



HISTORIC LANDINGS OF NORTHERN SHRIMP (*PANDALUS BOREALIS*) IN NORWAY

Data per county for 1908-2021

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Summary (English):

Time series of landed catches are often the only data source available that encompasses most or all of a fishery's history, providing important information for stock assessment and fisheries management. Although landings data were registered in Norway with a spatial resolution of landing county or lower for over a century, most of the data were only published in statistical yearbooks in the past and are therefore not readily available. Here, we digitalized spatially resolved information on shrimp landings and value of landings from 1908 to 1976, and combined them with landings data from 1977 to 2021 to produce a comprehensive overview of the shrimp fishery in Norway since its infancy more than a century ago until today. The resulting time series shows how the shrimp fishery after its beginning in the eastern Skagerrak and Oslofjord region at the turn of the 20th century, expanded west- and northwards along the Norwegian coast over the following decades, developing into a relevant coastal fishery as well as an offshore fishery in the Skagerrak. After World War II had temporarily halted the development of the fishery, it increased with a higher pace due to subsequent progress in industrial fishing and the emergence of offshore fisheries in the Barents Sea and around Svalbard. The latter development caused together with periods of long-distance fishing activities in the Northwest-Atlantic and around Greenland and Jan Mayen substantial increases in shrimp landings from the 1980s onwards. While total annual shrimp landings remained largely on the level of a few thousand tonnes in previous decades, they peaked above 80 000 tonnes in the 1980s and early 2000s. However, throughout the time series and particularly during the latest decades, substantial fluctuations in landings and their spatial distribution have been observed. In absence of catch limits for shrimp outside of the Norwegian Deep and Skagerrak area, the observed changes in the landings have mostly been driven by technological progress and economic factors, notably prices. However, masked by the large landings from the offshore segments of the fishery, the data also show a decline of shrimp landings in West- and Mid-Norway, indicating a disappearance of the shrimp fishery and possibly also the shrimp stock in these areas. The results underline the relevance of spatially resolved landings and value data for our understanding of the development of a fishery across its history, and thus the importance of making such data readily available to research and fisheries management.

Summary (Norwegian):

Tidsserier av landete fangster er ofte den eneste tilgjengelige datakilden fra mesteparten eller hele den historiske epoken til et fiskeri. Slike tidsserier bidrar derfor med viktig informasjon for bestandsvurdering og fiskeriforvaltning. Selv om norske landinger per fylke har blitt registrert i mer enn hundre år, ble mesteparten av disse dataene tidligere kun publisert i statistiske årbøker og er derfor ikke lett tilgjengelige. Gjennom arbeidet med denne rapporten har vi digitalisert norske rekelandinger per fylke og kommune, samt verdien av disse landingene, for tidsrommet 1908 til 1976. Tallene ble satt sammen med landingsdata fra 1977 til 2021 til en omfattende oversikt over det norske rekefisket siden dets spede begynnelse for mer enn hundre år siden og frem til i dag. Tidsserien viser hvordan rekefisket etter starten i det østlige Skagerrak og i Oslofjorden på slutten av 1800-tallet, bredte seg vestover og nordover langs norskekysten i de påfølgende tiårene og slik utviklet seg til et viktig kystfiske. På 1920- og 1930-tallet startet man også å tråle på rike rekefelt ute i Skagerrak. Under 2. verdenskrig stoppet veksten i fisket opp, men da krigen var slutt, økte landingene hurtig pga. utviklingen av et industrielt fiske og utviklingen av havfisket i Barentshavet og ved Svalbard. Dette, sammen med perioder med norsk rekefiske ved Jan Mayen og Grønland, samt i internasjonalt farvann ved Canada, førte til en vesentlig økning i rekelandingene fra rundt 1980. Mens de totale årlige rekelandingene hadde holdt seg på et nivå på et par tusen tonn i de foregående tiårene, nådde de over 80.000 tonn på 1980-tallet og tidlig på 2000-tallet. Gjennom tidsserien og spesielt de siste tiårene har det likevel vært store svingninger i de totale norske rekelandingene, og også i den romlige fordelingen av landingene. Da det ikke fastsettes rekekvoter med unntak av for bestanden i Skagerrak og Norskerenna, kan svingningene i landingene for det meste forklares med teknologiske fremskritt og økonomiske faktorer, dvs. pris. Men dataene viser også en nedgang i rekelandinger på Vestlandet og i Midt-Norge, noe som tyder på at rekefisket forsvinner eller allerede har forsvunnet fra disse områdene, og som indikerer at også selve bestanden flere steder er i ferd med å forsvinne. Resultatene våre understreker viktigheten av en god romlig oppløsning av landings- og verdidata for forståelsen av den historiske utviklingen av et fiske og dermed viktigheten av å gjøre slike data tilgjengelige for forskning og fiskeriforvaltning.

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1 - Introduction

The Norwegian fishery for northern shrimp (*Pandalus borealis*) (hereafter shrimp) started by mere chance in the late 1890s, as the large stocks of shrimp in the Oslofjord and eastern Skagerrak region were discovered through fishery investigations with other purposes than finding shrimp (Hjort and Ruud 1938). In 1897, Johan Hjort, together with Danish C. G. Johannes Petersen, discovered high densities of shrimp in the Swedish Gullmarsfjord, and the Larviksfjord and Langesundsfjord in southern Norway (Figure 1). Before 1897, large, harvestable stocks of shrimp were only known from the Drammensfjord, where a shrimp fishery by hand net had taken place.

A profitable shrimp fishery was established a year after the discovery of the new resource. In 1899, ten vessels participated in the shrimp fishery in the Langesundsfjord, and in 1901, eleven vessels trawled for shrimp in the inner parts of the Oslofjord. Much work was devoted to the development of suitable gear, equipment of vessels, mapping of shrimp fields, and development of a new market, mainly driven by the fishers themselves (Hjort and Ruud 1938, Iversen 1926). The fishery was first conducted by sailing vessels (Figure 2), but these were rather quickly replaced by steam and motorboats. During World War I, sails were again utilized due to fuel shortages. Shrimp trawling with sailing boats in the small and narrow shrimp fields along the Norwegian coast (Figure 1) was challenging. As new shrimp fields were discovered along the coast, the fishery gradually moved westwards.

Official statistics of shrimp landings are available from 1908 onwards (Hjort and Ruud 1938). In 1908, 405.8 tonnes (t) of shrimp were landed, and the shrimp fishery was by then conducted along the coast from Østfold county to Rogaland county. Since 1908, landings statistics by year and county, and for many years also by municipality, are available through “Norges Fiskerier” (Norwegian Fisheries), as scanned reports. The data were previously not digitized, and, thus, not readily available.

An overview over the Norwegian historic shrimp landings constitutes an important part of the history of the Norwegian fisheries. Landings statistics are also important input data to stock assessment models. The goal of our work was threefold: 1) provide the first description of the Norwegian shrimp landings and their value by county from the infancy of the fishery until today, 2) describe the shrimp landings over time from Sogn og Fjordane to Nordland, a region where the shrimp fishery has been declining or has disappeared in more recent years, and finally 3) provide historic Norwegian landings by statistical area as input data to the current stock assessment model for the shrimp stock in the Skagerrak and Norwegian Deep area (pra.27.3a4a). The last task was part of the data input to a benchmark of shrimp stocks in 2021-2022 conducted by the International Council for the Exploration of the Sea (ICES) (ICES 2022a).

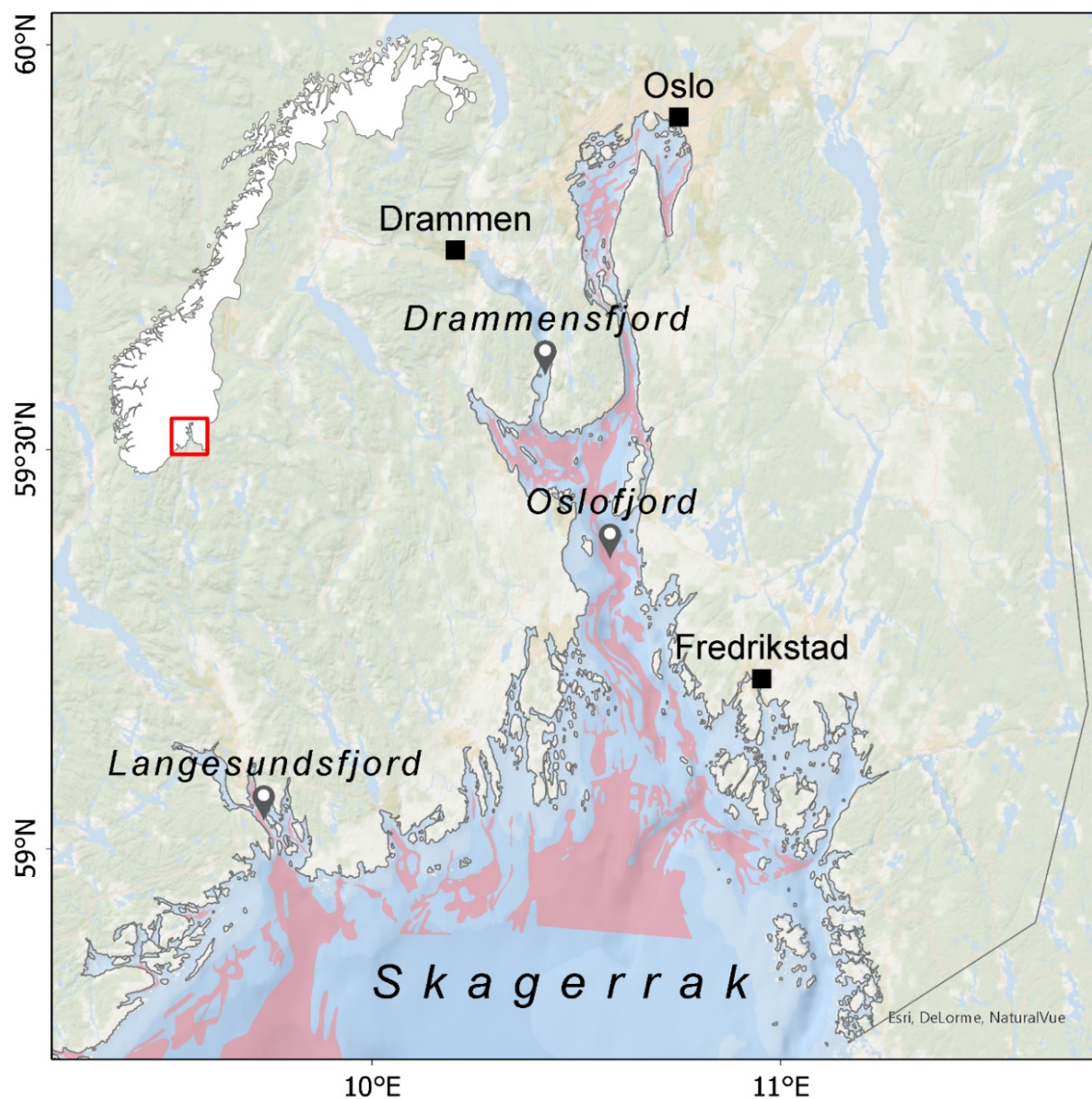


Figure 1. Map of the Oslofjord and eastern Skagerrak region. Pink shading are commercial shrimp fishing grounds (shrimp fields) from the Norwegian Directorate of Fisheries ([Maps from the Directorate of Fisheries](#)).



Figure 2. Shrimp trawler with sail in Langesundsbukta in 1925. Photo: Alf Dannevig.

2 - Material and Methods

2.1 - Data

Data on shrimp landings and their value were collected from the Statistisk sentralbyrå (SSB) landings register for 1908-1976 ([historical landings](#)), and combined with data on landings and value for 1977-2021 from the Norwegian landings and sales slips register (Landings- og Sluttseddelregister, Norwegian Directorate of Fisheries).

Landings per county and municipality were available from the time periods 1908-1929 and 1935-1976, while in 1930-1934, only landings per county were available. All data from 1908-1976 were digitized based on the scanned reports "Norges Fiskerier" (Norwegian Fisheries). Data on landings per municipality were also digitized, but are not presented in this report. Table 4 in the "Norges Fiskerier" reports was used to retrieve data for 1908-1952, Table 5 for 1953-1962, Table 1 for 1963-1975, and Table 2 for 1976.

The names of some counties and municipalities, as well as their borders, have changed throughout the century. In 1908-1918, Vestfold was recognized as Jarlsberg og Larviks amt, and Hordaland and Sogn og Fjordane were recognized as Søndre Bergenshus amt and Nordre Bergenshus amt respectively. Bergen had status as its own county, and Stavanger amt constituted the entire present-day Rogaland county (Thorsnæs 2021). Another, more current, regional reformation of the counties occurred in 2020, where some counties were merged, such that Akershus, Buskerud and Østfold became Viken, Vestland was created from the merging of Hordaland and Sogn og Fjordane, Vest-Agder and Aust-Agder became Agder, while Vestfold and Telemark were merged to form Vestfold og Telemark. County names were standardized across the time series to their definition post-2020 for the complete overview and pre-2020 for detailed county-level representation, respectively.

The resolution of the available data from the landings and sales slips register has varied over time. Landings and value per landing municipality, county and fishing area for 1977-2004 were made available to us upon request by the Norwegian Directorate of Fisheries, such that the historic time series could be extended until present. Data for this time span already in the database of the Institute of Marine Research (IMR) were only available per fishing area, not landing county. For the years 2005-2021, detailed sales slip documents including landing weight and first-hand price information for all fishing trips were available, by both fishing area and landing site (IMR database, shared through the Norwegian Directorate of Fisheries). All landings from 1977 onwards were assigned to a major fishing region (Greater North Sea, Norwegian Coast, Barents Sea, Svalbard, Greenland and Jan Mayen, Grand Banks and Flemish Cap) based on registered statistical area (Table 1). To achieve standardized time series, landings include all shrimp that have been landed in Norway independent of origin of catches or vessels, as information on nationality of the vessels landing shrimp in Norwegian ports or the fishing area were not available in the statistics until 1976.

All monetary data were corrected for consumer price inflation using the Norwegian consumer price index (SSB, [consumer price index](#)), adjusting prices and values to the level of 2014. Prices of individual landing transactions were only available from 2005 onwards. Mean prices before 2005 were therefore produced by dividing total value with total landings, while the mean of prices weighted by landings weight was used for 2005-2021.

Table 1. Major fishing regions by statistical area for the Norwegian shrimp fishery, as defined in this report. Landings outside these regions (statistical areas 30, 43, 47) may be misreported and are grouped together with registrations without statistical area (Figures 6, 10).

Fishing region	Statistical areas
Greater North Sea	08, 09, 28, 41, 42
Norwegian coast	00, 03, 04, 05, 06, 07
Barents Sea	01, 02, 10, 11, 12, 13, 14, 15, 16, 17, 18, 20
Svalbard	21, 22, 23, 24, 25, 26
Greenland and Jan Mayen	60, 61, 68, and 35, 36, 38
Grand Banks and Flemish Cap	80, 81, 82
Others	30, 43, 47

2.2 – Species and fishery

In the North-Atlantic, northern shrimp is distributed along the Norwegian coast, in the North Sea and Skagerrak, in the Barents Sea, around Jan Mayen, Iceland and Greenland, and off the Canadian coast (Figure 3) (Shumway et al. 1985). The species can be found at depths between 9 and 1450 m, with highest densities between approximately 100 and 400 m, predominately on soft bottom. Commercial shrimp fishing grounds (shrimp fields) have been mapped by the Norwegian Directorate of Fisheries ([Maps from the Directorate of Fisheries](#)). Shrimp fields along the Norwegian coast appear as a mosaic of large and small areas of soft sediment interspersed between rocky bottom (Zimmermann et al. 2019). In the Skagerrak, North Sea and the Barents Sea, on the other hand, large coherent areas of soft bottom (ICES 2021) provide suitable habitat for the much larger offshore shrimp stocks.

Shrimps are caught using bottom trawls with a mesh size of minimum 35 mm in the codend, and with an obligatory fish sorting device, i.e. a grid which excludes fish larger than approximately 20 cm length from the catch (ICES 2022b). The sorting grid was made compulsory for the counties Nordland, Troms and Finnmark in 1990 (within 12 nautical miles), and for the whole Norwegian exclusive economic zone (EEZ) north of 62°N in 1991. Shrimp grounds where bycatches of juvenile fish exceed legal limits are closed by the Norwegian Directorate of Fisheries (IMR 2021). There are two shrimp management units in Norwegian waters: 1) Skagerrak and Norwegian Deep and 2) Shrimp north of 62°N. Annual quotas (total allowable catch (TAC)) for the Skagerrak and Norwegian Deep stock have been determined since 1992 following advice from ICES, while there are no quotas for the shrimp stock north of 62°N (NAFO/ICES 2021).

Shrimp catches in the Skagerrak and Norwegian Deep are sorted on board, and the largest shrimp are boiled and landed fresh, fetching high prices (around 110 NOK/kg), while the medium-sized shrimp are landed raw to the industry, fetching much lower prices (15-18 NOK/kg) (ICES 2022b, Knutsen 2022). The smallest sizes can now also be landed but have traditionally been discarded (ICES 2022). Sorting and boiling on board take place also along the coast, while the offshore fleet in the Barents Sea and Svalbard area processes and freezes all catches on board. Frozen shrimp fetch lower prices than shrimp landed fresh ([prices](#)). Discards of shrimp are not estimated but are believed to be small as the Barents Sea fishery is not limited by quotas (NAFO/ICES 2021).

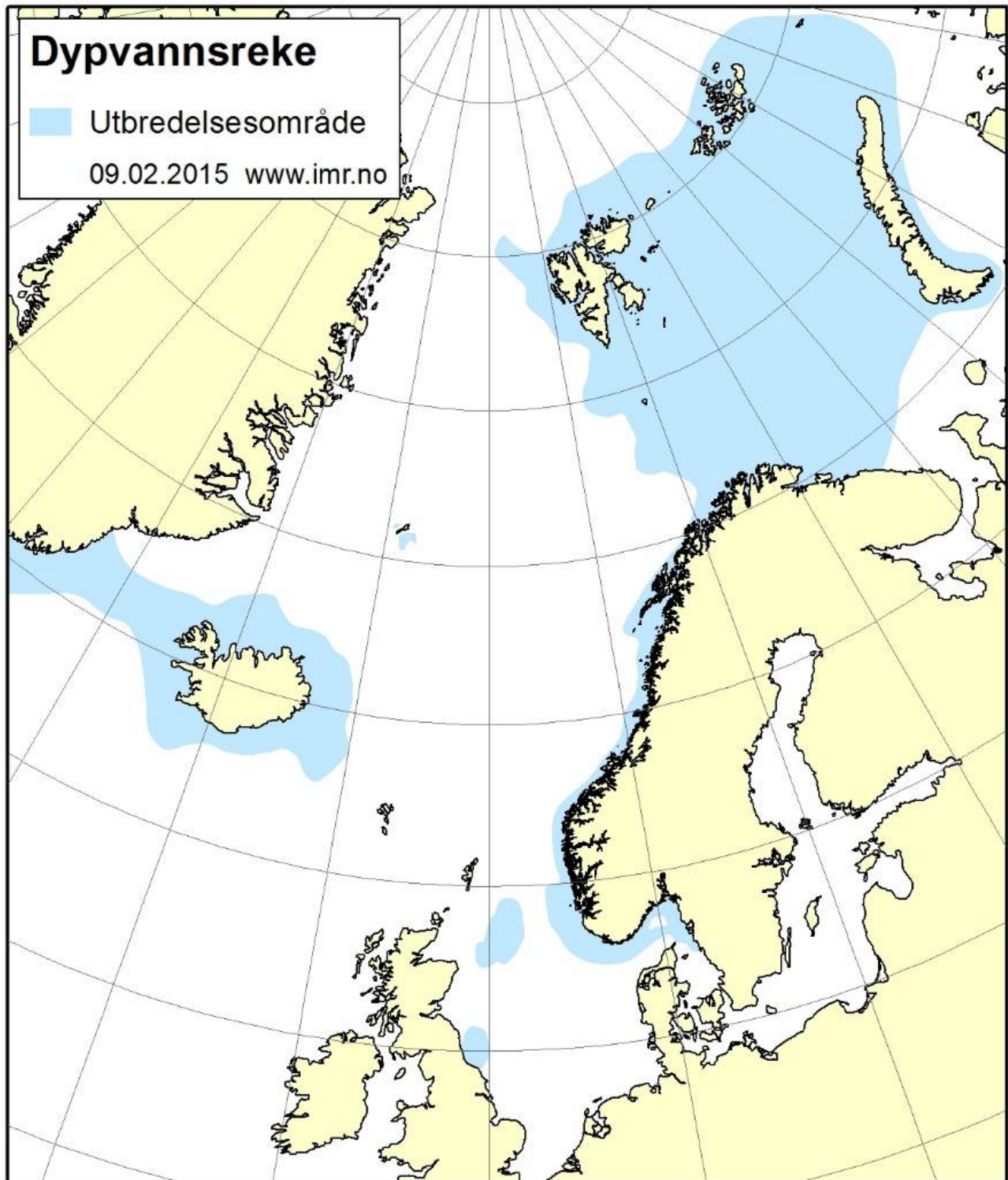


Figure 3. Distribution of northern shrimp, indicated by blue. Map from the Norwegian Institute of Marine Research (IMR).

3 - Results

3.1 - Landings

3.1.1 - National trends

The Norwegian shrimp fishery has developed substantially since its infancy more than a century ago (Figures 4, 5, Table 2 (Appendix)). As new shrimp fields were discovered along the coast, the fishery grew and expanded, from the inner part of Skagerrak, along the southern and western coast of Norway, to Nordland county, and then finally to Troms and Finnmark counties (Figure 5). Increases in landings were facilitated by technological progress, notably the initial advancements in shrimp trawling and later development of a powerful offshore fleet capable of bottom trawling in areas such as the Barents Sea and around Svalbard.

From 1908 to 2021, the total Norwegian shrimp landings have shown large fluctuations over time, both on a national and a regional scale (Figure 4). Five main periods with contrasting trends are seen in the time series of total landings. From 1908 to 1970, there was a gradual increase in landings, from only 419 t to 7 511 t, including a drop in landings during World War II as well as in the late 1960s. The latter drop was caused by decreasing landings in southern Norway. Then over a period of about 15 years, from 1970 to 1985, there was a more than twelvefold increase in landings, to 91 165 t in 1985, the highest annual landings in the time series. Total landings were high in the years 1980-2005, peaking in 1985, 1989-1993 and 2000. The high level was then followed by a drop in landings, to 17 397 t in 2013, and then a gradual increase again, to 39 974 t in 2021. The recent increase is due to increasing landings into ports in Troms and Finnmark.

Initially, in the 1920s, shrimp fishing was concentrated in southern Norway, including Skagerrak and the southern and western Norwegian coast, with only minor landings registered further north. Large offshore shrimp fields in Skagerrak and the Norwegian trench were discovered in the 1920s (Hjort and Ruud 1938) (see below). From the 1920s onwards, the shrimp fishery gradually moved northwards, with landings more and more evenly distributed along the Norwegian coast, including northern Norway. In 1970, Norwegian vessels started the offshore shrimp fishery in the Barents Sea (NAFO/ICES 2021). Due to the large catches in the Barents Sea and Svalbard area (Figure 6), the total Norwegian shrimp landings have since the 1980s been dominated by landings into ports in northern Norway (Figure 4). Norwegian vessels also have had quotas and have trawled for shrimp around West- and East-Greenland, and on the Grand Banks and Flemish Cap in international waters in the Northwest-Atlantic (Casas 2012). Changes in landings over time reflect therefore both the expansion of fishing areas as well as periods of long-distance fishing outside of the Norwegian EEZ (Figure 6). In several years in the 1990s and up to 2005, a substantial share of the total landings in Norway originated from the Grand Banks and Flemish Cap region, and to a lesser extent from Greenland and Jan Mayen. After 2010, this fishery has been negligible (Figure 6).

3.1.2 - Trends in southwestern Norway

The overall picture for southwestern Norway, from 1908 to 2021, is that of increasing landings, but there have been large fluctuations over the decades (Figure 7). A gradual increase in landings from 1908 to 1939, where landings from Agder and Rogaland dominated the statistics from 1931 onwards, was followed by a drop in landings during World War II. The increase from 1920 onwards is explained by the fleet moving offshore following the discovery of the shrimp stock on Svennerbanken in eastern Skagerrak, while the sharp increase in landings in the beginning of the 1930s was caused by the discovery of large amounts of shrimp on Revet, a large area of soft bottom stretching from Skagen into the North Sea (Hjort and Ruud 1938). From 1950 to 1963, landings increased sharply, followed by a large decline in the second half of the 1960s. Rasmussen (1967) explained this decline by unusual cold winters in 1963 and 1966 leading to formation of cold bottom water which penetrated into Skagerrak and displaced the shrimp. The cold bottom water held a temperature of 4-6°C compared to normally 6-8°C. Following these cold winters, landings increased almost sevenfold over the next 28 years, from 1970 to 1998, with the highest recorded landings in the time series of 9478 t. The 1980s, 1990s and 2000s were characterized by landings fluctuating at a high level, dominated by landings into Agder. After a sharp decline from 2008 to 2010, landings again increased to reach a new, although lower peak in 2016.

The most recent years have seen landings of around 4000-5000 t. The shrimp stock in southwestern Norway has since around 2010 been at a lower level (ICES 2022b), which explains the recent lower landings. Recruitment has been low since 2008, except for the 2013-year class, which caused an increase in biomass, reflected in increased quotas and transient higher landings.

To reconstruct a time series of historic landings of the pra.27.3a4a stock in the ICES divisions 3.a (Skagerrak) and 4.a East (the Norwegian Deep), counties were grouped into the statistical areas 09 and 08+28, which correspond quite well to 3.a and 4.a East, respectively (Figure 8). Area 09 was thus defined to consist of the counties Buskerud, Akershus, Østfold, Oslo, Telemark, Vestfold, Aust-Agder and Vest-Agder, while area 08+28 was defined to consist of Rogaland, Hordaland and Sogn og Fjordane. County borders do not completely overlap with the borders of the statistical areas but approximate them sufficiently (Figure 8).

3.1.3 - Trends in Mid-Norway

Although a minor shrimp fishing region explained by the limited area of suitable shrimp habitat in fjords and near-coastal areas, Mid-Norway (the counties from Sogn og Fjordane to Nordland) contributed a significant share of the total Norwegian landings from around 1975 to around 2005, with annual landings of 5000-12 000 t (Figure 9). Landings in Nordland have been relatively stable since the 1950s, whereas the landings in Møre og Romsdal and Sør-Trøndelag increased steeply around 1975 only to mostly disappear again in the early 1990s (Sør-Trøndelag) and mid-2000s (Møre og Romsdal). Landings in Sogn og Fjordane have always been marginal compared to the other counties. The highest total landings were in 1985 with 13 164 t and the county with the highest landings was Møre og Romsdal with 9483 t landed in 1976. In recent years, there have been few to no landings into ports outside of Nordland. In Nordland, however, an increasing trend has been observed since 2015. The trends are elaborated on in the section below.

3.1.4 - Trends on county level

Many counties have had their largest landings in more recent years, mostly between 1980 and 2021 (Figure 10, Table 2 (Appendix)), reflecting the overall national trend of increasing landings from 1970 onwards (Figure 4). Oslo, Akershus and Buskerud stand out with highest landings during earlier years around 1920-1950, and with low or no landings in more recent years. Stålesen (1963) described how the shrimp fishery in the Oslofjord decreased as the human population, and pollution, around the fjord increased. Trawling in the innermost Bunnefjorden ceased after 1949, and the fishery moved further out. The counties in southern Norway with the historical highest landings are Rogaland and Vest-Agder, followed by Aust-Agder, Østfold and Telemark. The high landings into Rogaland and Vest-Agder most likely came from the offshore shrimp ground Revet, supported by the fact that landings during World War II decreased in these two counties, but not in any of the other southern counties. There was a large peak in landings in Rogaland in the 1950s-1960s, which was notable in Hordaland as well, and to a lesser extent further east. The large decline in landings in the late 1960s is evident in the landings statistics for all counties from Østfold to Hordaland, and according to Rasmussen (1967), the decrease “moved” along the Norwegian coast from east to west. Landings have remained at a relatively high level in the Skagerrak counties in recent years, with the exception of Oslo, Akershus and Buskerud, while landings into Rogaland have declined by two-thirds from the beginning of the 2000s until today, reflecting the currently very low stock level in the Norwegian EEZ in the North Sea (ICES 2022b). A similar reduction, albeit starting earlier is seen in Hordaland, where the landings, and thus fishery, are now almost non-existent. In Sogn og Fjordane, the shrimp fishery has always been small and has presently ceased, as in Hordaland. Indeed, recent investigations have shown that currently there are practically no shrimp on the former shrimp fishing grounds in these two counties (Zimmermann et al. 2021).

The high landings into ports in mid-Norway in the years 1975-2005 (Figure 9) did not come from local shrimp grounds but the Barents Sea, Svalbard waters and the Northwest-Atlantic (Figure 10). In fact, more or less all the Norwegian landings from the Flemish Cap and Grand Banks were landed in Møre og Romsdal and Sør-Trøndelag. The much smaller landings in these counties from earlier years can be assumed to have come from local shrimp fishing grounds, but this local fishery has now ceased. Further north, catches from coastal areas (local grounds) dominate the landings statistics, particularly in Nord-Trøndelag and to a lesser extent in Nordland. However, Nordland totally dominates the

coastal shrimp landings in Mid-Norway when it comes to quantities. Both these counties had the highest landings in the 1950s-1970s when landings from the Barents Sea and Svalbard area into Nordland are ignored. The coastal shrimp fishery has since decreased in both counties. The fish sorting grid was made compulsory north of 62°N in 1990-1991, and unlike for the shrimp fishery in southwestern Norway, a fish retention device (collecting bag) at the grid's fish outlet is not legal. As shrimp fishers lost part of their revenue base, some may have left the fishery, thus contributing to the decrease in coastal landings seen in Nord-Trøndelag and Nordland in the beginning of the 1990s. Trends in the landings in Sogn og Fjordane have been described above. Occasionally large peaks in landings in this county were the result of shrimp caught in the Barents Sea, around Svalbard, or in areas outside the Norwegian EEZ being landed in the county (Figure 10).

The shrimp fishery in Troms started in 1931, and in Finnmark in 1935 (Table 2 (Appendix)). The highest landings have occurred during more recent years (Figure 10). In Finnmark, landings peaked in 1980-1995, while Troms had the highest landings in 1998-2005. In Finnmark, the Tanafjord and Porsangerfjord have been closed for all bottom trawling since the early 1970s (Søvik et al. 2020), thus the main shrimp fishing grounds are found in the Varangerfjord and Laksefjord. The decrease in coastal landings in Finnmark started in the mid-1980s and as such cannot be explained by the closing of the two fjords. While there have been relevant landings in Troms og Finnmark from coastal areas, the landings in later decades have become heavily dominated by shrimp caught in the Barents Sea and around Svalbard, especially so in Troms, which is the county with the highest landings in all of Norway. Landings from the Barents Sea and Svalbard area have shown great fluctuations due to variations in stock size caused by irregular recruitment and predation by cod, but the fishing effort has also varied (Garcia 2007).

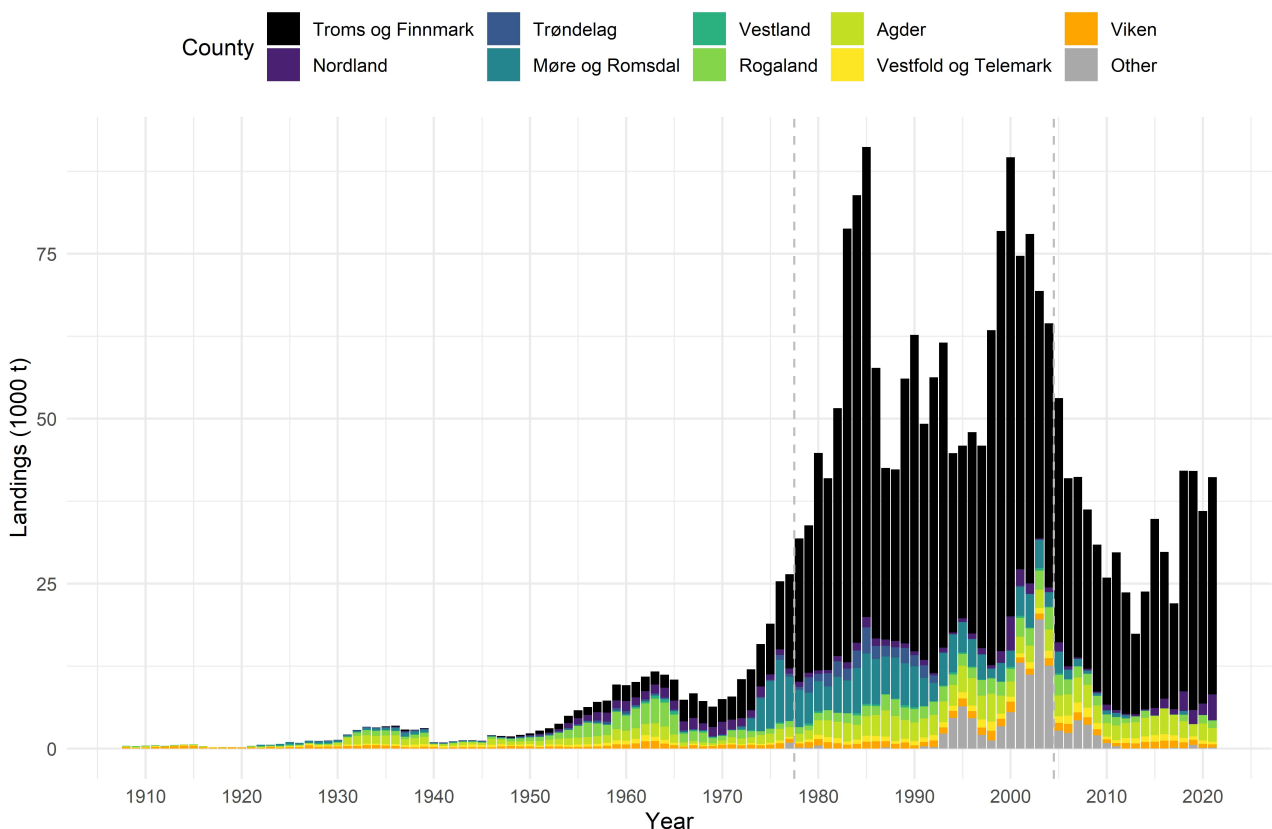


Figure 4. Total Norwegian landings (1000 t) per year and county (county borders since January 1, 2020), including landings from foreign vessels into Norwegian ports. The data include landings from both Norwegian waters as well as waters of other countries and international waters. "Other" includes landings landed abroad or at unknown locations. Annual amounts landed in Oslo were too negligible to be visible and are therefore included in Viken landings. Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries).

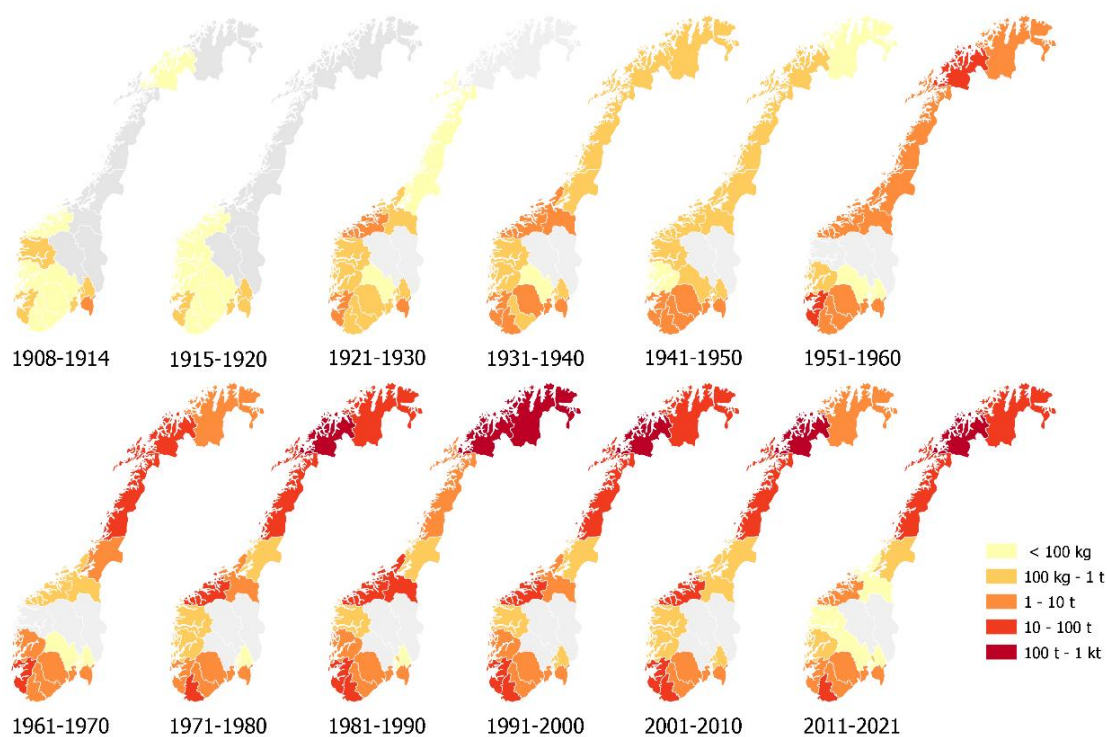


Figure 5. Landings of northern shrimp (t) by county (county borders until December 31, 2019) for 10-year periods, 1908-2021. The first two maps show shorter time periods. The colour scale shows weight of landings, from <100 kg (light yellow) to the highest landings (100 t-1 kt) (dark red).

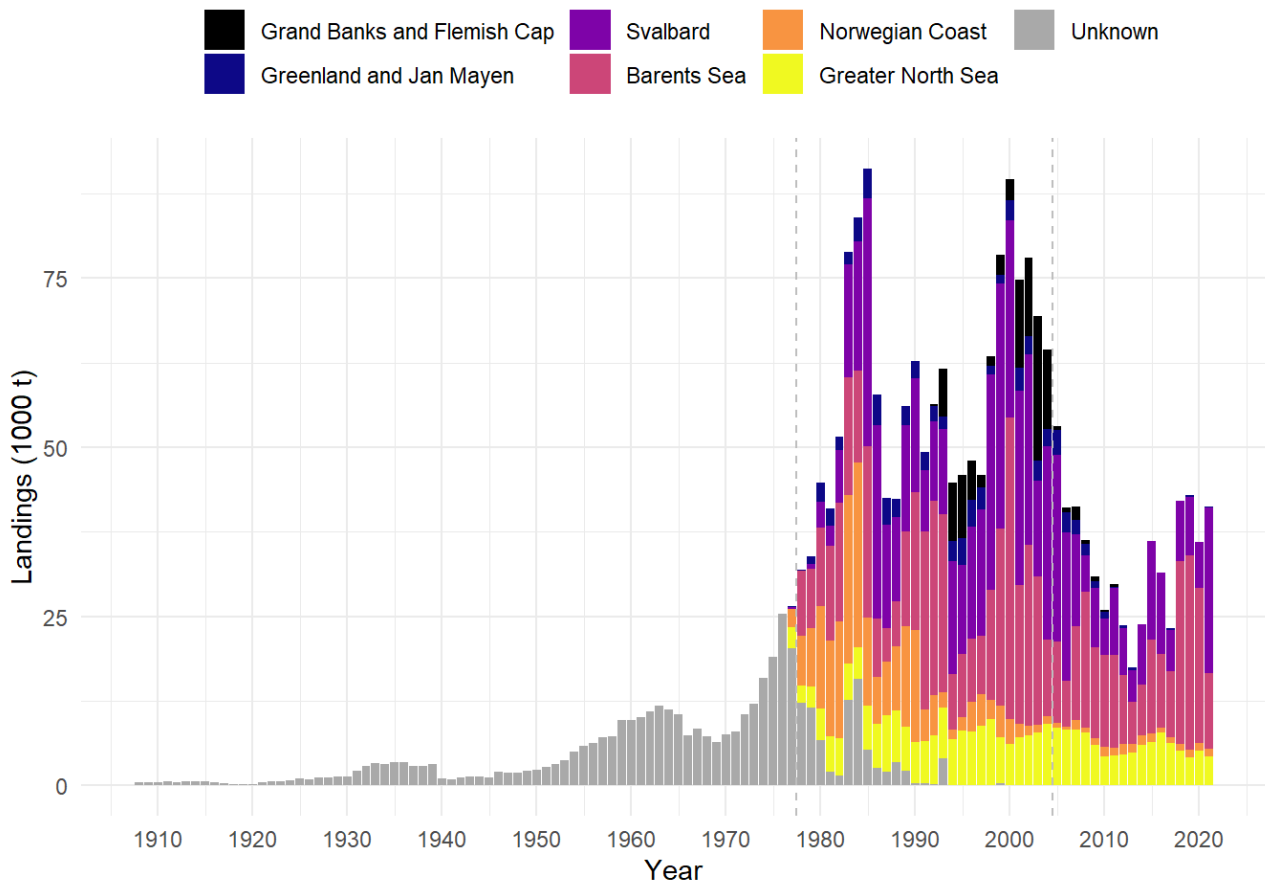


Figure 6. Total Norwegian landings (1000 t) per year and fishing region (Table 1), including landings from foreign vessels into Norwegian ports. “Unknown” includes landings without a fishing area listed (applies for all landings before 1977 and parts of 1977-2004). Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries).

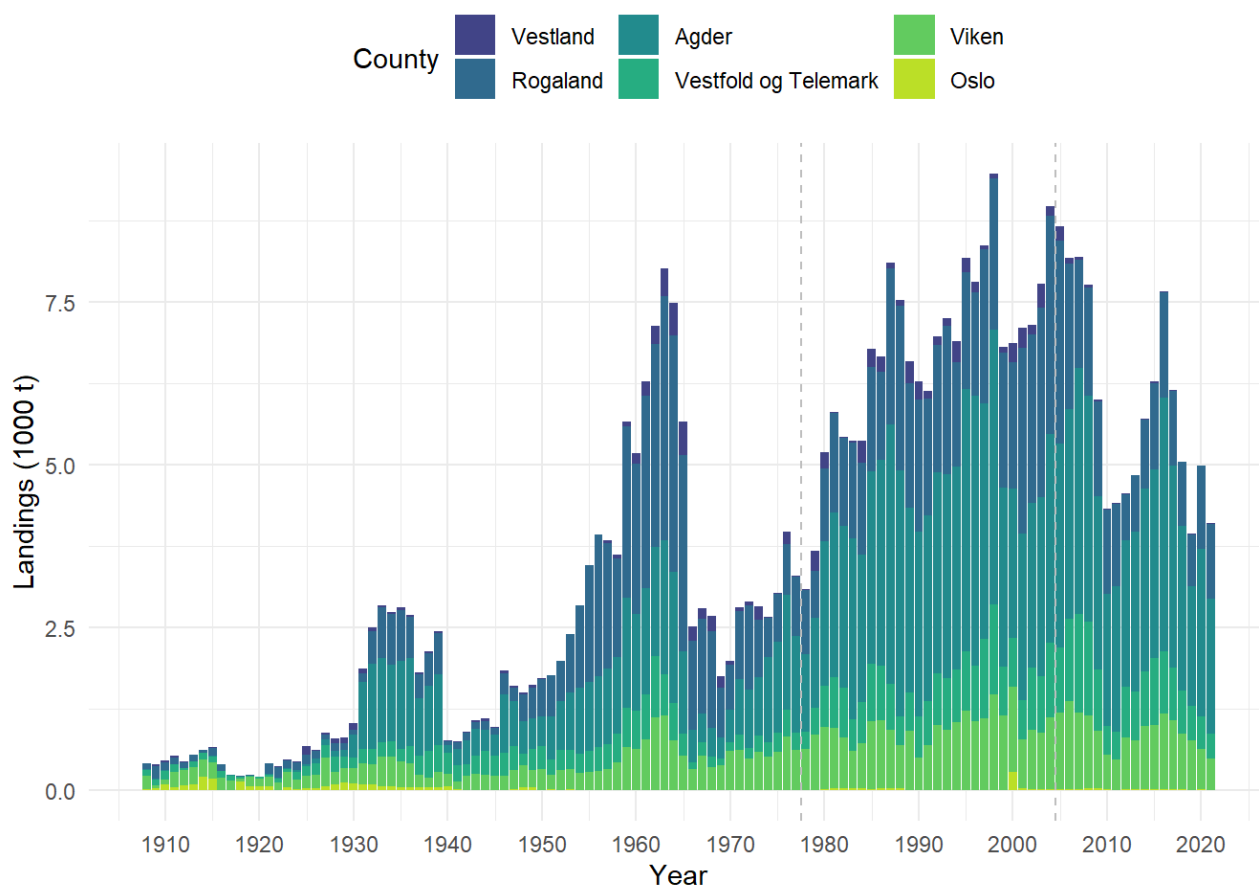


Figure 7. Total Norwegian landings (1000 t) per year and county in southwestern Norway (county borders since January 1, 2020), including landings from foreign vessels (mainly Swedish and Danish) into Norwegian ports. The data include landings from both Norwegian waters as well as waters of other countries. Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries).



Figure 8. Counties (county borders since January 1, 2020) (thick, blue line) and statistical areas from the Norwegian Directorate of Fisheries (thin, red line). Map from the Norwegian Directorate of Fisheries ([Maps from the Directorate of Fisheries](#)).

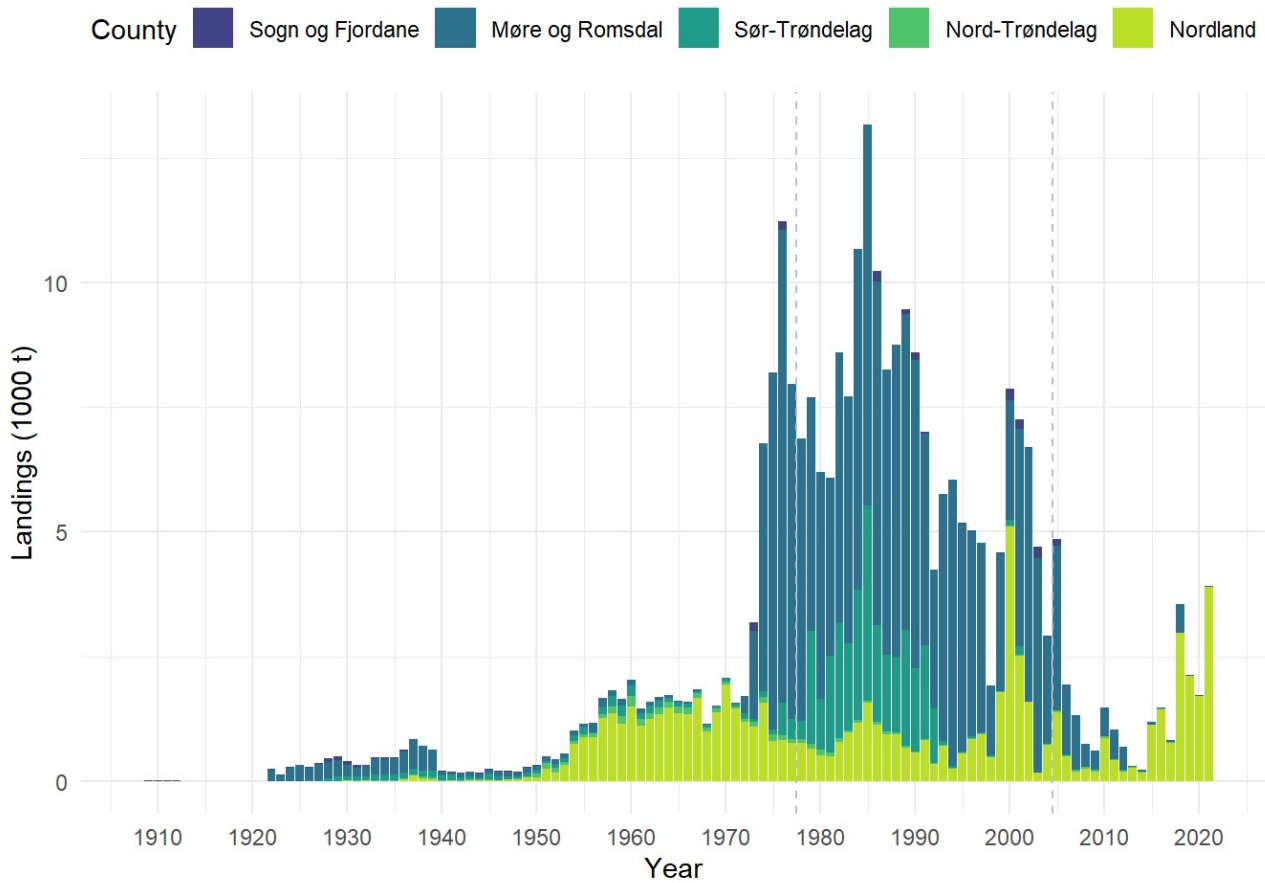


Figure 9. Total Norwegian landings (1000 t) per year and county in Mid-Norway (county borders until December 31, 2019), including landings from foreign vessels into Norwegian ports. The data include landings from both Norwegian waters as well as waters of other countries and international waters. Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries). Note that landings in Sogn og Fjordane are shown in Figure 7 as well, included in landings from the new county of Vestland.

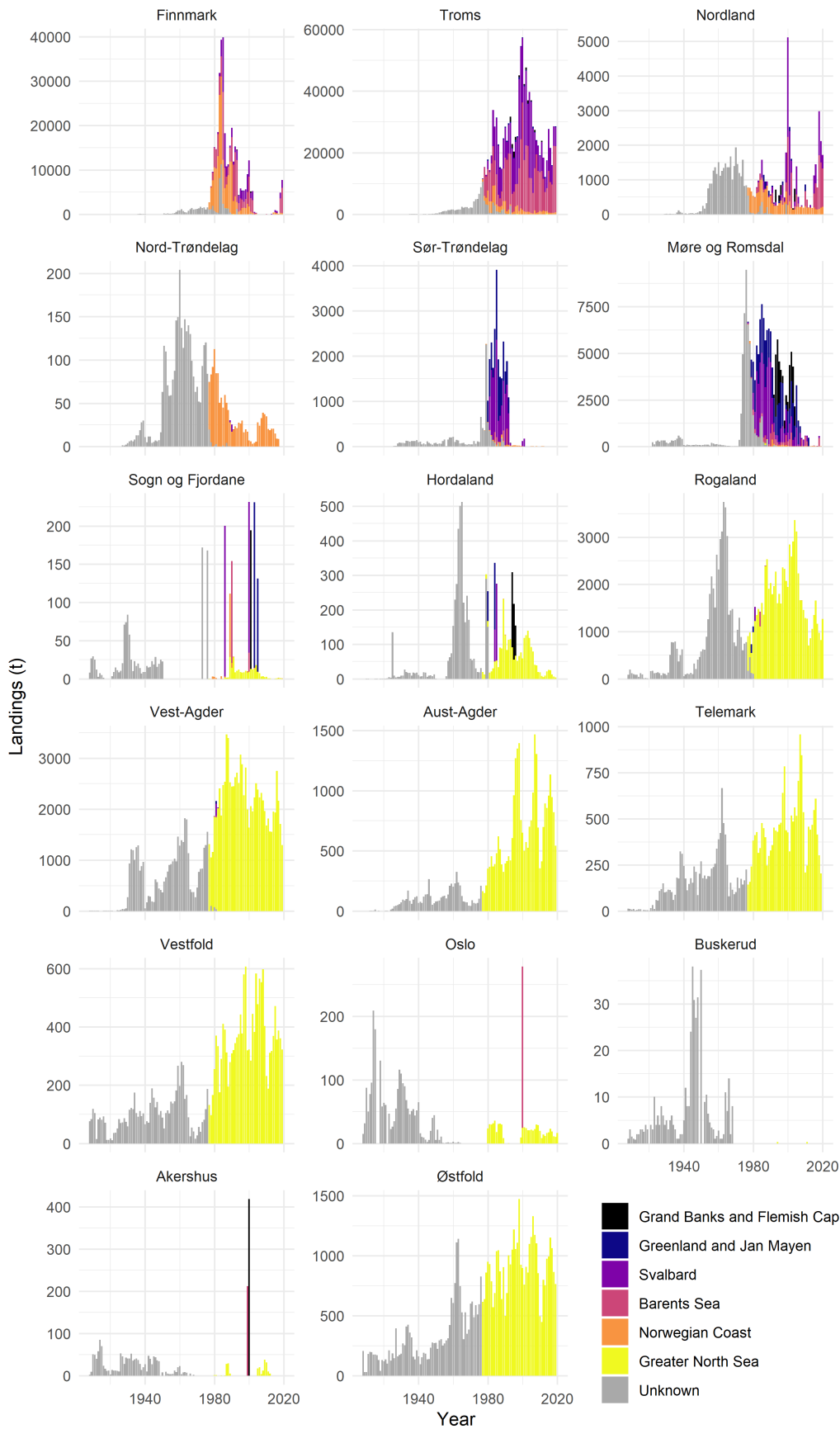


Figure 10. Total landing weight (t) per county (county borders until December 31, 2019) and fishing region (Table 1) for 1908-2020, including landings from foreign vessels into Norwegian ports. "Unknown" includes landings without a fishing area listed (applies for all landings before 1977 and parts of 1977-2004).

3.2 - Value of landings

The total value of the Norwegian shrimp landings has increased enormously throughout the time series (Figure 11). This trend is naturally much more pronounced for the nominal value due to increasing price levels over time. After correcting for consumer price inflation, the trend in value reflects more closely the development in landings over time (Figures 4, 11). There are no data on value from years prior to 1928, when the total value, corrected for inflation, was 29 747 NOK. Value (corrected for inflation) increased steadily from 1928 to 1965 to around 500 million NOK, followed by a drop to about 250 million NOK in 1970. The value then again increased steadily to peak in 1985 at 1 883 million NOK, the year of the highest total landings. A subsequent decline until 2010 was followed by a recent increase.

The pattern in total value is partly reflected in the mean price per kilo (first-hand price) that nominally increased almost exponentially from 2004 to the mid-2010s, to around 35 NOK/kg (Figure 12). When corrected for inflation, however, the first sale price has fluctuated substantially over the years, with two main peaks after World War II, one in the late 1940s and one in the mid-1960s (Figure 12). While total landings and, thus, total value increased and remained high until the early 2000s, the adjusted price per kg declined steadily during the same period. The first-hand price started recovering again following its lowest level in 2006, in parallel to the increasing shrimp landings in the past decade.

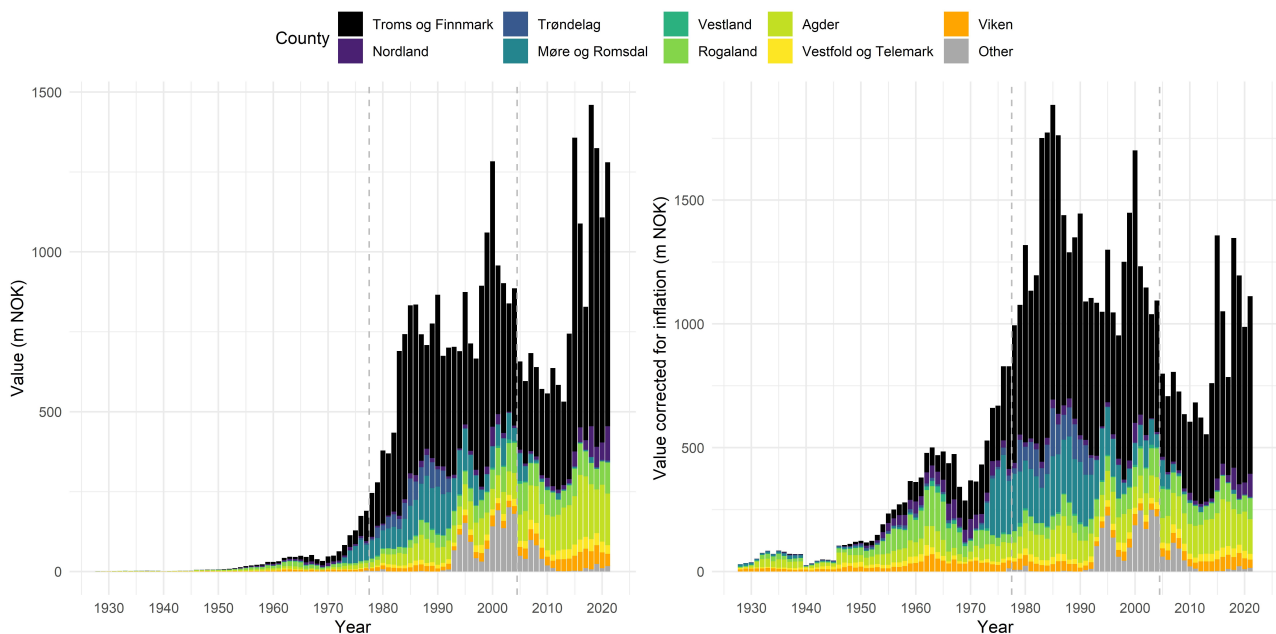


Figure 11. Total value of landings (million NOK) over time per county (county borders since January 1, 2020), nominal (left) and corrected for consumer price inflation (adjusted to 2014, right). "Other" includes landings abroad or at unknown locations. Value of landings in Oslo were too negligible to be visible and are therefore included in Viken values. Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries).

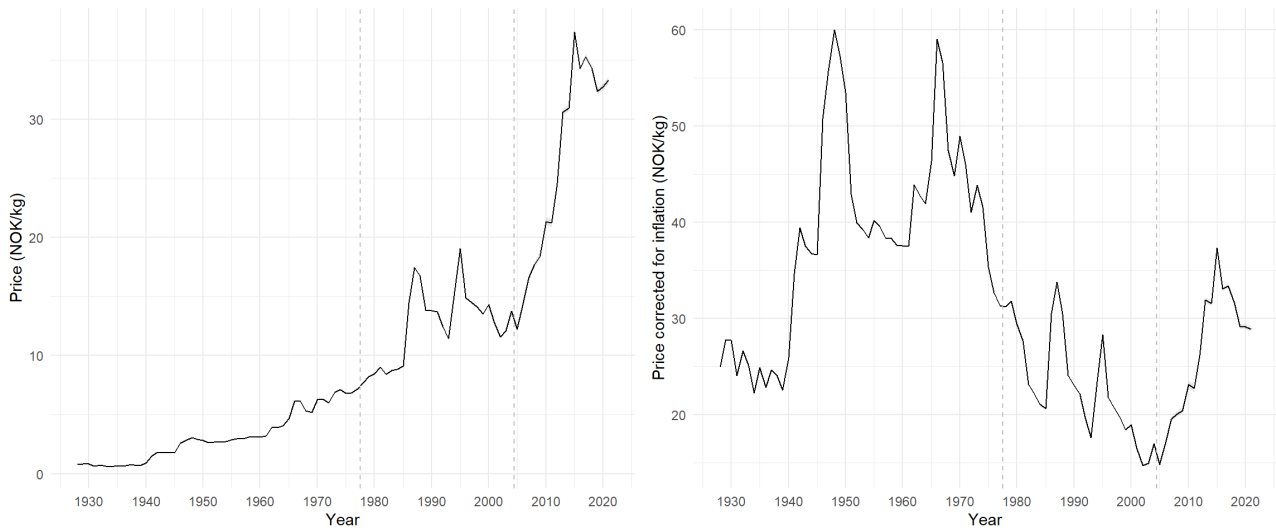


Figure 12. Landing price over time, nominal average prices (left) and average prices corrected for consumer price inflation (adjusted to 2014, right). The price in 1928-2004 is the ratio of total value over landings, while from 2005 onwards mean price per landing was used. Vertical dashed lines indicate the different time series: historic landings data (1908-1976, SSB), aggregated (1977-2004) and detailed sales slips (2005-2021, Norwegian Directorate of Fisheries).

4 - Discussion

Long time series of fisheries landings are an important source of information to trace the development of a fishery and provide a historic baseline. Although many fisheries in the Northeast-Atlantic Ocean have existed for centuries, fisheries data are often only available for the most recent decades, limiting our knowledge about the dynamics of fisheries and fish stocks. Archiving and digitalizing spatially resolved historic fisheries data, when such records exist, therefore produce a valuable data source for research and stock assessment. Here, we presented for the first time the complete time series of the Norwegian shrimp landings per county, enabling us to follow the Norwegian shrimp fishery across more than a century.

The emergence of shrimp fishing in the Oslofjord and eastern Skagerrak in the end of the 19th century, and its subsequent expansion along the Norwegian coast and into offshore areas that facilitated a large increase in production, were the result of technological and scientific progress. Because of their preferred habitat, northern shrimp remained a largely inaccessible resource until early fisheries scientists became capable of surveying deeper areas and discovered relevant shrimp fields. Progress in gear technology and vessel power around the same time enabled fishers to exploit the newly discovered resource and expand the fishery in subsequent years. As for many other major fisheries, a large increase in production occurred with the emergence of industrial fisheries after World War II that made offshore fishing viable and, thus, expanded the accessible fishing grounds drastically. These dynamics are reflected by increasing landings, first mainly from the Skagerrak and Norwegian Deep area, later from the Barents Sea that began to dominate shrimp landings in the 1970s. In addition, fishing grounds around Jan Mayen, Greenland, and in international waters on the Grand Banks and the Flemish Cap became accessible for Norwegian vessels during periods from the 1980s to the early 2000s, resulting in substantial landings of shrimp in Norway originating from distant regions. Over time, offshore landings have virtually eclipsed the amounts produced in the inshore areas that have been decreasing or disappearing in many counties in the most recent decades.

Since northern shrimp consist of different populations and are managed as several stocks, spatially resolved landings data detail the onset and changes in the stock-specific fisheries and therefore provide valuable information for stock assessment and management. However, landings data alone are not sufficient as indicators of changes in the shrimp stocks, as changes in landings are the result of multiple drivers, of which stock dynamics are but one. As previously detailed, significant changes in shrimp landings were caused by technological development, increased fishing efficiency and the emergence of long-distance fleets. In addition, landing catches in a specific county is conditional on the availability of landing sites and processing plants, which in turn often depend on a local fishing fleet. While landing sites are a reasonable proxy for the fishing location in smaller-scale inshore fisheries where fishing vessels operate in a limited area, long-range offshore vessels can deliver their catches to landing sites far away from their fishing areas. For shrimp in Norway, this can be observed for Troms and Finnmark where most landings from the 1980s onwards originate from the Svalbard area and the central Barents Sea, inflating the relevance of these two counties. Other striking examples are the counties from Sogn og Fjordane until Sør-Trøndelag where landings from coastal areas were always low and changes over time therefore largely driven by the inflow of catches originating from the Barents Sea and Svalbard area, Jan Mayen, Greenland, the Grand Banks and the Flemish Cap. Because in these cases fluctuations in landings were mostly the result of where fishing vessels had their port of registry or processing plants were available, time series of landings might give a biased perspective of changes in the fishery within the specific county if the fishing areas were not accounted for. It is, thus, not possible to determine from landings data alone whether the decrease or disappearance of shrimp landings in many counties in Mid- and West-Norway over the past three decades has been caused by declining shrimp abundance in these areas, driven by economic factors such as the consolidation of shrimp landing sites and the fishing fleet, or a combination thereof. Local populations in Møre og Romsdal and Sør-Trøndelag have, furthermore, never sustained a significant fishery due to limited shrimp habitat in this region.

The first-hand price reflects both the size and processing of the landed shrimp (frozen, boiled/fresh, raw) and therefore the fishing area. The peaks in the first-hand price occurred while the shrimp landings were still dominated by landings from southwestern Norway and coastal areas, where shrimp are landed fresh, fetching high prices. As frozen landings

from offshore areas started to dominate the total landings from the mid-1970s, the first-hand price decreased. The total value of the fishery similarly reflects fishing grounds; the landings into Troms og Finnmark (dominated by offshore landings) make up a disproportionally lower percentage of the total value of shrimp landings (Figure 11) than the landings volume should indicate (Figure 4). However, prices are also affected by an international market and other economic drivers, notably with the development of a global seafood trade in recent decades.

Fisheries dynamics are strongly governed by economic parameters such as landing prices and fuel costs, especially when they are not managed through catch limits. This applies for a large segment of the shrimp fishery in Norway, as only the shrimp stock in the Skagerrak and Norwegian Deep is regulated through a quota. Entry and catches in the fisheries for the shrimp stocks along the coast north of 62°N and in the Barents Sea are not restricted, and thus they are essentially open-access fisheries, as were many of the distant water fisheries in the past. Consequently, shrimp fishing vessels have likely been operating at the margin where total cost equate total revenue, making the fishing activity very price sensitive. As reported here, there have been substantial fluctuations in landing prices for shrimp over time, which likely have driven fluctuations in landings in response. In contrast to regional markets for fresh boiled shrimp along the coast, the largest share of landings is processed as frozen shrimp and is therefore part of an internationally integrated market. While there are probably feedbacks between prices and landings in Norway itself, it can be assumed that prices are strongly affected by the production of northern shrimp in other countries, as well as possibly of other shrimp species as substitutes. Unsurprisingly, the low point in mean prices in the early 2000s coincided with a peak in global production following large increases in landings in Canada and Greenland (Hvingel et al. 2021). The subsequent decline in global landings led to recovering prices and an increase in landings in Norway, especially from the Barents Sea and Svalbard area. These patterns demonstrate that economics can contribute substantially to our understanding of fisheries dynamics, and therefore underline the importance of maintaining and making available historic time series on landings value and prices, as achieved in this study.

Time series of landings that span the entire fishing history can provide an important reference against which today's state of the fishery and stock can be compared, especially when integrated into an analytical stock assessment. The spatial resolution of the shrimp landings presented here enabled us to approximate catch time series for the two assessment areas of the northern shrimp stock in the Skagerrak and Norwegian Deep as defined today, and use them as input in the stock assessment model. This allowed for the estimation of stock size from 1908 onwards (ICES 2022b), creating a time series of stock dynamics that is longer than for almost any other stock. Furthermore, this made it possible to test the robustness of the stock assessment to the length of the inputted landings time series, showing that the default approach of using landings dating only back until the 1970s produces stock estimates in line with those estimated from the complete time series. The case of shrimp in the Skagerrak and Norwegian Deep underlines therefore the practical relevance of historic landings data. Consequently, we recommend that all landings data for all species are made accessible in the highest possible spatial resolution to broaden our perspective of the development of fisheries, contributing to the sustainable management of marine resources.

5 - Acknowledgements

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7 - Appendix

Table 2. Landings (t) per county in 1908-2021. Landings that were less than 10 t were rounded to two decimal places, landings between 10 and 100 t were rounded to one decimal place and landings above 100 t were rounded to the nearest whole number.

	Østfold	Akershus	Buskerud	Oslo	Vestfold	Telemark	Aust-Agder	Vest-Agder	Rogaland	Hordaland	Sogn og Fjordane	Møre og Romsdal	Sør-Trøndelag	Nord-Trøndelag	Nordland	Troms	Finnmark
1908	206	2	1	15	76.4	12.6	1	8.5	88.5		8				0.05		
1909	30.1	9.3	3	31.9	83	11.5	0.8	8	193		26.6	1.2					
1910	30.1	51	1.5	87.8	118	9	1.6	7	116	0.2	29.4	0.2			0.03		
1911	180	49.4	1	50	104	11.5	1.7	8.1	102	0.8	25						
1912	200	40	0.85	77.5	15.5	4	1.8	4.5	89.2		12.3						
1913	197	58	2	95.9	82.2	6.5	3	7	90		2.56					1.2	
1914	176	85.2	2	209	88.6	9.5	2.1	4	42		7.5	4.25					
1915	176	70.5	3	180	81.2	10	12.2	3	120	0.6	5.2	1					
1916	172	23.9	3		93	1.1	0.6	5.5	97	0.3	1.4	10					
1917	130	16.5	2.5		70.8	6.5	3	6.2	10								
1918	40	11.4	4	131	12.2	5		6.7	16	0.5							
1919	130	12.6	3	58.2	12.3	5.5		8.5	10	0.5							
1920	120	3		64	16.9	2	0.1	8.6		0.4		1.5					
1921	135	14	4	60.4	10.9	16	3.8	6	166	0.8	3.4						
1922	102	12	3		35.8	33.6	3.2	3.5	168	1.4	8.9	237					
1923	212	12.5	10	47	37.3	11	1.7	4	118	5	15	121					
1924	127	11.7	4	22.5	51	60.1	12.2	17.9	127	3	11.5	280					
1925	188	10.4	6	26.4	83.7	57.7	20	12.6	139	135	8.4	325	2				
1926	145	52.7	4	35	69.8	109	39.5	27.5	120	9.3	10.5	264	12				
1927	395	46	8	55	72	120	45.4	40	74.1	3.7	20.3	325	16.3	1.5			
1928	161	28	6	86	87	150	50	39	119	6	71	319	68	1			

1929	173	43	4	116	74	101	57	54	108	6	74	331	91	2	2		
1930	185	41	5	110	59	105	72	276	81	9	84	219	83	4	16		
1931	269	41	3	95	116	117	96	934	130	9.4	58	169	81	6	10.3	0.2	
1932	255	52	5	90	122	114	87	1214	507	27	25	212	73	7	13	14	
1933	410	36	6	68	118	103		1193	776	20	10	328	127	6	6	14	
1934	425	39	4	55	174	61	170	1008	770	17	23	318	122	8	4	13	
1935	360	41	3	46	104	88	86	1256	791	17	17	335	110	13	8	109	3
1936	319	37	1	51	92	182	61	1292	635	9	20	425	118	13	50	109	58
1937	160	28	1	54	111	177	95	793	367	18	14	585	123	19	111	105	132
1938	135	14	2	44	94	323	116	882	502	16	7	495	124	28	65	27	47
1939	211	20	2	52	103	311	122	967	623	18	9	414	142	30	45	28	28
1940	162	27	5	65	66	245	67	56	57	11	9	91	97	11	3	4	20
1941	96	10	12	16	76	177	77	174	95	7	17	46	105	5	21	9	5
1942	153	47.4	8	10.2	70.8	112	68	300	115	7.9	15	96.5	48.7	11.6	9.3	12.8	11.2
1943	192	40.3	8	9.2	140	148	120	284	99.2	19	15.7	84.3	68.6	11.4	22.3	24.3	
1944	183	27.6	24	5.8	189	179	138	190	125	18.3	23.3	70.7	49	4.1	28.8	21.2	
1945	136	46.2	38	2.2	156	154	140	181	102	5.6	18.9	82	113	5.3	28.2	7.3	
1946	139	43.4	30.8	5.6	124	242	267	624	324	9.2	28.7	86.3	81.3	6.9	18.8	23.7	
1947	234	36.6	27	20	142	213	126	571	206	10.3	15.8	106	58.5	6	31.8	115	
1948	276	34.8	31.4	40.4	98	87.1	53.9	444	407	7.9	19.5	78.1	41.4	7.3	49.7	179	
1949	272			44.6	112	203	65.2	417	463	12.9	25.3	86.2	73.9	16.6	87.6	212	
1950	275	7.8	37.3	5.5	89.1	269	79.9	366	577	0.6	22.8	73.6	83.6	63.1	87.9	273	
1951	224			21.5	51.5	179	83	583	622			84.5	53	116	245	293	173
1952	294	9.4	8.9	5.5	104	193	87	665	618			104	65.2	110	167	559	104
1953	304	4.9	10.5	10.8	114	175	112	774	895			106	63.9	70.7	324	647	152
1954	251	3.6	6.4	0.6	103	190	123	903	1264			98.5	119	58.4	746	972	121

1955	269	3.6	4.5	0.3	144	188	129	921	1796			57	151	59.4	888	1087	127
1956	294	4.6	3.4	1.1	137	231	105	979	2172	7.3		202	5.8	77.5	888	1004	205
1957	312	12.1	3	1.8	144	238	138	1027	1916	52.1		172	157	87.3	1260	1330	219
1958	422	8.8	1	0.9	182	257	210	974	1511	62.5		115	203	146	1357	1322	499
1959	648	20	1.6	1	266	338	228	1460	2631	74.2		138	204	149	1162	1553	831
1960	606	22.8	2.8	2.9	197	388	204	1282	2317	153		107	214	204	1504	1534	876
1961	772	4	1	1	280	423	231	1388	2963	229		106	102	137	1117	1250	1106
1962	1110	8	1	1	269	667	327	1354	3119	275		73	149	114	1257	1432	752
1963	1140	9	2	2	153	478	237	1823	3744	435		64	135	147	1338	1530	468
1964	746	7	11	1	166	415	213	1797	3629	501		54	71	133	1471	1571	416
1965	528		7		90	250	126	1134	3022	512		38	75	140	1357	2406	769
1966	305	5	14		24	80	81	426	1360	221		39	80	130	1353	2165	1132
1967	529		2		54	154	76	371	1449	164		23	46	99	1669	2334	1413
1968	349	2	8		41	117	72	371	1481	241		23	44	81	1004	2318	1051
1969	386				16	92	45	272	772	171		16	57	63	1389	1970	1138
1970	601				28	104	44	460	691	58		19	46	69	1932	2255	1204
1971	618				57	182	91	767	1040	54		19	49	52	1456	2154	1350
1972	487				40	125	67	831	1296	58		353	119	51	1193	4229	1667
1973	589				73	175	62	835	888	30	172	1773	61	93	1092	4838	1385
1974	511				81	144	67	1242	603	20		4958	117	117	1574	4924	1525
1975	596				118	167	103	1293	744	19		7158	98	120	813	6632	1088
1976	827				187	225	211	1553	776	31	168	9483	657	84	832	8772	1547
1977	616				132	144	166	1312	907	20	0.13	6698	407	74.6	775	11589	2711
1978	638				96.7	159	151	1052	982	13		5664	363	83.1	768	15395	6317
1979	860				167	242	214	1162	730	303	3	4669	2269	92.1	656	12836	9527
1980	950	1.62		23.5	255	383	355	1863	1110	254	2.62	4546	1016	113	530	17775	15162

1981	929	1.37		30.3	369	412	369	2158	1524	18.1	0.87	3567	1935	84.6	498	14415	14627
1982	786	0.24		29.7	334	429	457	2032	1349	21.3		5426	2304	84.7	781	19038	18526
1983	570	0.36		31.5	175	315	371	2405	1479	30.4		4951	1744	50.5	972	33861	31849
1984	688	0.7		35.8	290	342	390	1873	1420	336	3.37	6836	2600	56.4	1176	28481	39341
1985	1038			17.8	410	478	481	2473	1607	276	0.24	7638	3908	45	1573	31383	39836
1986	1045	0.86		30.8	390	450	620	2535	1357	33.9	200	6894	1930	59.5	1139	22734	18256
1987	870	28.2		31.1	312	401	514	3466	2398	91	1.63	5701	1544	50.5	948	15224	10787
1988	637	29.4		29.7	196	247	387	3394	2532	88.2	1.83	6249	1510	42.3	947	14739	11254
1989	905	5.5		8.44	279	299	326	2524	1905	232	112	6327	2322	30.4	676	24638	15489
1990	497				309	329	395	2440	2032	128	154	6189	1664	25.5	570	28517	19452
1991	688				320	357	416	2449	1795	84	28.9	4243	1884	19.8	826	23885	11891
1992	1004			0.3	344	453	456	2624	1968	113	8.7	2780	1090	23.5	341	29542	15298
1993	928				364	437	420	2716	2272	115	10.4	4942	78.6	21.3	712	31663	14575
1994	1051		0.3		375	430	606	2515	1598	309	12.2	5739	20.4	27.6	253	22831	4359
1995	1218				443	469	961	3072	1797	217	9.13	4561	27.9	26.5	551	20334	5821
1996	1055				377	478	1268	2880	1592	155	8.09	4108	30.8	30.1	842	25158	5355
1997	1108				580	641	1350	2271	2364	51.8	8.76	3795	20.4	16.3	944	25362	5313
1998	1473				606	785	1393	2815	2329	66.3	10.5	1399	18.6	19.8	482	45175	5591
1999	926	213		9.37	319	439	756	1992	2075	76.9	10.2	2760	15.6	17	1781	54681	8997
2000	898	419		278	322	426	651	1637	1948	59	231	2394	119	7.03	5112	57439	12157
2001	758			25.3	284	324	500	2060	2847	119	194	4362	175	6.05	2524	42315	5165
2002	906	0.12		24.1	444	517	574	1955	2589	126	12.4	5077	2.39	3.3	1598	47711	5235
2003	860	0.31		20.6	382	486	526	2229	2909	140	231	4291	0.84	4.19	175	36985	544
2004	1098			21	583	563	701	2506	3362	118	18	2147	0.81	5.77	738	39733	295
2005	1157	17.4		21.6	478	516	753	2385	3121	91.9	131	3290	10.8	27.9	1387	37020	4.24
2006	1328	20.2		20	565	706	984	2229	2236	79.2	7.45	1401	9.28	23.9	499	28507	1.49

2007	1175	3.9		22.5	553	958	1467	2318	1664	40.5	2.94	1084	2.82	32.9	203	27359	
2008	1104	12.4		30	597	844	1304	2172	1662	38.9	3.4	452	4.69	39	256	24114	0.3
2009	855	38.1		28.7	403	536	693	1964	1462	19.5	2.28	376	3.05	37.4	193	22273	
2010	496	31.8		19.8	231	209	357	1680	1290	18.5	2.77	584	2.21	34.8	861	19210	44.3
2011	449	9.98	0.3	8.39	188	246	414	1818	1274	8.26	0.75	591	7.63	20.3	425	23905	7.86
2012	799	5.03		14.2	311	458	698	1562	706	5.07	0.65	470	10.2	19	196	18402	5.36
2013	754			11.7	317	441	894	1557	863	9.57	0.06	22.6	0.1	20.6	271	12107	102
2014	975			16.3	369	467	857	1951	1058	21.5		28.9	0.11	20.7	178	17466	375
2015	992			17.3	471	548	960	1937	1330	26.1	0.44	55	0.2	15.2	1126	27687	941
2016	1152			23.1	356	610	1135	2753	1617	25.5	0.81	17.8	0.17	9.24	1446	21506	736
2017	1063			18.9	388	415	947	2165	1147	12.4	1.33	42.6	0.08	8.74	775	15917	141
2018	864			11.4	361	302	822	1710	978	6.88	0.92	567			2976	28554	4874
2019	763			10.5	322	204	545	1296	794	4.48	0.52	18.4			2118	28544	7692
2020	620			16.6	500		2579		1270	2.61		8.45	21.6		1712	29184	
2021	478			10.4	376		2077		1157	2.1		23.8	22.8		3895	32928	



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