Stock Annex: Golden redfish (*Sebastes norvegicus*) in Subareas I and II (Northeast Arctic)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Golden redfish (*Sebastes norvegicus*) in Subareas I and II (Northeast Arctic)
Working Group	Arctic Fisheries Working Group (AFWG)
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A. General

A.1. Stock definition

The stock of *Sebastes norvegicus* (golden redfish) in ICES Subareas I and II is found in the northeast Arctic from 62ºN in the south to north of Spitsbergen. The Barents Sea area is first of all a nursery areas, and relatively few fish are distributed outside Spitsbergen. *S. norvegicus* are distributed all over the continental shelf southwards to beyond 62ºN, and also along the coast and in the fjords. The main areas of larval extrusion are outside Vesterålen, on the Halten Bank area and on the banks outside Møre. The peak of larval extrusion takes place ca. one month later than *S. mentella*, i.e. during beginning of May. Genetic studies have not revealed any hybridisation with *S. norvegicus* or *S. viviparus* in the area.

A.2. Fishery

The fishery for *Sebastes norvegicus* (golden redfish) is mainly conducted by Norway which accounts for 80–90% of the total catch. Germany also has a long tradition of a trawl fishery for this species. The fish are caught mainly by trawl and gillnet, and to a lesser extent by longline and handline. The trawl and gillnet fishery have benefited from the females concentrating on the "spawning" grounds during spring. Some of the catches, and most of the catches taken by other countries, are taken in mixed fisheries together with saithe and cod. Important fishing grounds are the Møre area (Svinøy), Halten Bank, the banks outside Lofoten and Vesterålen, and Sleppen outside Finnmark. Traditionally, *S. norvegicus* has been the most popular and highest priced redfish species.

Until 1 January 2003 there were no regulations particular for the *S. norvegicus* fishery, and the regulations aimed at *S. mentella* had only marginal effects on the *S. norvegicus* stock. After this date, all directed trawl fishery for redfish (both *S. norvegicus* and *S. mentella*) is forbidden in the Norwegian Economic Zone north of 62°N. During 2003 and 2004, when fishing for other species it was legal to have up to 20% redfish (both species together) in round weight as bycatch per haul and on board at any time. Since 1 January 2005 this percentage has been reduced to 15%.

A minimum legal catch size of 32 cm has been set for all fisheries (since 14 April 2004), with the allowance to have up to 10% undersized (i.e., less than 32 cm) specimens of *S.norvegicus* (in numbers) per haul.

Until April 2004 there were no regulations of the other gears/fleets than trawl fishing for *S. norvegicus*. Since then, different limited moratoriums have been enforced in all fisheries except trawl and handline vessels less than 11 meters. The moratorium has been from 1-31 May in 2004, 20 April-19 June in 2005 and during April-May and September in 2006. Since 2007 the moratorium has been during 5 months, i.e., March-June and September. Directed trawl fishery is not allowed. From 2012, the moratorium was extended to 20 December-31 July and September. When fishing for other species (also during the moratorium) it is allowed for these fleets to have up to 15% (in 2004, 20%) bycatch of redfish (in round weight) summarized during a week fishery from Monday to Sunday.

Since 1 January 2006 it is forbidden to use gillnets with meshsize less than 120 mm when fishing for redfish.

Since 1 January 2006, the maximum bycatch of redfish (both *S. mentella and S. norvegicus*) juveniles in the international shrimp fisheries in the northeast Arctic has been reduced from ten to three redfish per 10 kg shrimp.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

The landings statistics used by the Arctic Fisheries Working Group (AFWG) are those officially reported to ICES. In cases where such reports to ICES do not exist, reports made directly to Norwegian authorities during the fishery have been used as preliminary figures. Norwegian commercial catch in tonnes by quarter, area and gear are derived from the sales notes statistics of The Directorate of Fisheries. Data from about 20 sub areas are aggregated for the gears gill net, long line, hand line, Danish seine and bottom trawl. For bottom trawl the quarterly area distribution of the catches is area adjusted by logbook data from The Directorate of Fisheries. No discards are reported or accounted for. Reliable estimates of species breakdown (*S. mentella* vs. *S. norvegicus*) by area are available back to 1989. The national landings of redfish for Norway and Russia are split into species by the respective national laboratories. For other countries (and areas) the AFWG has split the landings into *S. mentella* and *S. norvegicus* based on reports from different fleets to the Norwegian fisheries authorities.

The Norwegian sampling strategy is to have age-length samples from all major gears in each area and quarter. There are at present no defined criteria on how to allocate samples of catch numbers, mean length and mean weight at age to unsampled catches, but the following general process has been applied: First look for samples from a neighbouring area if the fishery extends to this area in the same quarter. If there are no samples available in neighbouring areas, search in neighbouring quarters, first from the same gear in the same area, and then from neighbouring areas and similar gears. The last option is to search for samples from other gears with the most similar selectivity in the same area or in neighbouring areas. For some gears, areas and quarters length samples taken by the coast guard are applied and combined with an ALK from a neighbouring area, gear or quarter. ALKs from research surveys (shrimp trawl) are also used to fill holes.

For Norway, weights at age in the catch are estimated according to the formula which gives the best fit to the length-weight data pairs collected during the year and applied to the mean length at age.

The text table below shows which country supplies which kind of data:

	Kind of data					
Country	Caton (catch in weight) on unidentified redfish	Caton (catch in weight) on S. norvegicus	Canum (catch at age in numbers)	Weca (weight at age in the catch)	Matprop (proportion mature by age)	Length composition in catch
Norway		x	x	x		x
Russia		x				x
Germany	x	x2)				x
United Kingdom	x	1)				
France	x	1)				
Spain	x	1)				
Portugal	x	1)				
Ireland	x	1)				
Greenland						
Faroe Islands1)	x	1)				
Iceland						

1) As reported to Norwegian authorities during the fishery (only for the Norwegian Economic Zone and Svalbard)

2) Irregularly

The Norwegian and German input files are Excel spreadsheet files, while the Russian input data are supplied on paper and later punched into Excel spreadsheet files before aggregation to international data. The data should be found in the national laboratories and with the stock co-ordinator.

The national data have been aggregated to international data on Excel spreadsheet files. The Russian and German length composition has been applied on the Russian and German landings, respectively, using an age-length-key (ALK) and weight at age data from the Norwegian trawl landings. Catches from the other countries were assumed to have the same age composition and weight at age as the Norwegian trawl landings. In some years the final German and Russian numbers at age have been adjusted to remove SOP discrepancies before aggregation to international data. The Excel spreadsheet files used for age distribution, adjustments and aggregations can be found with the Norwegian stock co-ordinator and for the current and previous year in the ICES computer system under **w:\acfm\afwg\<year>\personal\name** (of stock co-ordinator).

The result files (FAD data) can be found at ICES and with the stock co-ordinator, either in the IFAP system as SAS datasets or as ASCII files on the Lowestoft format, either under **w:\acfm\afwg\<year>\data\smr-arct** or **w:\ifapdata\eximport\afwg\smr-arct**.

B.2. Biological

The total catch-at-age data back to 1991 are based on Norwegian otolith readings. In 1989–1990 it was a combination of the German scale readings on the German catches,

and Norwegian otolith readings for the rest. In 1984–1989 only German scale readings were available, while in the years prior to 1984 Russian scale readings exist.

Weight at age in the stock is assumed to be the same as weight at age in the catch.

When an analytical assessment is made, a fixed natural mortality of 0.1 is used both in the assessment and the forecast.

Both the proportion of natural mortality before spawning (Mprop) and the proportion of fishing mortality before spawning (Fprop) are set to 0.

A knife-edge maturity at age 15 (age 15 as 100% mature) has been used for this stock. Since 2006 a maturity ogive has been modelled and estimated by the GADGET model.

B.3. Surveys

The results from the following research vessel survey series have annually been evaluated by the Working Group:

1) Norwegian Barents Sea bottom trawl survey (February) from 1986–2009 in fishing depths of 100–500 m. Data are available on length for the years 1986–2009, and on age for the years 1992–2008. This survey covers important nursery areas for the stock

2) Norwegian Svalbard (Division IIb) bottom trawl survey (August-September) from 1985–2008 in fishing depths of 100–500 m. This survey covers the northernmost part of the species' distribution.

3) Data on length and age from both these surveys have been simply added together and used in the assessments.

4) Catch rates (numbers/nautical mile) and acoustic indices of *Sebastes norvegicus* from the Norwegian Coastal and Fjord survey in 1995-2008 from Finnmark to Møre. Since 2003, only catch rates are available.

A schematic illustration of these survey series is given below in Figure 1.

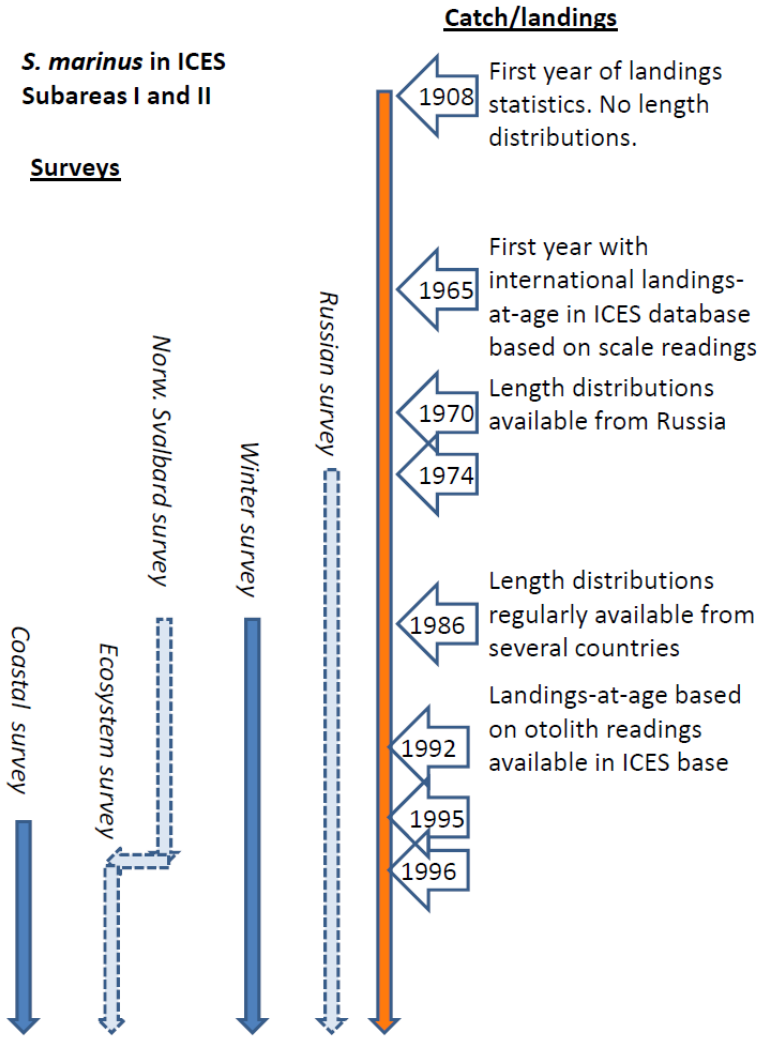


Figure 1. Illustration of the available time series of surveys and catch/landings data. Solid blue arrows show the scientific surveys currently used in the Gadget model, while the dotted light blue arrows show available surveys currently not used.

B.4. Commercial CPUE

The former (until 2002) CPUE-series for *S. norvegicus* from Norwegian 32-50 meter freezer trawlers has been improved (e.g., analysing the trawl data with regards to vessel length instead of vessel tonnage) and presented from 1992 onwards. Only data from days with more than 10% *S. norvegicus* in the catches (in weight) were included in the annual averages together with data on vessel days (i.e., effort) meeting the 10% criterion.

B.5. Other relevant data

None.

C. Analytical Assessment model

Since WG2005, experimental analytical assessments have been conducted on this stock using GADGET, and results presented for the years 1990 – last year. This model has

been evaluated at the WKRED benchmark (2012), and it is recommended that this remain the basis for advice, with results from a Schaefer model being used to "sanity check" the results.

The GADGET model used for the assessment of *S. norvegicus* in areas I and II is closely related to the GADGET model that currently is used by the ICES North-Western WG on *S. norvegicus* (Björnsson and Sigurdsson 2003). As a GADGET model is rather complex the full model is not described here. Rather, the functioning of a Gadget model, including parameter estimation, is described in Bogstad et al. (2004), and full details of the model are available at http://www.hafro.is/gadget. Only the specific settings and data sources used for this stock are described below.

The main model period has been considered to be from 1990, with earlier years acting as a lead-in period to the model. *S. norvegicus* has been modelled with a single-species, single-area model, with mature and immature fish considered as two population groups. The fish were modelled in 1cm length categories. The age and length ranges were defined as 3-30+ and 1-59+ cm, respectively. *S. norvegicus* was considered to have Von Bertanlanffy growth (Nedreaas 1990) with parameters estimated within the model. The length-weight relationship $w=0.000015*l^{3.0}$ (where w is in kilogram and l in cm) was used and kept constant between seasons and years. There has been no cannibalism or modelled predation – mortality has been exclusively due to fishing and residual natural mortality was set initially at 0.1. Following the WKRED benchmark meeting 2012, natural mortality within the model has been altered to 0.05. Recruitment was handled as a number of recruits estimated per year, and no attempt at closure of the life cycle was attempted. Maturity is explicitly modelled with an age based logistic function for the probability of becoming mature in a given year, allowing for a direct estimate of the spawning stock.

The fishing was handled as two main fleets. The Norwegian trawl- and gillnet fleets were both fully modelled, with estimated selectivity for each, accounting for about 70-80% of the total catch in tonnes. The amount fished in each time step of one quarter of the year was input from catch data as a fixed amount. No account of possible errors in the catch-in-tons data was made. Two additional fleets have been considered; the international trawl fleet and a fleet made up by combining all other minor Norwegian fishing methods. Both these fleets have quarterly catch-in-tons specified, and have used the same selectivity as the Norwegian trawl fleet, and are thus combined into the "trawl fleet" within the model. In addition to catch-in-tons, quarterly catch-in-numbers-at-length and age-length keys have been used. The format of the selectivity (a logistic function) was selected and assumed to remain constant over time for each fleet.

Estimated parameters were: an a50 and slope for the maturation, two growth parameters, annual recruitment parameters, four parameters governing commercial selectivity (two per fleet), several parameters per survey governing selectivity (two per fleet), initial population numbers for mature and immature fish by age.

Data used for tuning are:

- Quarterly length distribution of the landings from two commercial fishing fleets
- Quarterly age-length keys from the same fishing fleets
- Length disaggregated survey indices from the Barents Sea (Division IIa) bottom trawl survey (February) from 1990–2009 (Table D12a).
- Age-length keys from the same survey (Table D12b).
- Estimated maturity ogives for the population for 1993-2007

The Barents Sea survey data were used as both age-length keys, and as a purely length based survey index. This allows for estimation of growth without having the model totally dependent on accurate age readings. Prior to 1992 only length and weight data were recorded; after that data on annual age readings (and hence age-length data) are also available. The time period 1990-2006 was used, and the age-length key for 1992 was also used as age-length key for 1990-1991.

D. Short–Term Projection

Model used: Visual inspection/analysis of survey results together with information from the fishery and Gadget model outputs. As a result of uncertainties surrounding the recruitment signal,no full analytical short-term projection has been made for this stock. However, Gadget model runs can be conducted to estimate the optimum yield-per-recruit, and the optimum catch from the stock if recent average recruitment were to continue.

E. Medium–Term Projections

Model used: Visual inspection/analysis of survey results together with information from the fishery and Gadget model outputs. As a result of uncertainties surrounding the recruitment signal, and the lack of a good SSB-recruitment relationship, no full analytical medium-term projection has been made for this stock. However, Gadget model runs can be conducted to estimate the optimum yield-per-recruit, and the optimum catch from the stock if recent average recruitment were to continue.

Uncertainty models used: None

F. Long–Term Projections

Not done

G. Biological Reference Points

Analysis at WKRED (2012) using a Schaefer model suggested that the stock is heavily depleted. Uncertainties over recent recruitment (from erratic signals in the survey data and concerns over species identification for young fish) and the absence of knowledge on productivity or SSB-recruitment relationships precludes medium-long term projections of the stock.

Until an analytical assessment can be accepted and used as basis for reference points calculations for this stock, candidate reference points for the biomass could be set at the average biomass level, or at a certain percentage of this level, estimated by the Russian and Norwegian trawl surveys since 1986. ACFM is supporting this suggestions and states that U-type reference points could be developed provided that a sufficient long time series demonstrating a dynamic range is available. Also the reference point should be expressed in biomass units (SSB or fishable stock), and work has hence been initiated to present the survey time series also in biomass units (also as SSB and fishable stock).

A maximum exploitation rate of 5% has been suggested sustainable for long lived species like *Sebastes* spp. when the stocks show no sign of reduced reproductive potential (ref. pelagic redfish in the Irminger Sea and for several rockfishes in the Pacific). Based on the selection curves for the fleets, a reasonable classification of the fishable biomass would be the mature biomass. A corresponding 5% harvest of this would yield not more than 1.500 tonnes. Work conducted at WKRED (2012) using GADGET suggested

that a catch of around 1,500 tonnes represented the optimum given current stock size and recruitment levels. This figure was similar to that obtained by a Schaefer model at the same meeting.

H. Other issues

A major source of uncertainty in the *S.norvegicus* stock is the level of recent recruitment. This is uncertain for two different reasons. Firstly, the recruitment signal in the winter survey has been erratic, with the small fish being observed intermittently between years. Secondly, the good yearclasses in the survey correspond with the years of known good recruitment in the much larger *S. mentella* stock in the region. Species indentification is difficult for young fish of these species, and a species mis-indentification rate of less than 5% of *S. mentella* as *S.norvegicus* would completely account for the recent apparent recruitment of *S. norvegicus*. Until these fish enter the fishery caution is needed in evaluating the estimates of recent recruitment.

I. References

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