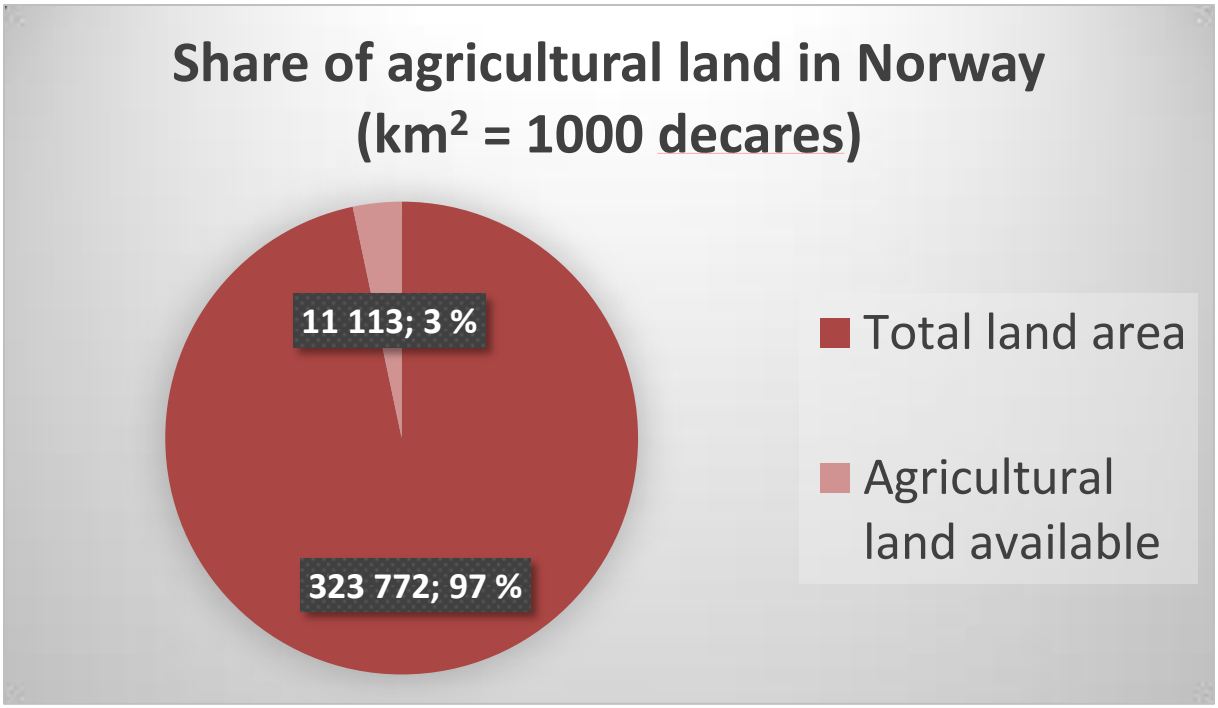


Figure 1: Agricultural land available in Norway in relation to total land area

In contrast to the relatively small area of agricultural land (also called "innmark") there are huge areas of outfield grassland ("utmark") (Arnoldussen, Forbord et al. 2014) show that in Norway there is around 250 000 km^2 of outfield grassland with a production potential corresponding to 8 million sheep units. Of these, 3 million sheep units are used today by domesticated animals (sheep, goats, cattle) and 1.4 million sheep units are used by cervids ("hjortevilt"). The rest (corresponding to 3.6 million sheep units) is not used for agricultural purposes, often due to carnivores, limited possibilities for increasing number of animals due to lack of winter fodder, long distances from farm to fields and marginal plant production on the areas.

Regarding agricultural land, this is divided into three categories: arable land, surface cultivated land and cultivated pastures. Arable land is agricultural land that is cultivated to normal ploughing depth and can be used for field crops or meadow, and which can be renewed by ploughing. Surface cultivated land is agricultural land which are mostly cleared and levelled in the surface so that machining harvesting is possible. Cultivated pastures are areas that are fenced in and can be grazed, but not harvested by machine. Not all available agricultural land is used, i.e. some of it is out of operation. Data on the use of the cultivated area is collected from the farmers' annual application of economic subsidies and are published by Statistics Norway (statistical topics "Agriculture, forestry, hunting and fishing" and "Nature and the environment", see: https://ssb.no). In total, 11.3 million decares of cultivated land was available in Norway in 2012 (see e.g. Table 3). Of this, 9.9 million decares (88 %) were in use for agricultural production. The rest (12 %) was not in use, of which most is suitable only for extensive grazing, and the potential value in terms of food production (measured e.g. as energy) is significantly less than 12 per cent.

Table 3 provides a county wise list of total land, available agricultural land and agricultural land in use in Norway. Both the volume of available agricultural land and the share of agricultural land vary hugely across counties. Also, share of agricultural land in use differs significantly across regions, with the lowest shares (66-85 %) in southern, western/north-western and northern Norway, and highest shares (90-97 %) in the eastern, middle and south-western part of the country. These differences have to do with huge differences in production conditions due to latitude, altitude and topography.

Table 3: Total land area, available agricultural land (2015) and agricultural land in use in Norway (2012). Counties and total (1000 decares = 1 km2)(Statistics-Norway 2016).

County	Total land area (2015)	Agricultural land available (2015)	Share of agricultural land (%)	Agricultural land in use, total (2012)	Share of agricultural land in use (%)
Østfold	4 181	756	18	732	97
Akershus and Oslo	5 372	813	15	772	95
Hedmark	27 398	1142	4	1043	91
Oppland	25 192	1079	4	1003	93
Buskerud	14 911	559	4	508	91
Vestfold	2 225	424	19	409	96
Telemark	15 296	289	2	243	84
Aust-Agder	9 158	141	2	110	78
Vest-Agder	7 277	224	3	182	81
Rogaland	9 377	1042	11	998	96
Hordaland	15 437	504	3	404	80
Sogn og Fjordane	18 619	520	3	429	82
Møre og Romsdal	15 100	642	4	548	85
Sør-Trøndelag	18 840	818	4	740	90
Nord-Trøndelag	22 415	904	4	864	96
Nordland	38 481	735	2	560	76
Troms	25 863	370	1	244	66
Finnmark	48 631	144	0.3	95	66
Total	**323 772**	***11 113***	**3.4**	***9891***	**89**

Over time, the volume of agricultural land has been relatively stable. However, there has been a slight downward trend since year 2000. Figure 2 depicts the amount of agricultural land in use and changes in the period 1995-2014.

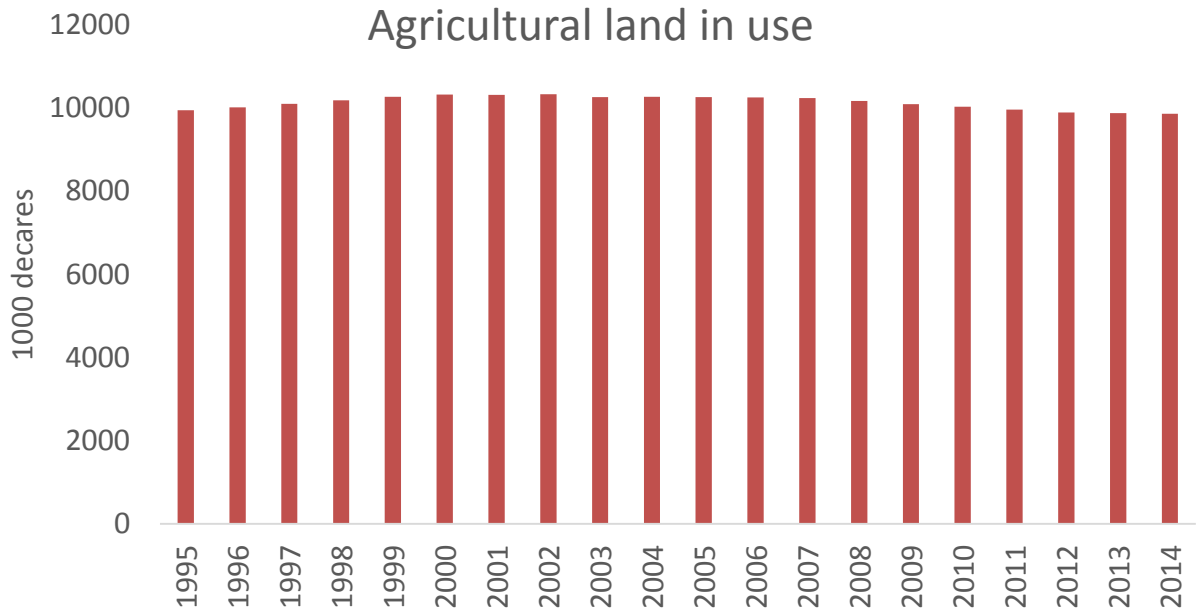


Figure 2: Development in agricultural land in use in Norway 1995-2014. 1000 decares. Source: Statistics Norway

Table 4 shows the agricultural land in use across the categories fully cultivated, surface cultivated and grazing land nationally and in the counties. Fully cultivated land corresponds to the international term "arable land". We observe that most of the agricultural land (82 %) is arable ("ploughable"). Also here the shares vary significantly between the counties, but the pattern is not identical to that of agricultural land in use (see Table 3). For example, Oppland and Buskerud in Eastern Norway and Rogaland in Western Norway has a relatively high share of surface cultivated and grazing land. The climate differs with latitude and altitude. In combination with topographic characteristics, these factors mean that production conditions for the same type of land varies regionally (Arnoldussen, Forbord et al. 2014). For example, most arable land in Western and Northern Norway is only suitable for growing grass. However, agricultural land in Western Norway is suited for growing of fruits and berries due to good weather conditions, which to some extent results from hilly, southward terrains.

Table 4: Different categories of agricultural land in use in Norway in 2012. Counties (1000 decares)(Statistics-Norway 2016).

County	**Fully cultivated agricultural land (arable)**	**Surface cultivated and grazing land**	***Agricultural land in use, total***	**Share of arable land (%)**
Østfold	711	21	*732*	97
Akershus and Oslo	736	35	*772*	95
Hedmark	975	68	*1 043*	93
Oppland	828	175	*1 003*	83
Buskerud	437	71	*508*	86
Vestfold	399	9	*409*	98
Telemark	211	32	*243*	87
Aust-Agder	93	16	*110*	85
Vest-Agder	137	45	*182*	75
Rogaland	537	460	*998*	54
Hordaland	206	198	*404*	51
Sogn og Fjordane	255	174	*429*	59
Møre og Romsdal	449	99	*548*	82
Sør-Trøndelag	632	107	*740*	85
Nord-Trøndelag	785	78	*864*	91
Nordland	443	116	*560*	79
Troms	209	34	*244*	86
Finnmark	82	13	*95*	86
Total	***8 133***	***1 758***	***9 891***	***82***

4.2.2 LIVESTOCK

In Norway, farmers keep four main types of livestock. These are cattle, sheep, pigs and poultry. Most of these animals are held for the purpose of producing food (milk, meat, eggs). Table 5 provides an overview of the number of different types of livestock in the various counties and on national level. Domestic production (grass, grain) provides a significant input of feed to this livestock, but the share of imported feed has increased since 2000 for ruminants and pigs. For these, in 2010, the shares of imported feed were 25 percent. For poultry the share has been quite stable the mid-1990s at around 40-45 per cent (Forbord 2015).

Table 5: Number of livestock in Norway per 1 January 2015. Counties and total (Statistics-Norway 2016).

County	Cattle	Sheep and goats	Pigs	Poultry
Østfold	19 864	6 806	114 890	12 914 932
Akershus and Oslo	19 083	11 219	65 364	1 748 255
Hedmark	58 695	56 283	225 485	15 590 729
Oppland	109 725	119 093	118 853	712 102
Buskerud	23 471	47 889	14 188	999 468
Vestfold	13 453	6 438	120 948	3 037 556
Telemark	12 034	26 201	19 467	311 628
Aust-Agder	8 741	14 054	11 335	395 445
Vest-Agder	21 688	25 279	14 868	407 234
Rogaland	139 824	220 764	466 901	15 420 700
Hordaland	37 802	109 732	33 681	808 229
Sogn og Fjordane	48 481	96 241	24 247	82 210
Møre og Romsdal	70 862	68 463	35 600	264 190
Sør-Trøndelag	74 370	69 701	31 823	9 732 455
Nord-Trøndelag	94 284	43 471	237 392	15 402 524
Nordland	59 272	96 473	95 643	99 771
Troms	14 687	59 328	11 437	40 282
Finnmark	6 273	10 814	706	11 646
Total	***832 609***	***1 088 249***	***1 642 828***	***77 979 356***

As with land resources, livestock resources are unevenly distributed across Norway. Since the biomass of the different types of animals differs hugely, simply adding the numbers has no meaning. However, a simple way of "standardizing" across categories of livestock is to define one sheep as a basic "animal unit" and convert the other types of livestock to this unit. Then, in terms of biomass, goats and pigs can on average roughly be treated as 1 animal unit, cattle as 4 animal units and poultry as 0.01 animal units. Using these coefficients and adding the converted figures for the four different types of livestock shown in Table 5, gives a result as in Figure 3. The figure shows that Rogaland is the livestock county "par excellence" in Norway. This county holds much cattle and sheep as well as pigs and poultry. Also Hedmark, Oppland and Nord-Trøndelag have much livestock resources. Western Norway generally has much sheep. Østfold and Vestfold have much concentrated feed based livestock in proportion to total livestock. Southern Norway (Telemark and Agder) and the northernmost counties (Troms and Finnmark) have minor amounts of livestock resources.[8]

[8] Note that we do not analyze reindeer herding in this report, which is an important bioeconomic production in Finnmark.

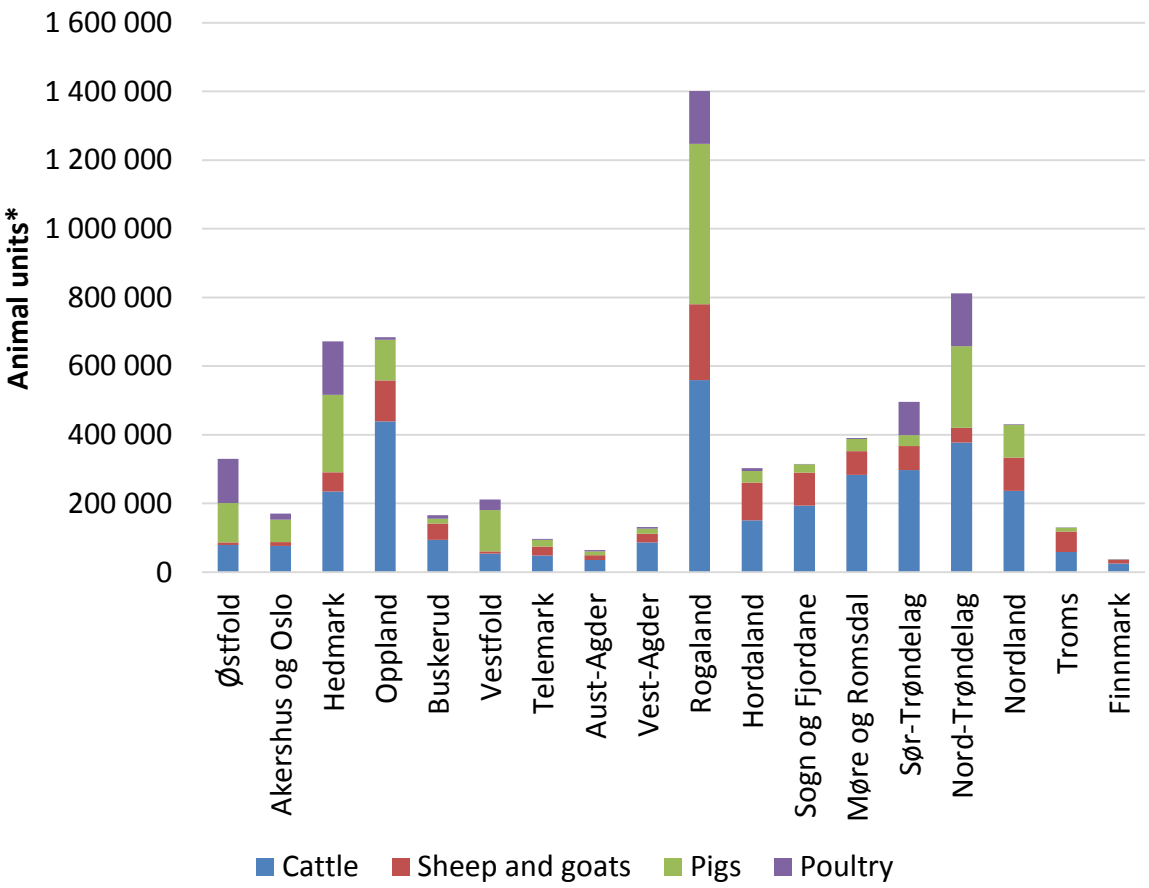


Figure 3: Calculation of livestock resources in the different counties in Norway in 2015 in terms of animal units. Source: Own calculations based on statistics provided by Statistics Norway

*Coefficients used: Sheep, goats and pigs: 1 animal unit; cattle: 4 animal units; poultry: 0.01 animal unit

4.3 FISHERIES

4.3.1 WILD STOCKS

Since the majority of the biomass harvested are from stocks shared with other countries, the biomass available for harvesting in Norway is dependent on the stock size, the part of the total allowable catch allocated Norwegian vessels, as well as the stock size of stocks that are not shared. Thus, biomass available is determined by a combination of biological factors and international negotiations. Fluctuations in stocks are due to natural variability as well as human harvesting. Important pelagic species for Norway include Barents Sea capelin, Norwegian Spring Spawning (NSS) and North Sea herring, Blue whiting and Northeast Atlantic mackerel. Northeast Arctic (NEA) cod, haddock and saithe are important groundfish species. Figure 4 and Figure 5 illustrates how some of the main pelagic- and groundfish populations important for Norway have fluctuated the past 30 years. Generally, the pelagic

species have a shorter life cycle than the groundfish species, and therefore show larger fluctuations. The NEA cod stock is currently at a historic high level.

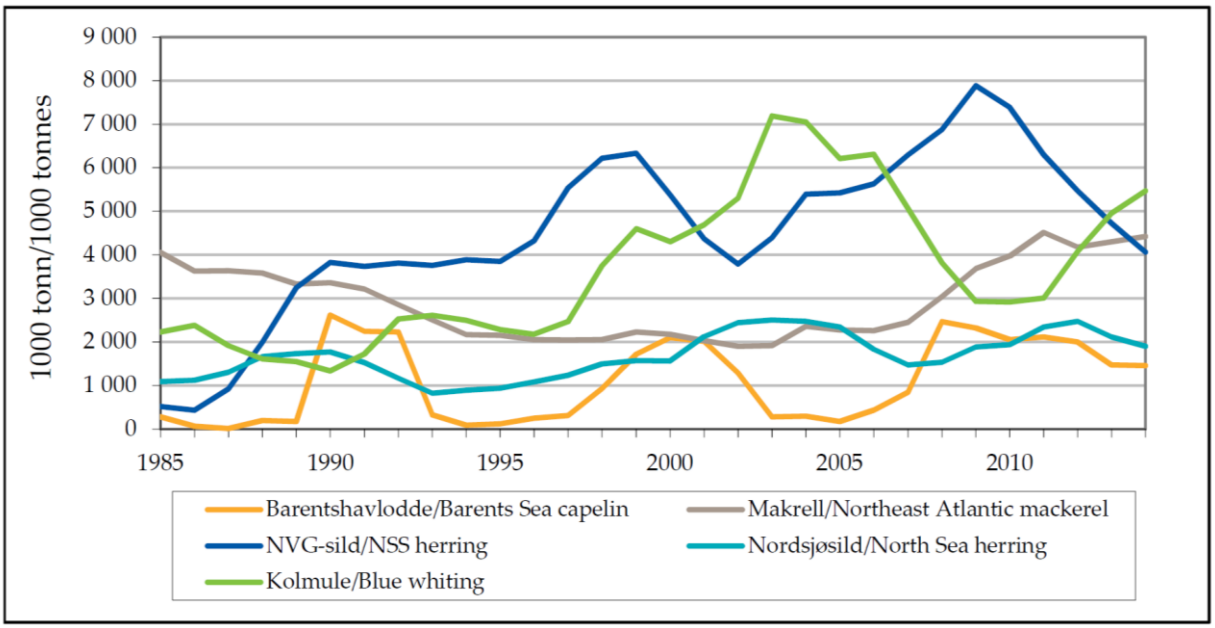


Figure 4: Spawning stock biomass of main pelagic stocks in the Barents Sea 1985-2014 (Figure from Fiskeridirektoratet (2015)).

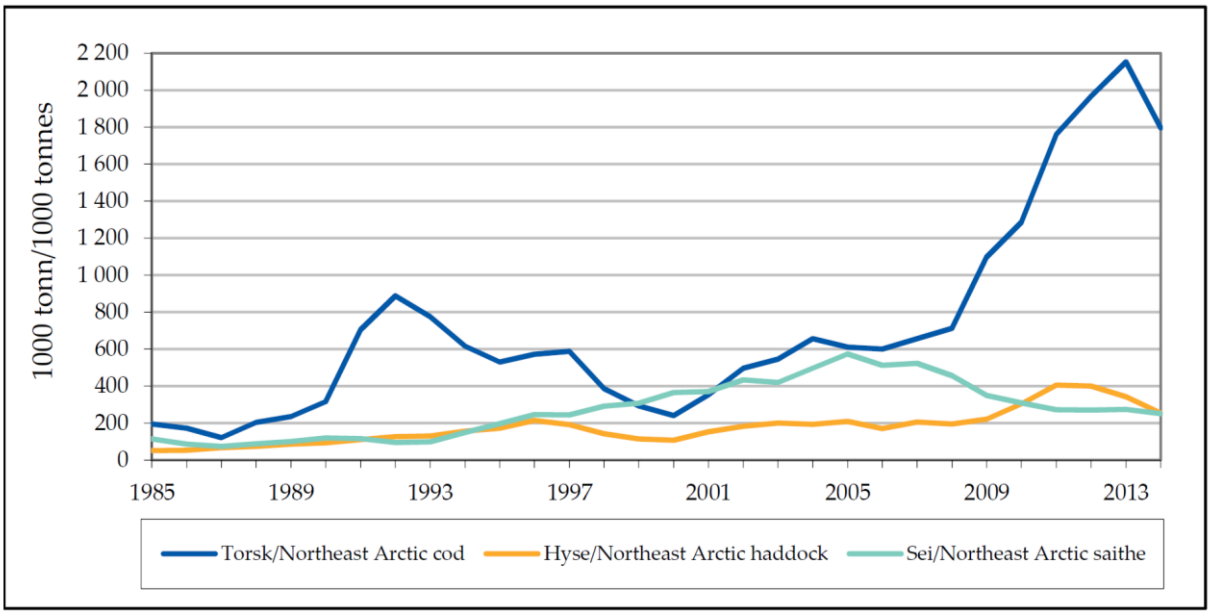


Figure 5: Spawning stock biomass of main groundfish species in north of 62° N 1985-2014 (Figure from (Fiskeridirektoratet 2015)).

Quotas allocated to Norway also show fluctuations, which partly reflect the status of the spawning stock biomass (Figure 6 and Figure 7).

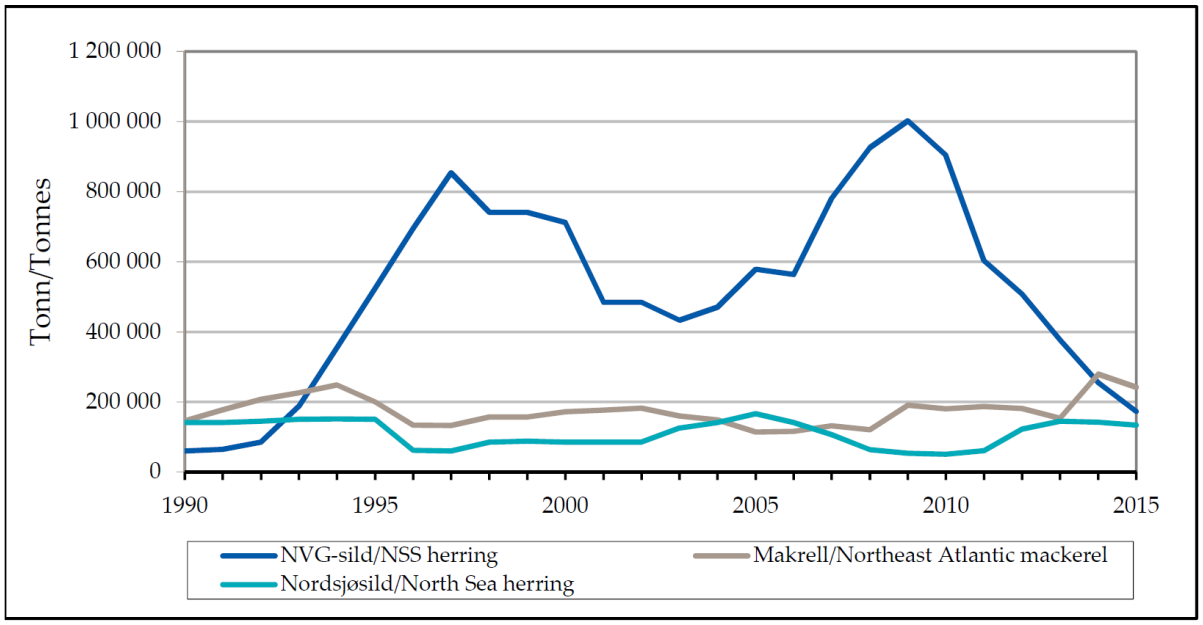


Figure 6: Quotas allocated to Norway of main pelagic species from 1990-2015 (Figure from (Fiskeridirektoratet 2015)).

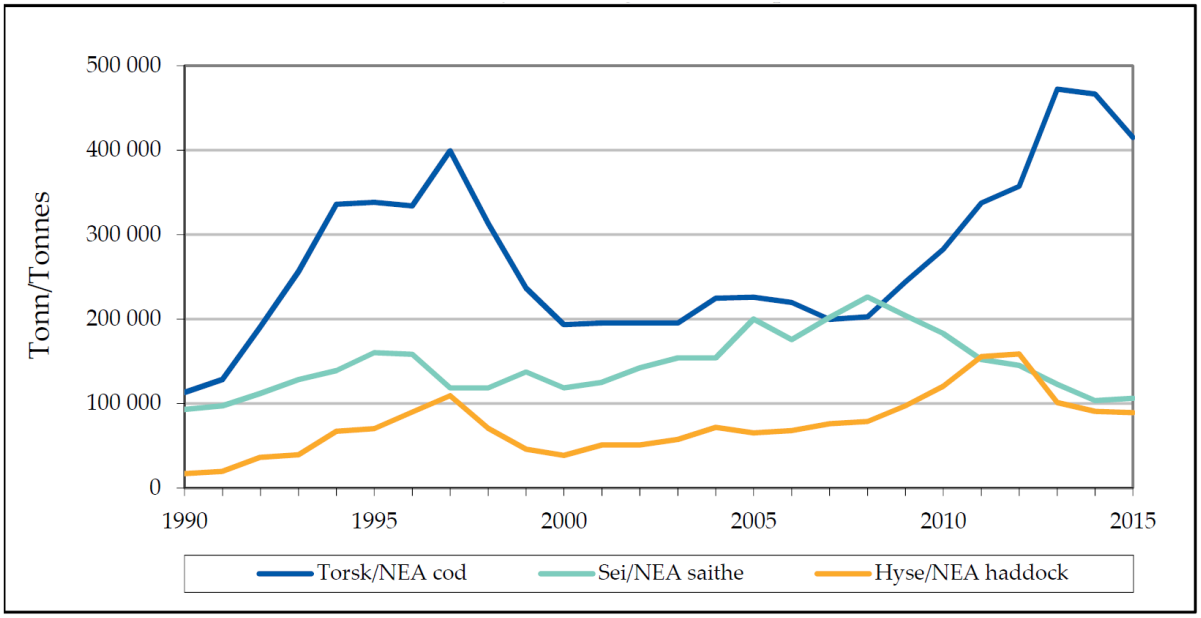


Figure 7: Quotas allocated to Norway of main groundfish species north of 62°N (Figure from (Fiskeridirektoratet 2015)).

Table 6 gives an overview of the quotas allocated to Norwegian vessels in 2014 in the different waters where Norway has rights to harvest. It illustrates that the Norwegian vessels have access to fisheries resources in different regions of the sea, from the Barents Sea in the north (north of 62°N) to Skagerrak in the south. The total biomass of the quotas is about 2.4 million tons, plus around 30 400 marine mammals (Statistics-Norway 2016).

Table 6: Quotas allocated Norwegian vessels in 2014 by species and area. Source: Fisheries Directorate, Quota overview 2014.

Species	Quota Norway (tons)
Cod, haddock, saithe, greenland halibut and redfish north of 62^{0}N	842 848
Saithe, North Sea and Skagerrak	39 749
Cod, haddock, whiting and plaice, North Sea	18 292
Cod, haddock, whiting and plaice, Skagerrak	733
Ling, tusk, blue ling, greenland halibut, sole, saithe and other spp, EU zone	14 083
Ling, blue ling, tusk, other spp, Icelandic zone	625
Cod, NAFO area	1343
Cod, greenland halibut, halibut, redfish, roundnose grenadier, by-catch other spp and shrimp, Greenl. zone	11 145
Shrimp, wolf-fish, sole and other spp, Russian zone	7200
Norwegian spring spawning herring, nort of 62N	255 277
North Sea herring	141 681
Mackerel, NE Atlantic	277 903
Capelin, Barents Sea	38 980
Capelin, Greenland/Iceland/Jan Mayen (2014/2015 season)	81 069
Blue whiting, Norwegian economic zone, Jan Mayen, Svalbard, International waters	386 697
Sprat, sandeel, Norway pout, Greater Argentine, Norwegian- and EU zone	276 070
Shrimp, North Sea/Skagerrak, Greenland-, Russian and Svalbard zone and Flemish Cap	17 862
King crab	1150
Total	***2 412 707***

Species	Quota Norway (individuals)
Minke whale, Norwegian economic zone, Jan Mayen, Svalbard	1286
Harp seal, west ice	21 270
Harp seal, east ice	7000
Hooded seal, west ice*	0
Harbour seal, Norwegian coast	425
Grey seal, Norwegian coast	460
Total	***30 441***

*Scientific purposes only

4.3.2 OTHER HARVESTING

Calanus is a genus of marine copepods with an annual production in the Norwegian Sea of 300 million tons. Since only 10-15 per cent of the biomass is incorporated in the next trophic level, it is believed that these lower trophic levels have a great potential as a resource that can be harvested (calanus.no 2015). However, zooplankton biomass show large interannual and spatial variations (Dalpadado, Arrigo et al. 2014), furthermore, a precautionary harvesting strategy should be adopted as zooplankton is an important source of food for higher level predators. Currently there is a small trial fishery outside Northern-Norway, but it is expected that the harvest will increase in the future. Adding the biomass numbers for zooplankton in the Norwegian-Barents Sea model (Dommasnes, Christensen et al. 1997), gives a biomass of 216 million tons zooplankton in the Norwegian-Barents Sea area.

Egg wrack and kelp are the only macro algae harvested in Norway. 130-180 000 tons of kelp and 10-20 000 tons of knotted wreck are harvested annually in Norway today. Harvesting of macro algae accounts for about 0.3 per cent of the estimated total biomass of 50 million tons.

In Northern Norway sea urchins graze down large parts of the kelp forests. Stakeholders have been concerned about the impact of kelp harvesting on the ecosystem, since it represents a habitat for a number of organisms, including fish. While it takes 5 years for the biomass of kelp to recover, it takes 6-7 years for the flora and fauna in kelp forests to re-establish (Fiskeridirektoratet 2015). Cultivation and processing of macro algae has been suggested as a potential bio-economy industry in Norway in the future. Skjermo, Aasen et al. (2014) have a future vision of a yearly harvest of 17 000 tons cultivated seaweed per km^2.

4.4 AQUACULTURE

Production of aquaculture products may be dependent on input factors, such as fodder for the fish farmed in Norway. Thus, biomass produced of farmed fish is dependent on biomass input. Shellfish, on the other hand, feeds on the food that floats past with the water currents. Previously the main ingredient in salmon feed was fish meal and oil (up to 90 % in 1990), but by 2013 70 per cent of the feed was of plant origin (Ytrestøyl, Aas et al. 1012). The average fodder used for salmon in Norway consists of fish oils (11 %), vegetable protein and carbohydrates (50 %), vegetable oil (19 %), fish meal (17 %), fish protein concentrate (1 %) and other products (3 %). About 25 per cent of the feed consists of soya proteins (Laksefakta.no 2016).

In 2012, 1.63 million tons of feed (representing 35 million GJ, 577 000 tons of protein and 530 000 tons of lipids) was used in the Norwegian salmon feed production. The same year, 1.27 million tons of farmed Norwegian salmon was slaughtered (Ytrestøyl, Aas et al. 1012). Around 220 000 tons of the feed was fishmeal, of which 1/3 originating from South America. 44 per cent of the 143 000 tons of fish oil used had the same origin. The rest came from the North Atlantic and can be regarded of Norwegian origin. The 1 million tons of plant ingredients used in feed production, were all imported (Ytrestøyl, Aas et al. 1012). Thus, of the 1.83 million tons of feed produced, 1.44 million tons of feed ingredients were imported. In conclusion, almost 80 per cent of the feed ingredients supporting the Norwegian salmon production are imported.

Aquaculture production is also dependent on allocation of space, or licences, along the coastal zone. In 2014 there were 1 015 licences for salmon and rainbow trout, 100 for other marine fish species, 124 shellfish licences, 189 licences for hatchery-produced fish for stocking salmon species, and 50 for other stocking other marine fish species (Statistics-Norway 2016). Nordland, Hordaland and Møre og Romsdal had the licences for salmon and trout (Figure 8). There has been a steady increase in the number of aquaculture licences for salmon and rainbow trout over the past 20 years, up from 722 licences in 1994 (Statistics-Norway 2016).

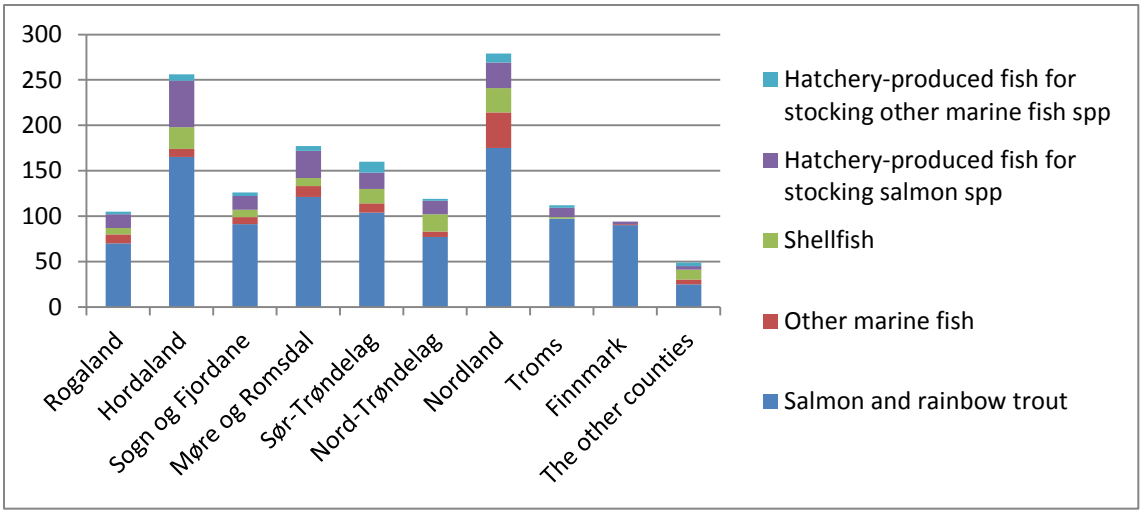


Figure 8: Number of aquaculture licences in Norway in 2014 by county.

5 OUTPUT OF BIOMASS FROM HARVESTING AND PRODUCTION

5.1 FORESTRY

The annual logging has varied over the years. In the lowest years (2003 and 2009) the annual logging was below 7 million m^3 annually. In the "top" years (1987-1990 and 2014), the annual logging was nearly 10 million m^3 or above. Figure 9 shows the logging in Norway from 1986 – 2014 (Statistics-Norway 2016).

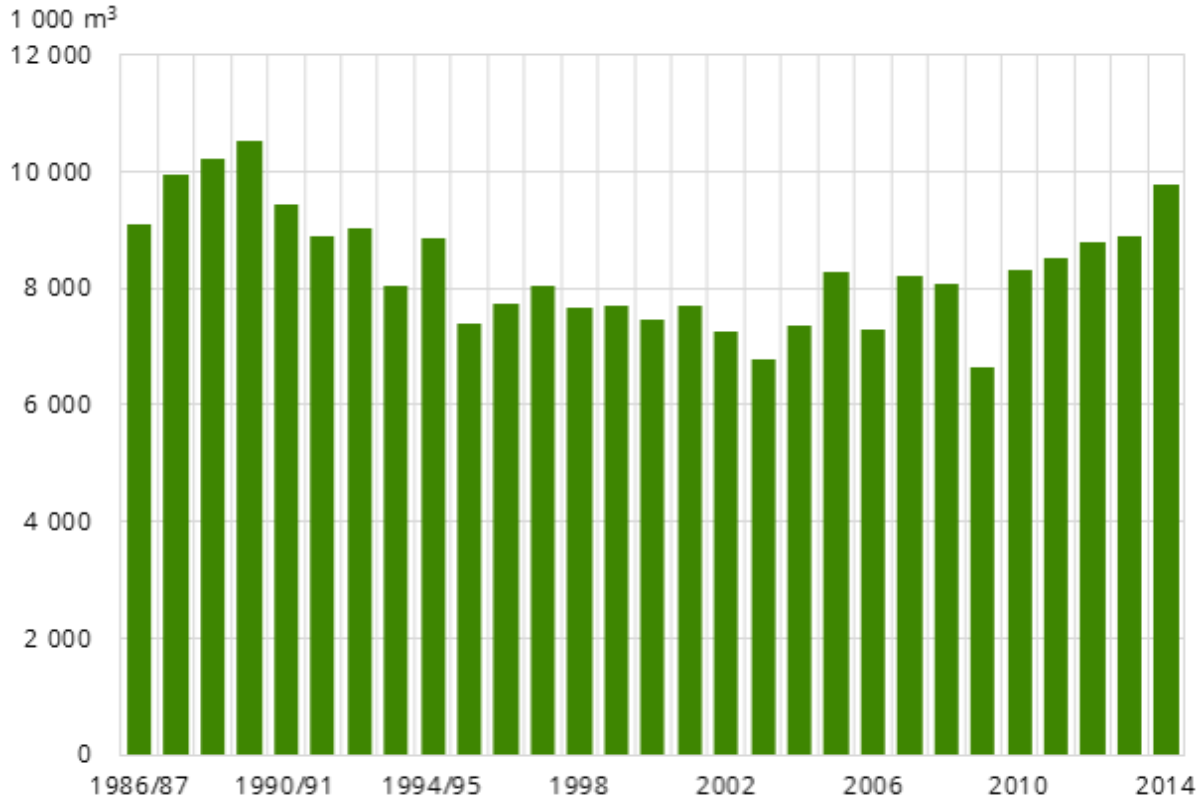


Figure 9: Volume of logged timber in Norway 1986-2014. Source: Statistics Norway

In the north of Norway most of forests are broadleaves. By the fjords at the West-Coast nearly all forest are planted after WWII. This means that volume of logging is not equally shared between regions in Norway. Hedmark is the county with decidedly most logging (2.8 million m^3 in 2014). The statistics on logging for sales is presented on county level (Table 7). The table shows the logging measured as volume (1000 m^3) for each category of timber and total. The column to the right shows the total logging converted to mass in terms of 1000 tons. As coefficients for the conversion, we have used 0.8 tons per m^3 for conifer (spruce and pine) and 0.9 tons per m^3 for broadleaves.

Table 7: Logging in Norway in 2014 by county. Volume in 1000 m3 and mass in 1000 tons.

County	**Spruce (1000 m3)**	**Pine (1000 m3)**	**Broadleaves (1000 m3)**	***Total logging (1000 m3)***	***Total logging (1000 tons)****
Østfold	541	154	9	*704*	*564*
Akershus and Oslo	583	109	11	*706*	*564*
Hedmark	1875	925	77	*2877*	*2309*
Oppland	1002	246	4	*1252*	*1002*
Buskerud	590	368	6	*964*	*772*
Vestfold	270	15	4	*289*	*232*
Telemark	334	198	5	*537*	*430*
Aust-Agder	167	143	3	*313*	*251*
Vest-Agder	176	43	1	*220*	*176*
Rogaland	110	24	0	*134*	*107*
Hordaland	170	11	0	*181*	*145*
Sogn og Fjordane	167	10	0	*177*	*142*
Møre og Romsdal	202	19	1	*222*	*178*
Sør-Trøndelag	378	41	3	*422*	*338*
Nord-Trøndelag	569	12	2	*583*	*467*
Nordland	169	5	2	*176*	*141*
Troms	4	3	0	*7*	*6*
Finnmark	-	9	-	*9*	*7*
Total	***7310***	***2334***	***128***	***9772***	***7830***

* Coeffisients used: Spruce and pine 0.8 tons per m^3. Broadleaves 0.9 tons per m^3.
Source: Statistics Norway (2016)

5.2 AGRICULTURE

Most of the resources in the Norwegian primary agriculture is used for producing raw materials for further processing by the industry into various, mainly nutritional products (feed and food). A smaller part of the production is processed on the farm or sold directly.[9] Farming also results in some other products (straw, manure, wool etc.) that are either exploited on the farm (e.g. as fertilizers and energy sources) or sold (e.g. wool). Moreover, industrial food processing leads to some non-food by-products, such as hides and waste from grain mills.

5.2.1 DEVELOPMENT IN PRODUCTION

The total annual production of feed and food in agriculture has been relatively stable over the last 30-40 years. However, there have been fluctuates from year to year, mainly due to variations in the share of grain classified as food (Forbord 2015). This variation has mainly to do with weather, but the proportion of domestically produced food grain has increase much

[9] For example, in 2014 0.2 per cent of the total milk production was processed on the farms Landbruksdirektoratet. (2015). "Leveranser fra bonde til matindustri." Retrieved 17.12, from https://www.slf.dep.no/no/leveransedata..

since the 1970s due to development of new varieties, especially of wheat. Concerning feed, a main trend has been that the share of grass and other domestically produced fodder have decreased, while import of feed concentrates to livestock productions have increased significantly over the last 15 years (Norske Felleskjøp 2012).

Figure 10 depicts development in the total amount of biomass from agriculture that is used for food. The curve in the figure shows nutritional value of the annual food production for the years 1999-2015 measured as energy in terms of Tera joule (TJ).

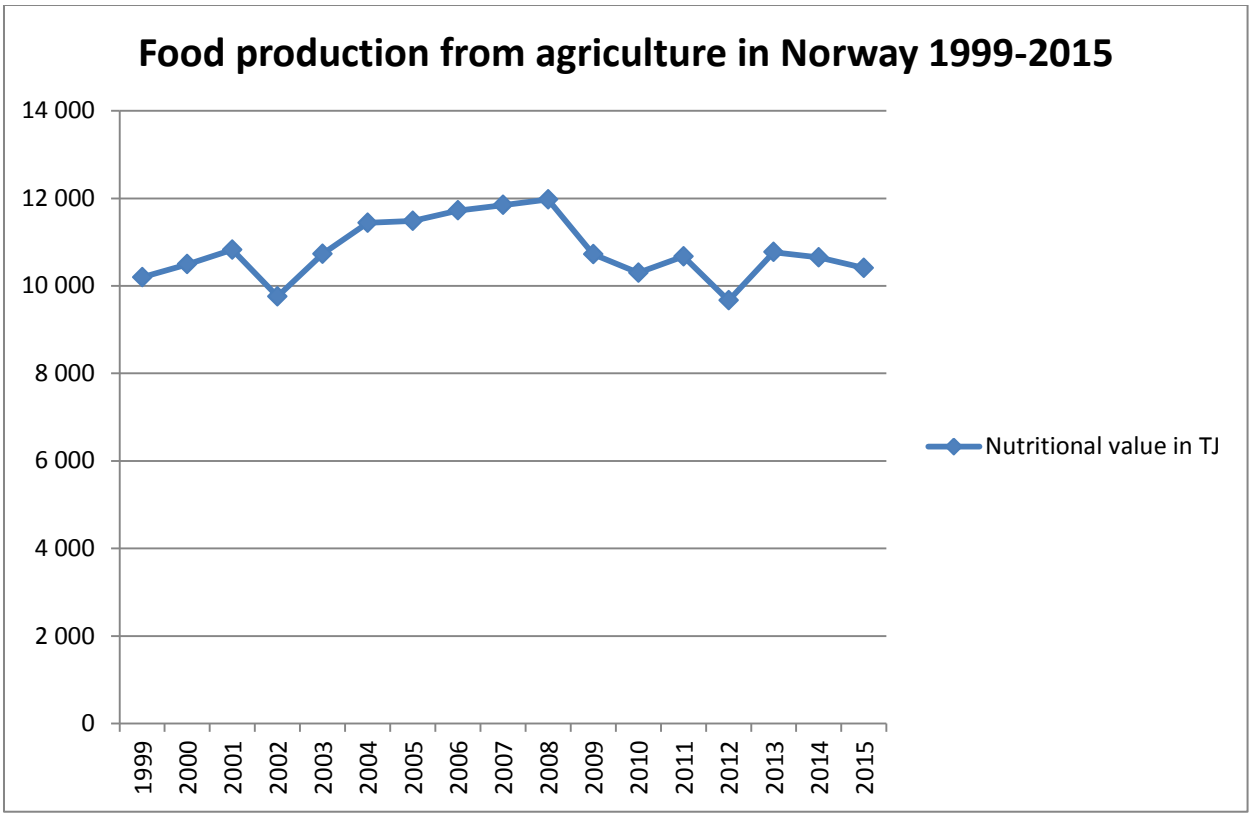


Figure 10: Annual food production from agriculture in Norway 1999-2015. Source: NIBIO.

The figure shows that the annual contribution from agriculture to food supply has varied around an average of 11 000 TJ over the years 1999-2015, with fluctuations of about +/- 10 per cent from year to year. The fluctuations have mostly to do with the amount of grain classified as food from year to year. Since a top year in 2008, there has been a slight downward trend in food production from agriculture.

Concerning figures on outputs from agriculture today, we present two tables. One shows the use of agricultural land for different crops (Table 8), and one presents data on produced volume of different agricultural biomass in terms of feed and food (Table 9).

5.2.2 USE OF LAND FOR DIFFERENT CROPS

Table 8: Use of agricultural land for different crops in Norway in 2012. Counties and total (1000 decares) (Statistics-Norway 2016).

County	Grain and oil seeds (a)	Potatoes (b)	Fruits, vegetables and other arable crops (c)	Meadow and pasture	Share of arable crops (a-c) (%)
Østfold	559	5	46	122	83
Akershus og Oslo	581	6	37	148	81
Hedmark	533	48	35	427	59
Oppland	195	10	41	758	25
Buskerud	209	3	36	260	49
Vestfold	248	16	60	85	79
Telemark	67	2	16	158	35
Aust-Agder	7	3	5	96	13
Vest-Agder	7	1	2	173	5
Rogaland	25	8	16	949	5
Hordaland	0	0	9	395	2
Sogn og Fjordane	0	1	8	421	2
Møre og Romsdal	16	2	5	527	4
Sør-Trøndelag	168	2	10	560	24
Nord-Trøndelag	308	14	25	518	40
Nordland	3	2	5	551	2
Troms	0	3	4	237	3
Finnmark	0	0	3	93	3
Total	***2 927***	***127***	***361***	***6 477***	**35**

On a national level around 65 percent of the agricultural land is used for grass, 30 percent for grain and 5 percent for other arable crops (Arnoldussen, Forbord et al. 2014). Table 8 shows huge differences between regions when it comes to cultivation of different crops. The difference is most remarkable for grain, which to large extent is grown in two regions: Eastern and Mid Norway. Also, the cultivation of other arable crops (potatoes, fruits etc.) takes for the most part place in these two regions, while plant production in the southern, western and northern regions is dominated by grass.

5.2.3 PRODUCED VOLUMES

Table 9 shows county wise figures for seven categories of agricultural produce in the year 2014; coarse fodder (grass, green crops, hay, silage), three types of plant production and three types of livestock. Note that the figures for grain include both grain used for feed (on national level 80 % in an average year) and food (on national level 20 % in an average year).

Table 9: Output of biomass from various agricultural productions in 2014 in Norway. Counties and total. 1000 tons. (Statistics-Norway 2016).

County	Coarse fodder (dry matter)	Grain*	Potatoes	Fruits, berries and vegetables**	Meat	Milk***	Egg	*Total biomass output*
Østfold	72	257	11	28	30	35	7	*441*
Akershus og Oslo	77	257	22	22	10	29	3	*420*
Hedmark	257	223	154	21	44	89	5	*793*
Oppland	462	79	27	25	25	177	4	*798*
Buskerud	107	92	10	22	6	32	2	*270*
Vestfold	47	110	46	36	17	17	2	*274*
Telemark	64	25	6	10	4	14	2	*124*
Aust-Agder	37	1	6	3	3	12	1	*63*
Vest-Agder	66	1	3	1	4	34	1	*109*
Rogaland	371	0	20	10	76	281	18	*776*
Hordaland	128	0	0	5	9	75	2	*219*
Sogn og Fjordane	152	0	2	5	8	105	1	*274*
Møre og Romsdal	262	0	5	3	10	147	2	*430*
Sør-Trøndelag	295	65	5	6	26	147	4	*547*
Nord-Trøndelag	308	116	34	15	46	174	9	*701*
Nordland	210	0	3	3	15	106	1	*338*
Troms	70	0	4	2	4	35	1	*116*
Finnmark	28	0	0	2	1	20	0	*51*
Total	***3 011***	***1 225***	***358***	***217***	***338***	***1 530***	***66***	***6 528***

* Of this about 20 per cent is classified as food grain in an average year (2000-2015) (Norske Felleskjøp 2015).
** Figures for counties calculated based on national production and land used for fruits, vegetables and other arable crops in the counties in 2012.
*** Approximation based on 1 liter of milk corresponding to 1 kg of milk.

Table 9 shows much of the same pattern as Table 8. Output in the plant productions (except coarse fodder) mainly takes place in Eastern Norway (especially the lowland in Østfold, Vestfold, Akerhus/Oslo and Hedmark) and Mid Norway (especially the lowland around Trondheimsfjorden). Production of coarse fodder corresponds, not surprisingly, to the location of milk production, that is, in the uplands of Eastern Norway (Hedmark, Oppland, Buskerud), Western and Mid Norway and southern part of Northern Norway (Nordland). For potatoes, the distribution of production is very uneven, with Hedmark having more than 40 per cent of the production. Livestock production shows a different geographical pattern with much more production in Western Norway, and the counties Oppland and Nordland. Rogaland is the livestock county par excellence. We also note that southern Norway (especially Agder) and the northernmost counties (Troms and Finnmark) have very modest volume of agricultural production.

5.3 FISHERIES

Norwegian fisheries harvest has been around 2.5 million tons annually since the 1992, after a dip in the mid-80s to only 1.6 million tons in 1990 (Figure 11). The decline in total catches in this period was largely due to a reduction in the harvest of capelin, whose population crashed in 1985-86. After the first closure in 1987, there have been a number of periods where there has been no harvest of capelin. The total increase in Norwegian harvest since 1991 has been due to some occasional peaks in the harvest of capelin, and increased harvest of other stocks such as herring and blue whiting, as well as the total biomass caught of other stocks than the main pelagic and groundfish stocks. In addition to in the mid-90s, the harvest of cod has also been relatively high the later years (Statistics-Norway 2016).

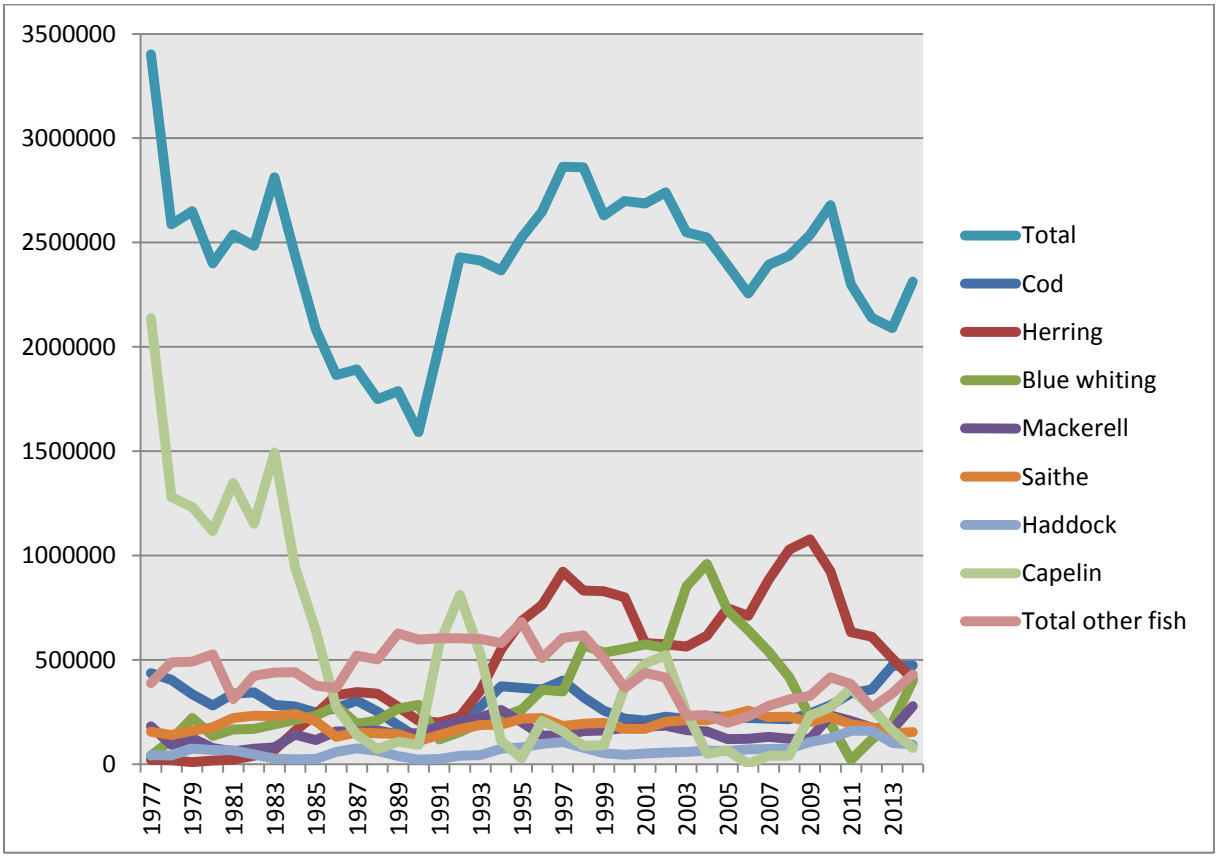


Figure 11: Total catches, catches of main pelagic and groundfish stocks and other stocks 1977-2014 (tons) (Statistics-Norway 2016).

Statistics on landings according to the home port of vessels for 2014 is available from Statistics-Norway (2016) both at county and municipal level. Total biomass harvested in 2014 was about 2.3 million tons and the latest numbers for marine mammal harvest is from 2012 when 66 tons seals and 589 tons whales were harvested (Statistics-Norway 2016). Figure 12 illustrates that the main species landed in terms of biomass were cod, herring, blue whiting and mackerel. It also illustrates the diversity of non-mammal species landed in the Norwegian fisheries. Appendix 3 lists the raw data on species landed.

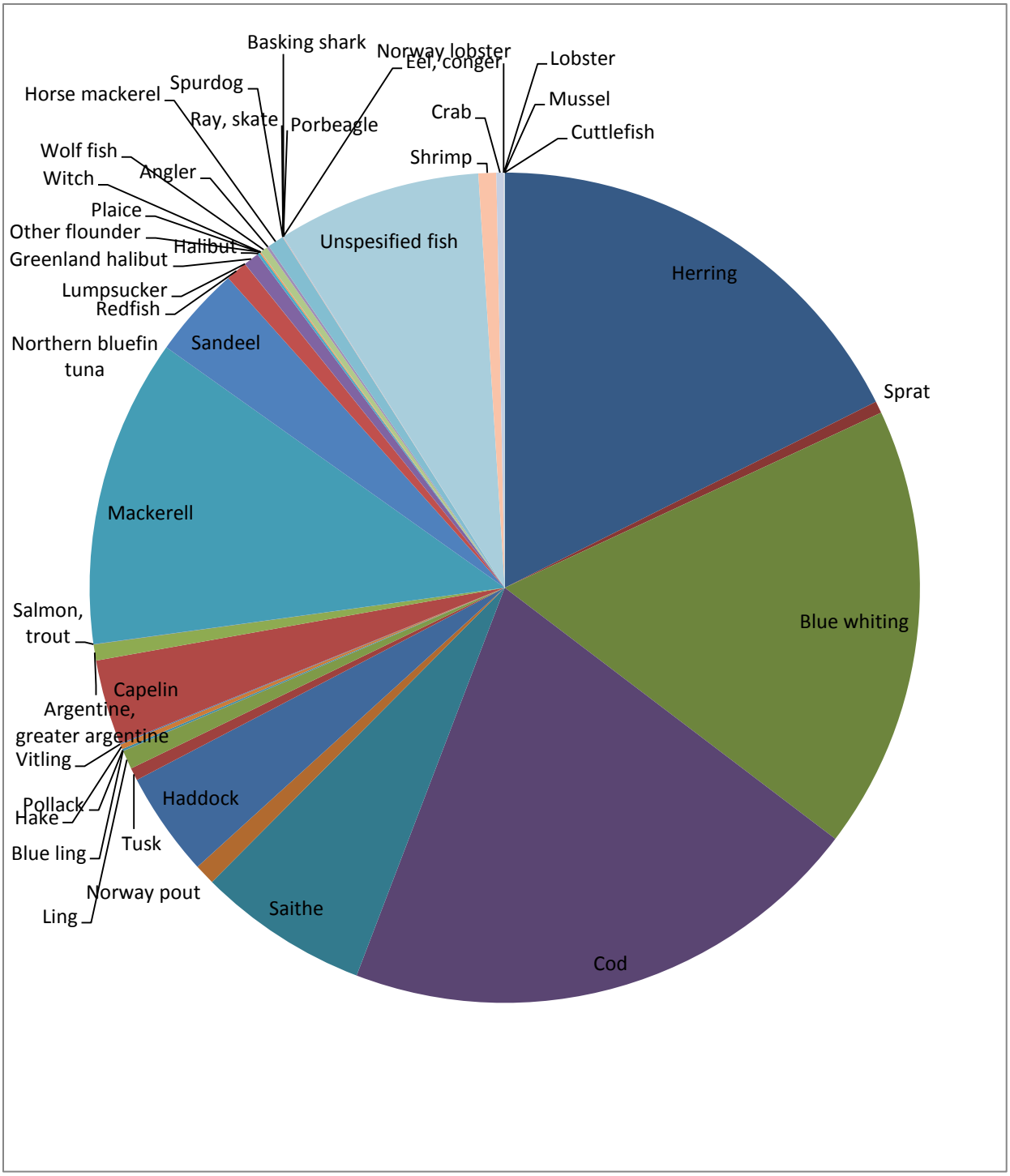


Figure 12: Proportions of wild seafood harvested in Norway in 2014 by species (Statistics-Norway 2016)

Feil! Fant ikke referansekilden. illustrates that Hordaland and Møre og Romsdal on the west coast are the main home ports for pelagic fishing vessels. Møre og Romsdal and Nordland, Troms and Finnmark are important home ports for vessels targeting cod and codfish. The home port of the vessel, however, does not necessarily correspond to the county where the fish is landed. Landings according to county landed in 2011 shows that the majority of the fish were landed in Møre og Romsdal and Nordland, followed by Troms (Figure 14 and Table

10).[10] For some analysis, it may also be important to keep in mind that landings are highly seasonal.

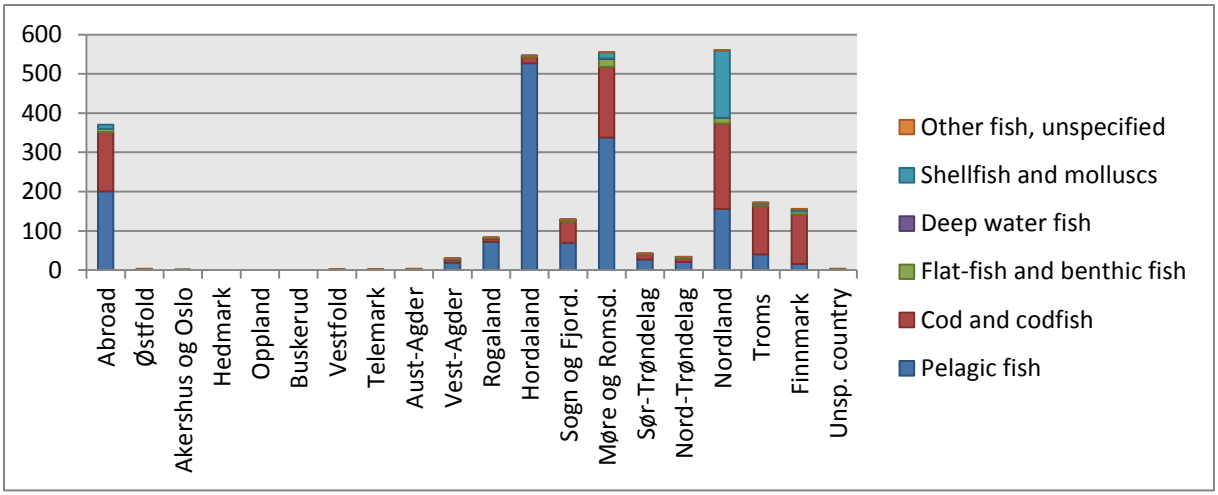


Figure 13 Total landings of wild seafood in Norway according to the home port of vessels in 2014. 1000 tons (Statistics-Norway 2016).

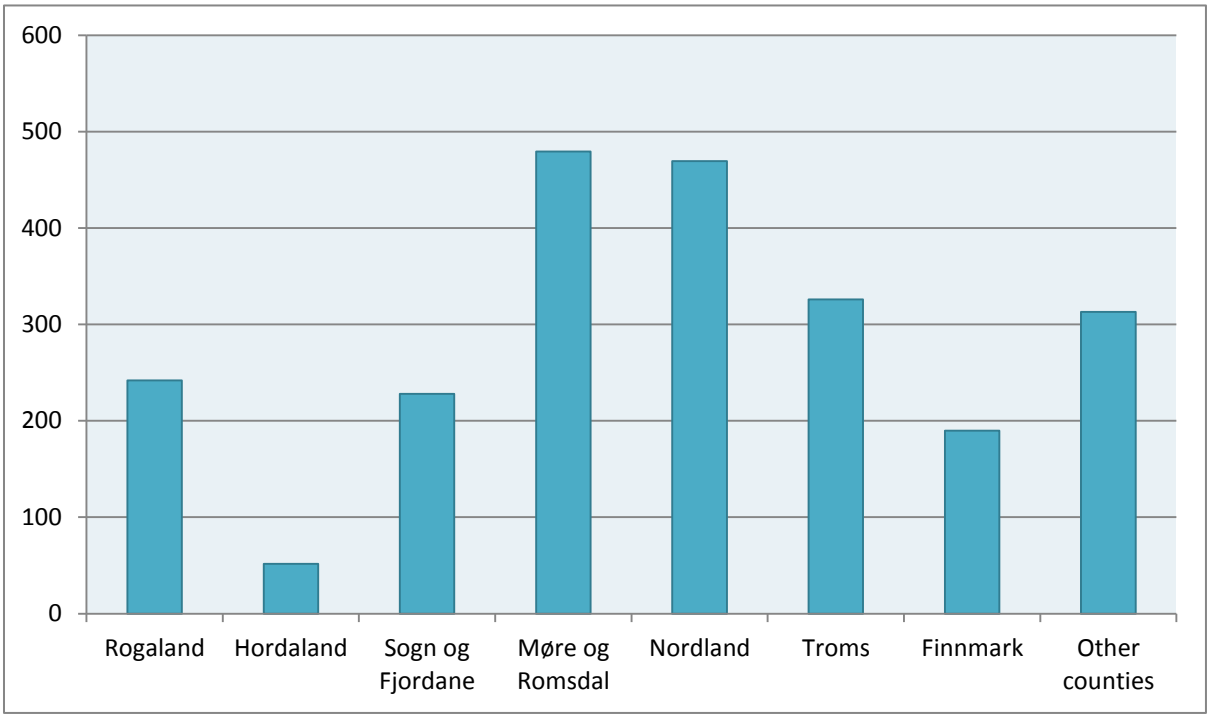


Figure 14: Landings of wild seafood by county in 2011 in 1000 tons. Source: Statistics-Norway (2013).

[10] To get the raw data for Table 11, you need to request the data from Statistics Norway.

Table 100: Landings of catches by country and species in 2011. Tons. (From Statistics-Norway (2013)).

Fiskeslag	Alle fylka	Rogaland	Hordaland	Sogn og Fjordane	Møre og Romsdal	Nordland	Troms Romsa	Finnmark Finnmárku	Andre fylke[1]
					Tonn rund vekt				
Mengd i alt	**2 298 903**	**241 983**	**51 545**	**228 053**	**479 324**	**469 391**	**325 881**	**189 661**	**313 065**
Lodde	362 368	76 400	4 429	39 770	36 861	73 213	31 877	30 686	69 132
Augepål	3 210	2 592	-	-	:	-	-	-	:
Kolmule	20 540	4 592	:	49	1 457	198	107	:	14 108
Tobis	108 983	61 115	-	22 835	16 866	-	-	-	8 167
Hestmakrell	21 135	14 274	2 152	:	3 083	:	-	-	857
Atlantisk makrell	207 955	39 321	:	53 260	77 831	15 764	:	-	10 637
Sild	633 103	30 282	31 153	80 264	121 126	201 108	98 455	9 975	60 739
Brisling	12 357	7 997	1 222	1 663	:	-	-	-	:
Annan pelagisk fisk[3]	20	-	-	-	:	-	-	-	:
Torsk	340 167	380	161	7 906	49 527	110 911	89 895	76 375	5 013
Hyse	159 550	194	68	4 961	33 829	28 755	53 984	36 376	1 384
Sei	190 344	1 254	627	4 555	106 081	22 315	18 767	29 712	7 033
Brosme	14 754	26	34	4 505	6 599	633	1 843	912	201
Lange	15 821	119	43	4 595	7 917	1 636	667	52	793
Blålange	318	5	5	105	192	0	1	0	10
Lyr	1 736	141	118	148	695	130	15	0	488
Lysing	2 304	169	40	221	1 330	51	:	:	466
Kviting	86	13	:	4	22	23	5	:	18
Blåkveite	10 232	:	-	346	3 645	1 897	3 528	807	:
Kveite	1 974	7	3	88	304	520	592	381	78
Raudspette	1 805	9	1	14	34	93	69	156	1 429
Tunge	7	0	-	-	-	-	-	-	7
Smørflyndre	48	16	1	-	-	-	-	-	31
Sandflyndre	41	4	0	:	-	-	:	-	37
Lomre	68	1	0	0	0	2	4	19	42
Slettvar	21	0	:	-	:	-	-	-	20
Piggvar	40	1	0	1	2	1	0	0	33
Anna flyndre	18	0	0	0	4	2	6	3	2
Ål	:	-	-	-	-	-	-	-	:
Uer	9 799	1	2	227	4 582	1 893	2 007	668	421
Straum- og vassild	12 061	371	-	-	3 293	5 484	-	-	2 913
Steinbit	6 130	1	0	733	1 000	168	3 443	772	11
Breiflabb	5 693	173	147	129	596	2 044	1 122	526	955
Rognkjeks	1 209	-	-	:	-	412	501	291	:
Annan botnfisk[3]	1	:	0	:	0	-	-	-	1
Pigghå	247	32	15	28	29	3	2	1	138
Håbrann	11	:	-	2	3	3	:	-	2
Brugde	:	-	-	-	:	:	-	-	-
Andre hår og haiar[3]	23	:	-	:	22	-	-	-	1
Skate, rokke[3]	375	13	12	121	86	14	48	23	59
Annan djupvassfisk[3]	533	333	0	35	117	:	:	-	31
Villaks	314	24	:	:	21	4	23	122	116
Annan og uspesifisert fisk[3]	1 271	73	245	423	283	8	25	1	213
Krabbe	5 322	736	89	282	481	1 536	:	:	2 197
Kongekrabbe	1 782	-	-	-	:	-	:	1 778	-
Hummar	58	10	10	8	15	-	-	-	15
Sjøkreps	215	39	17	7	16	-	-	-	135
Reke	24 467	1 260	8	:	591	425	18 626	:	3 548
Skjel	745	-	-	-	:	:	-	-	741
Andre skaldyr og blautdyr[3]	119 643	3	0	-	:	139	:	:	119 489

5.3.1 OTHER HARVESTING

1000 tons *of Calanus finmarchicus* is harvested annually as a trial fishery outside Northern-Norway (IMR 2012). Currently the *Calanus* harvested is used for production of calanus oil, an omega-3 supplement (calanushelse.no). The aquaculture industry is evaluating if Calanus can be a component of fish fodder in the future (IMR 2012)

Around 130 000-180 000 ton kelp and egg wrack is harvested annually, mainly from Rogaland to Sør-Trøndelag. The majority of this harvest is kelp. Harvesting is area-regulated and each area is opened every five years for trawling (Fiskeridirektoratet 2015).

5.4 AQUACULTURE

Figure 14 shows how aquaculture production in Norway has developed from its early years in the 1970s up to 2014. Except a downturn in the early 1990s, the increase in production has been steady. During the 20 years from 1991 to 2012 the production almost ten-doubled.

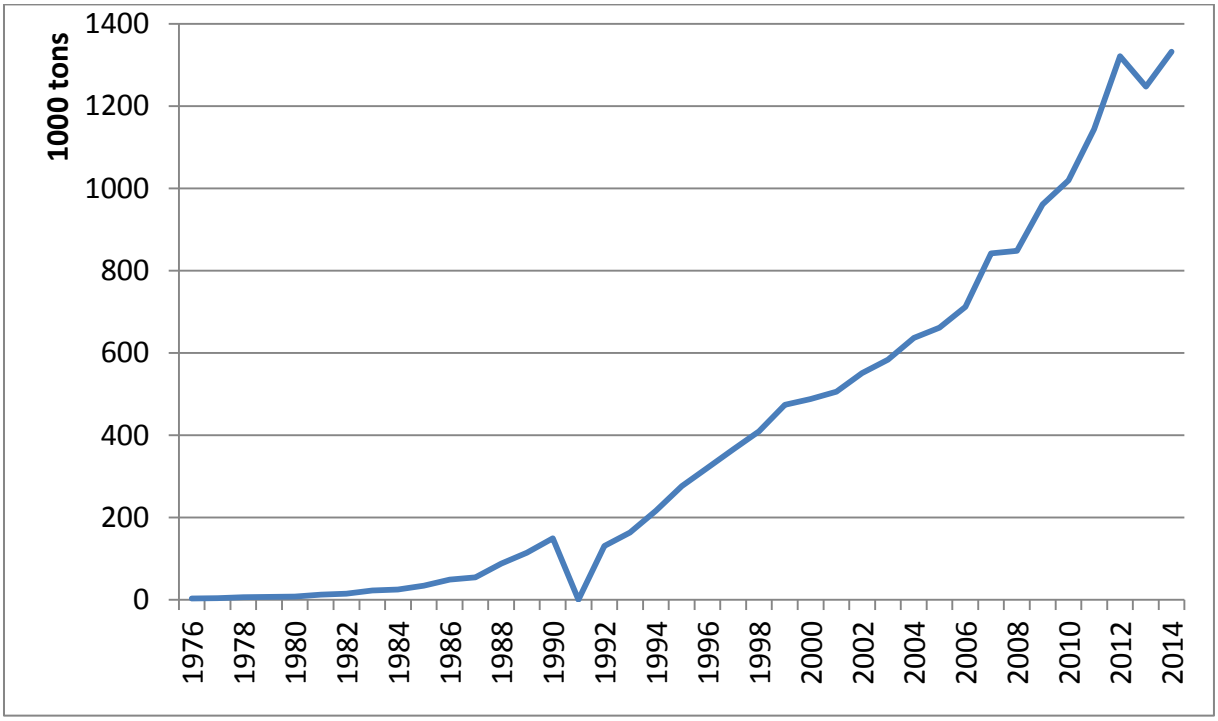


Figure 15: Development in aquaculture production in Norway 1976-2014 in 1000 tons. Source: (Statistics-Norway 2016)

In 2014 a total of around 1.3 million tons biomass of aquaculture fish species was sold. Salmon dominates the production, followed by rainbow trout. Nordland, Sør-Trøndelag and Hordaland are the main salmon producing counties, followed by Troms and Møre og Romsdal (Table 11, Figure 15). These numbers do not include fish that were not sold for human consumption, which is reported in the section on by-products under "Current uses of biomass". Shellfish aquaculture amounted to 1933 tons in 2016 and was dominated by blue mussels. The other species that were farmed were scallops (13 tons), oysters (4 tons) and "other species" (15 tons) (Statistics-Norway 2016).

Table 111: Amount of aquaculture species sold in 2014 by species (1000 tons) and county (Statistics-Norway 2016)

County	Salmon	Rainbow trout	Cod	Halibut	Shellfish	Char	*Total biomass*
Østfold	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Akershus og Oslo	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Hedmark	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Oppland	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Buskerud	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Vestfold	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Telemark	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Aust-Agder	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Vest-Agder	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Rogaland	62,17	..	..	..	0,02	..	62,19
Hordaland	175,34	36,91	..	..	0,00	..	212,25
Sogn og Fjordane	97,07	14,64	1,10	..	..	..	112,81
Møre og Romsdal	123,48	..	..	..	..	..	123,48
Sør-Trøndelag	204,45	..	..	..	0,97	..	205,42
Nord-Trøndelag	103,57	..	..	..	0,52	..	104,09
Nordland	235,55	..	0,25	..	0,38	0,22	236,41
Troms	158,62	..	..	..	..	..	158,62
Finnmark	95,68	..	..	..	..	..	95,68
Unspec. county	16,44	0,10	..	..	0,04	..	16,58
Abroad	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Total	***1272,36***	***51,65***	***1,35***	***0,00***	***1,93***	***0,22***	***1327,51***

* Two dots (..) means that the numbers cannot be published, or that there was no production.

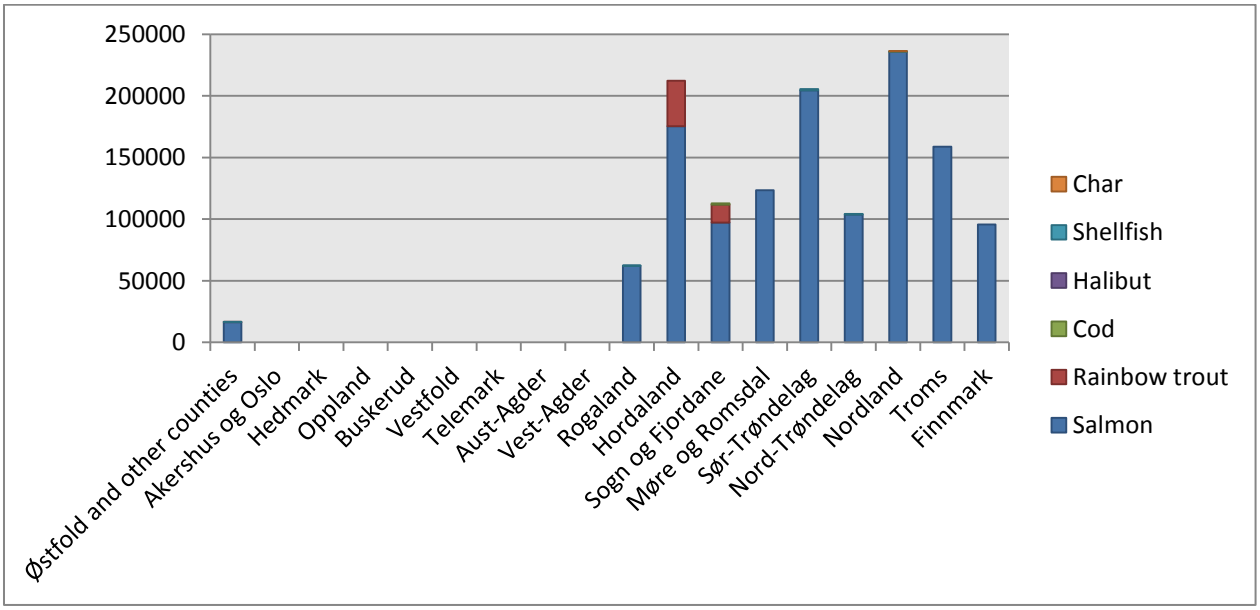


Figure 16: Amount of aquaculture species sold in 2014 by species (1000 tons) and county (Statistics-Norway 2016)

5.5 COMPARING BIOMASS OUTPUT IN THE FOUR SECTORS

One striking observation on the foregoing pages is the geographically uneven distribution of the different bioeconomical resources and production. This is illustrated in Figure 17, where we have juxtaposed the biomass production in the different counties for the four sectors (year 2014). Also, the terrestrial and marine area and the number of inhabitants differ hugely between the counties, which contribute to explain the diversity in bioeconomic resources and differences in production.

We observe that most forestry production takes place in one region, Eastern Norway, especially in the three inland counties (Hedmark, Oppland and Buskerud), while the two northernmost counties (Troms and Finnmark) have almost no such production.

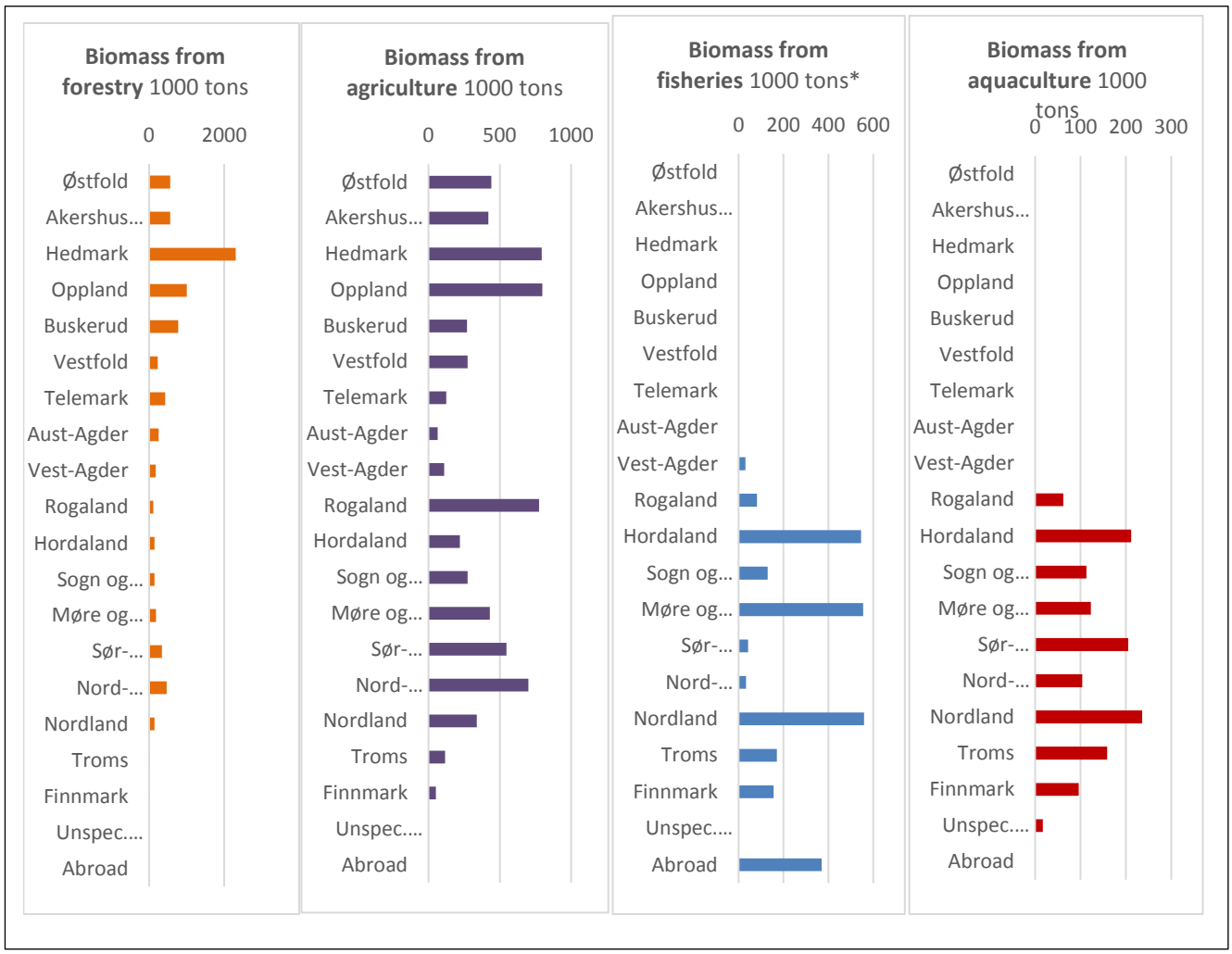
Fisheries and aquaculture are located in another part of the country, the coastal region from Rogaland in the south to Finnmark in the north. More specifically, the home port of the majority of the fishing fleet is located to three counties (Hordaland, Møre og Romsdal and Nordland), while aquaculture production is spread on more counties. We also observe that in the two northernmost counties Troms and Finnmark, aquaculture production is significantly more important than fisheries, as represented by biomass landed according to the home port of the vessel (remember that this can deviate from the county the fish is landed in).

Agriculture is more evenly distributed geographically, as it takes place in all counties to more or less extent. Nevertheless, a handful of counties (Hedmark, Oppland, Rogaland, Sør-Trøndelag and Nord-Trøndelag) contribute most of the agricultural production.

No county scores high on all four sectors, but some counties are more versatile than others. For example, Møre og Romsdal and Nordland have significant output from fisheries and aquaculture as well as agriculture. Finally, we note that the two southernmost counties (Aust-Agder and Vest-Agder) and the two northernmost counties (Troms and Finnmark) have the lowest total production of biomass, around 300 to 400 thousand tons annually, while the county producing most (Hedmark) have ten times more than this (over 3 million tons).

The variation in production can partly be explained by the size, type and quality of the terrestrial and marine resources of each region. However, also other factors matter, like population size, available infrastructure and distance to markets, entrepreneurial culture and history, and more. Lastly, we should keep in mind that the quality and value per ton biomass differ a lot across and within the sectors depending for example on type of resource, processing and marketing.

Figure 17: Comparing annual output of biomass in forestry, agriculture, fisheries and aquaculture across counties in Norway in 2014 (*Biomass from fisheries is according to home port of vessel). 1000 tons



6 CONCLUSION AND FUTURE POTENTIALS

This report presents an overview of the development and status of biological resources and production across the four primary bioeconomic sectors forestry, agriculture, fisheries and aquaculture in Norway.

Resources and output in the sectors vary both geographically and over time. Forestry is mostly inland in the southeast, fisheries and aquaculture is along the Southwestern and Northern coasts, while agriculture is more spread across the country.

The *pattern of change* over time differs in the four sectors. The annual increment in the productive *forests*, at around 25 million m^3 for many years, has been bigger than the annual logging at 7-10 million m3, leading to increased standing volume. The share of *agricultural* land in Norway is small at 3 per cent, but a high proportion of this is arable. The use of agricultural land has decreased slightly over the last decade, but the production of food from

agriculture has been quite stable at 10 000-12 000 Terajoule/year. A reason for this being possible has been a significant increase in imports of feed concentrates. In contrast, the marine sectors exhibit significant changes and variations. In *fisheries*, spawning stock of different species fluctuates markedly over time with corresponding variations in catches. However, the total harvest of wild seafood has been around 2.5 million tons annually since the mid-1990s. Change in *aquaculture* is, with one exception, characterized by continuous growth since the birth of this sector in the 1970s. From 1992 to 2012, the production of biomass in aquaculture (for the most part salmon) ten-doubled. As with agriculture, this growth has been fuelled by import of feed.

The *potential for increased production* also differs between the sectors, depending on the biological resource base, and various techno-economic and environmental challenges.

In *forestry*, there is an obvious potential for increased production due to the high proportion of annual increment that for the time being is not logged. However, there are techno-economic and environmental challenges of increasing the level of logging from today's 8-9 million m^3 up to, let us say 15 million m^3. In addition, there has to be a market for an eventual increased production.

In *agriculture*, there are possibilities of increased production on the land through better agronomic practices, such as crop rotation, utilization of crops with higher yield potential and use of outfield grazing areas (Arnoldussen, Forbord et al. 2014). There are some possibilities for expanding the agricultural land through new cultivation, but the extent of such expansion is limited by natural conditions and environmental concerns. In addition, there is the possibility of increasing livestock production through more import of concentrated feed.

In *fisheries*, the exploitation of traditional fish species is largely in balance with the fluctuating resource base. Hence, the potential for expansion is through exploiting other species of fish and other marine species, for example plankton and seaweed. Also here, environmental concerns have to be sorted out and dealt with.

The *aquaculture* sector has an ambition of a five-fold production increase. The realization of this requires among other things control with diseases, securing sufficient feed with the right quality and handling of negative impacts on the environment.

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Appendix 1
Overview of statistical resources on forestry, agriculture, fisheries and aquaculture.

#	Sector	Resource/ production	Units	Dependent on import of input factors.	Spatial resolution	Taxonomic resolution	Time series	Data base
1	Forestry	Total area and productive area of forest	1000 ha / Km^2		Regions (7 regions)		1994-2014	SSB, The National Forest Inventory
2	Forestry	Growing stock of spruce, pine and broadleaf wood ("Stående kubikkmasse")	M^3		Regions (7 regions)		2005-2014	SSB, The National Forest Inventory
3	Forestry	Annual increment of spruce, pine and broadleaf wood ("Årlig tilvekst")	M^3		Regions (7 regions)		2005-2014	SSB, The National Forest Inventory
4	Forestry	Annual logging removals of spruce, pine and broadleaf wood ("Årlig avvirkning")	M^3		Municipality		1976-2014	SSB, Commercial round wood removals
5	Agriculture	Outfield grassland	Decare		(Some) counties			NIBIO (AR18X18)
6	Agriculture	Available arable land (divided in "in use" and "not in use")	Decare		Municipalities ;National		2011-2015	AR5 (NIBIO); SSB statistical topic "Nature and the environment", subtopic "Area"
7	Agriculture	Types of arable land (divided in "fully cultivated", "surface cultivated", and "graze land")	Decare		Municipalities; counties		1995-2012; 2010	AR5 (NIBIO); SSB statistical topic "Agriculture, forestry, hunting and fishing", subtopic "Agriculture".

#	Sector	Resource/ production	Units	Dependent on import of input factors.	Spatial resolution	Taxonomic resolution	Time series	Data base
8	Agriculture	Arable land by type of crop	Decare		County		(1939) 2006-2015	SSB statistical topic "Agriculture, forestry, hunting and fishing", subtopic "Agriculture".
9	Agriculture	Livestock	Number of animals		County		1998-2015	SSB statistical topic "Agriculture, forestry, hunting and fishing", subtopic "Agriculture".
10	Agriculture	Milk production	Mass (liter); Energy (terajoule)		National; county		1959-2015; 2008-2015	«Totalkalkylen for jordbruket» (NIBIO) (Budsjettnemnda for jordbruket 2015).; (Landbruksdirektoratet 2015)
11	Agriculture	Production of feed grain and food grain	Mass (tonne); Energy (terajoule)		National; County (total grain only)		1959-2015; 2001/02-2013/14	Norske Felleskjøp («Årlig prognose korn»); (Landbruks- direktoratet 2015)
12	Agriculture	Other productions (coarse fodder, potatoes, fruits and vegetables, meat)	Mass (tonne); Energy (terajoule)		County (except Fruits and vegetables) ; National (own calculation); Municipality (by request to SSB)		2000-2014	SSB statistical topic "Agriculture, forestry, hunting and fishing", subtopic "Agriculture".; Parameters on nutria-tional content retrieved from Norsk landbruks-rådgivning (feed) and Helsedirektoratet (food)

#	Sector	Resource/ production	Units	Dependent on import of input factors.	Spatial resolution	Taxonomic resolution	Time series	Data base
	Aquaculture	Species of fish	Number of fish - standing stock	YES	Region	Species	2010-2014	SSB
13	Aquaculture	Species of fish	Tons slaughtered fish sold and losses	YES	Region	Species	2010-2014	SSB
14	Fishing	Species	Kg catch and catch-and-release	NO	River		1993-2014	SSB
15	Fishing	Group	Tons by municipality of vessel and municipality landed in	NO	Municipality		2000-2013	SSB
16	Fishing	Species	Tons	NO	Total landed in Norway		1977-2013	SSB
17	Fishing	Group	Tons	NO	Total landed in Norway		1968-2012	SSB
18		Zooplankton	Dry weight (g/m^2)	NO	Barents Sea	Group	1988-2014	Imr.no
19		Zooplankton	Dry weight (g/m^2)	NO	Norwegian Sea		1995-2014	Imr.no
20		Fish, shrimp	Tons	NO	Norwegian waters		1996 (or earlier)-2014	Imr.no, Ices.dk
21	Fishing	NEA cod haddock and saithe, Norwegian spring spawning herring, Barents Sea Capelin	Tons	NO	Biomass		1950-2014	SSB
22	Fishing	Whales and Seals	Stock in numbers	NO	Northeast Atlantic		1993-2008	Imr.no
23	Fishing	Fish, shrimps, shellfish and mammals	Traffic light assessed	NO	Norwegian stocks		2014	Fiskeridir.no

Appendix 2:
Quotas allocated Norwegian vessels in 2014 by species and area (source: fisheries directorate quota overview 2014)

Species	Quota Norway in tonnes
NEA Cod north of 62N, including 21 000 tonn coastal cod	466 439
Haddock north of 62N	90 484
Seithe north of 62N	103 450
Greenland halibut north of 62N	9 675
Redfish north of 62N	172 800
Ling/ blue ling/tusk Icelandic zone	500
Other spp Icelandic zone	125
Greenlad halibut Greenlandic zone	2325
Cod Greenlandic zone	1 200
Halibut Greenlandic zone	310
By-catch other spp Greenlandic zone	2550
Roundnose grenadier Greenlandic zone	60
Redfish Greenlandic zone	2150
Cod North Sea	4 911
Haddock North Sea	5 498
Whiting North Sea	669
Plaice North Sea	7 214
Saithe North Sea and Skagerrak	39 749
Cod Skagerrak	114
Haddock Skagerrak	99
Whiting Skagerrak	19
Plaice Skagerrak	501
Ling EU zone	5 500
Tusk EU zone	2 923
Blue ling EU zone	150
Greenland halibut EU zone	1 000
Sole EU zone	10
Saithe EU zone	500
Other species EU zone	4 000
Shrimp Greenlandic zone	2550
Shrimp Russian zone	4000
Wolf-fish Russian zone	2500
Sole Russian zone	200
Other spp Russian zone	500

Species	Quota Norway in tonnes
Norwegian spring spawning herring, north of 62N	255277
North Sea herring	141681
Mackerel NE Atlantic	277903
Capelin Greenland/Iceland/Jan Mayen (2014/2015 season)	81069
Capelin Barents Sea	38980
Blue whiting Norwegian economic zone, Jan Mayen, Svalbard, International waters	386697
Sprat, Norwegian and international zone	47520
Sandeel Norwegian economic zone and EU zone	90000
Sprat, EU zone	3550
Norway pout Norwegian economic zone	108000
Norway pout EU zone	15000
Greater argentine Norwegian economic zone	12000
Cod NAFO area	1343
Shrimp North Sea/ Skagerrak	5469
Shrimp Greenland zone	2550
Shrimp Russian zone	4000
Shrimp Svalbard zone	5795
Shrimp Flemish Cap	48
King crab quota regulated (2014/2015)	1000
King crab damaged male	100
King crab female	50
SUM	**2 412 707**

Species	Quota Norway in individuals
Minke whale (Norwegian economic zone, Jan Mayen, Svalbard)	1286
Harp seal west ice	21270
Harp seal east ice	7000
Hooded seal west ice*	0
Harbour seal Norwegian coast	425
Grey seal Norwegian coast	460
Total	**30441**
*Scientific purposes only	

Appendix 3

Tons of fish harvested in Norway in 2014 by species (Statistics-Norway 2016)

Species harvested 2014	Tons round weight
Herring	407303
Sprat	10725
Blue whiting	399520
Cod	473478
Saithe	153833
Norway pout	18665
Haddock	94214
Tusk	11406
Ling	16887
Blue ling	193
Pollack	1787
Hake	4331
Vitling	961
Capelin	76683
Argentine, greater argentine	14470
Salmon, trout	219
Mackerell	277735
Northern bluefin tuna	0
Sandeel	82499
Redfish	19350
Lumpsucker	94
Greenland halibut	14055
Halibut	2349

Species harvested 2014	Tons round weight
Plaice	1014
Witch	144
Other flounder	189
Wolf fish	6346
Angler	2319
Horse mackerel	14660
Spurdog	313
Ray, skate	568
Basking shark	0
Porbeagle	5
Eel, conger	0
Unspesified fish	183511
Shrimp	15983
Crab	6515
Norway lobster	198
Lobster	52
Mussel	748
Cuttlefish	7
SUM	***2313329***