Stock Annex: Orange roughy (*Hoplostethus atlanticus*) in subareas 1–10, 12 and 14 (the Northeast Atlantic and adjacent waters)

Stock specific documentation of standard assessment procedures used by ICES.

Stock: Orange roughy

Working Group: Working Group on Biology and Assessment of Deep-sea Fisheries Resources (WGDEEP)

Created:

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A. General

A.1. Stock definition

The current practice is to assume three assessment units;-

- Subarea 6;
- Subarea 7;
- Orange roughy in all other areas.

Orange roughy is an aggregating species and the spatial scale of current management units would not prevent sequential depletion of local aggregations. ICES recommended that where the small-scale distribution is known, this be used to define smaller and more meaningful management units.

A.2. Fishery

The main fishery for Orange Roughy was conducted in areas 6 and 7 on the peak fisheries. Small fisheries have existed in divisions 5.a and 5.b and subareas 8, 10 and 12.

In 6, there was a French target fishery, centred on spawning aggregations around the Hebrides Terrace Seamount. Irish vessels fished there for two years starting in 2001, but they have now abandoned it. The fishery began in 1989 with landings peaking at 3500 t in 1991, and 5300 t were removed from the stock by the end of 1993 (fig. 1). It is not clear if over-reporting was a feature of the fishery in this area in the years preceding the introduction of TACs. Reported landings since 2003 have been decreasing to very low levels.

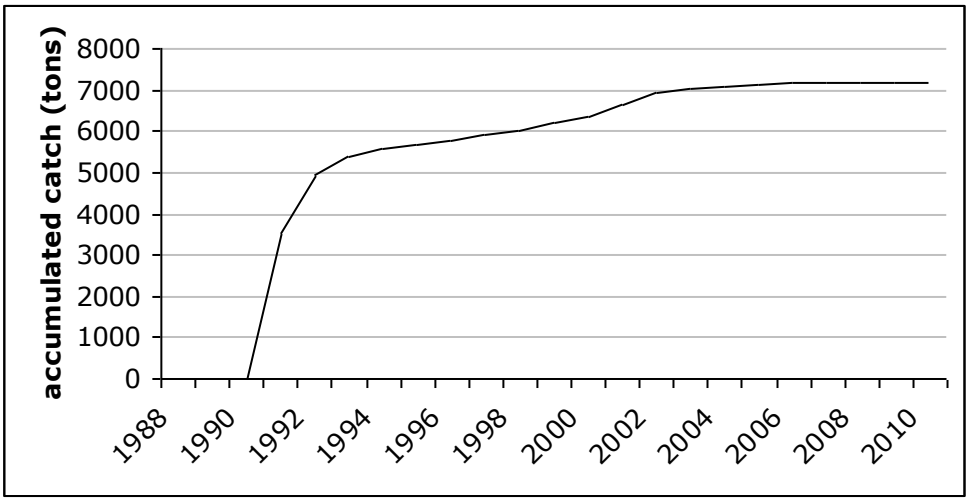


Figure 1. Cumulated catches of Orange roughy in ICES Subarea 6.

After the collapse of the fishery in Subarea 6, the main fishery for orange roughy in the northern hemisphere moved to subarea 7. French vessels used to prosecute this fishery alone, but in 2001, new Irish vessels became heavily involved in this fishery for a short number of years. Orange roughy aggregations are mainly associated with seamounts, but they are also found close to other features and on the flat grounds of the continental slope. Initially, trawlers targeted orange roughy at the base of seamounts, but from 2000 onwards, there was a shift to fishing down the slopes of seamounts. Before the fishery closure, new features were found to replace them, as catch rates declined. Large (~50 m) French trawlers targeted orange roughy in Subarea 7 up to 2001. These large trawlers have reduced their activity in 7. There were two fisheries for Orange Roughy in the area. A single targeted peak fishery that has been occurring on distinct topographical features and a mixed trawl flat fishery that occurs along the continental slope and has Orange Roughy as a bycatch. In the late 2000s some targeted fishing from a few or even one single 20-24m trawlers was carried out until 2008. Since 2010, the TAC has been set at zero.

When the French fishery in 7 developed in 1991, landings peaked at over 3000 t in 1992. By the end of 2000 the French fleet had removed over 13 500 t of orange roughy from subarea 7 (fig.4). An Irish fishery commenced in 2001, and since then the combined Irish and French accumulated landings have amounted to a further 10 800 t (Fig. 4). Historical landings data suggest several pulses in landings (Figures 9.3.1 and 9.3.2). The first occurred in 1992 when over 3000 t were landed. Landings declined until 1995, but then increased again to the highest in the series in 2002. The total accumulated catch in Area 7 is close to 25 thousand tons. A restrictive quota was introduced in 2003 and resulted in a decrease in declared landings since then. Since 2010, the TAC has been set at zero.

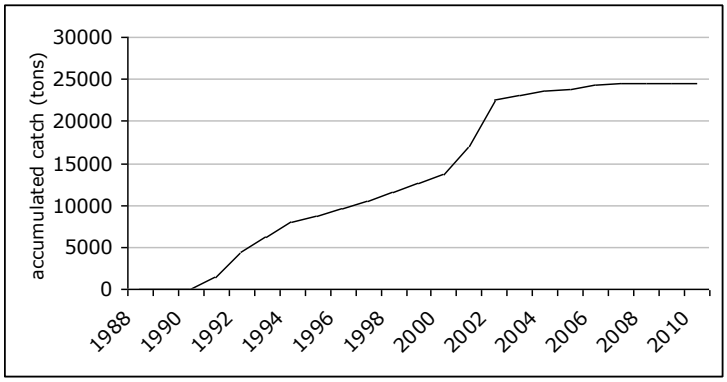


Figure 2 Cumulated catches of Orange Roughy in ICES Subarea 7.

In Division 5.a, the fishery peaked with landings of over 700 t in 1993, and landings have declined to very low levels by 2002. In Division 5.b, landings were highest in 1995, at 420t, but since 1997 they have been negligible except for 2000.

In Subarea 8, there have been small landings by France since the early 1990's. In Subareas 8 and 9, Spain has recorded small landings in some years.

In Subarea 10, there are fluctuating Faroese landings, and in 2000, there was an experimental fishery by the Azores (Portugal).

In Subarea 12, the Faroes dominated the fishery throughout the 1990's, with small landings by France. New Zealand and Ireland have targeted orange roughy in this area for single years. There are many areas of the Mid-Atlantic Ridge where aggregations of this species occur, but the terrain is very difficult for trawlers.

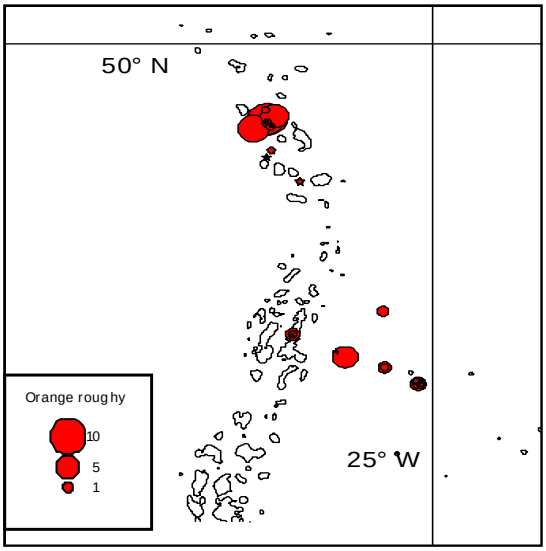


Figure 3. Total catches of orange roughy (tonnes) during the Faroese exploratory Orange Roughy fishery on the Mid Atlantic Ridge (10 and 12) in 2008. .

A.2.1. Fleet

A.2.2. Regulations

In 2003 an EU TAC was introduced for orange roughy in 6 and 7. For the other areas, an EU TAC was introduced in 2005. EU TACs have been decreasing in the last years and are now set to zero for all three management areas.

Since 2017, trawling deeper than 800m is banned in EU waters and to EU vessels in International waters (EU regulation 2016/2336).

Table 1. EU TAC for Orange Roughy in subareas 6 and 7 and other areas since from 2003 (first time a TAC was set) to 2010 (TAC remained 0 afterwards).

Year	EU TAC (t) 6	EU TAC (t) 7	EU TAC (t) other
2003	88	1349	
2004	88	1349	
2005	88	1149	102
2006	88	1149	102
2007	51	193	44
2008	34	130	30
2009	17	65	15
2010	0	0	0

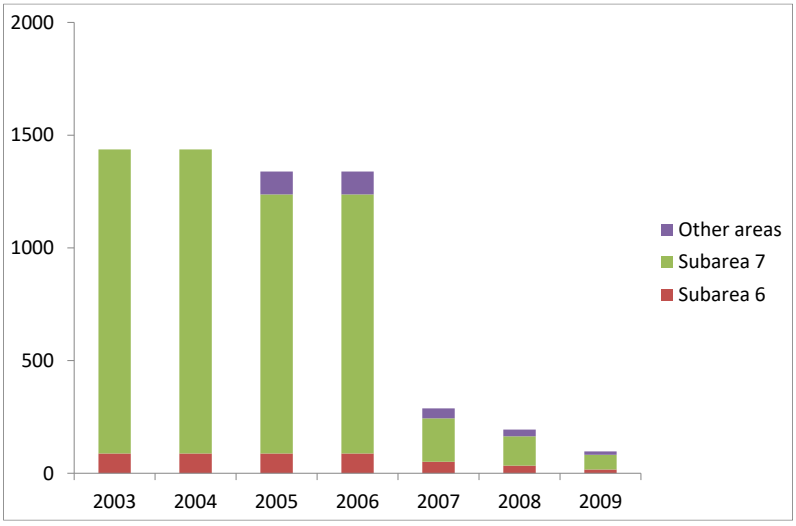


Figure 4. Total allowable catch for Orange Roughy in ICES subareas 6 and 7 and in all other areas combined for EU vessels since 2003. I

A.3. Ecosystem aspects

Directed trawl fisheries for orange roughy have been associated with seamounts and other bathymetric features. In ICES divisions 6 and 7 there has been a spatial overlap of historic orange roughy fisheries with vulnerable habitats such as cold water corals. The direct impact of this fishery on vulnerable habitats has not been evaluated. However, in other areas of the world, such fisheries have been demonstrated to have considerable impact. There can be no fishing of orange roughy in EU waters. The spatial resolution of catch data for orange roughy in other areas currently available to the working group is not sufficient to assess the spatial overlap with vulnerable habitats. After 2010, the only orange roughy fisheries occurring in the ICES area have been in subareas 10 and 12. The potential impact of these fisheries on vulnerable habitats should be evaluated. However, NEAFC have introduced precautionary closed areas to protect VMEs on the Mid-Atlantic Ridge.

B. Data

B.1. Commercial catch

Landings data are available for all fleets. On-board observations of the French deep-water fishery in 2010-2016 in Division 5.a and subareas 6 and 7 are available and suggested that the bycatch of orange roughy might be minor on most fishing grounds. Irish discard information is available from three observer discard trips carried out in 2003 and 2004, covering targeted fishery on peaks and in canyons for orange roughy and fishing on flat grounds for a mixture of roundnose grenadier, black scabbard, blue ling, siki sharks and orange roughy. Discarding of Orange roughy was zero in the peak fishery and <1% of landed orange roughy on the flat fishery.

B.2. Biological

Summary of life characteristics

Table 2- summary of biological parameters for Orange roughy in subareas 6 and 7.

LHC	Best estimate	Derived from?
Maximum observed length	70.6 cm SL	Nolan(ed) 2004
	60 cm SL	Shepard and Rogan 2004
Maximum observed age	>130	Thompson 1998
	169 years	Shepard and Rogan 2004
	187 years	Nolan(ed) 2004
Length at 50% maturity	34 -37 cm SL	Shepard and Rogan 2004
Age at 50% maturity	Approx 30 years	Shepard and Rogan 2004
	20-40 years	Nolan(ed) 2004
	27.5 years (37cm)	Minto and Nolan 2006
Length at recruitment	30-34 cm SL	Shepard and Rogan 2004
	Approx 35 cm	Nolan(ed) 2004
Age at recruitment	30-40 years	Shepard and Rogan 2004
	30-35 years	Nolan(ed) 2004
Growth parameters: (von Bertalanffy parameters: B_0,T_0, L infinity, for example)	$L\infty$=476 mm,	Shepard and Rogan 2004
	k=0.039 yr^{-1} and	
	t_0=2.61 years.	
Fecundity, egg size etc	22000 eggs per kg body weight. Diameter 2mm	Panchurts & Conroy 1987
	48,530 eggs per kg body mass	Gordon 1999
	33376 eggs	Minto and Nolan 2006
Natural mortality	M= 0.04	Annala (1993)
	M=0.025	WGDEEP, 2002
	M= 0.045	Large (2002) WD from WGDEEP 2002

Length compositions

There are a number of historic length frequencies available for subareas 6, 7 and 10 & 12 from observer programmes (Fig. 5 to 7). Length frequencies from most of the commercial catches show a distribution between 45 and 65cm. Survey data show that the length frequency distribution on bathymetric features is mainly between 38 and 55cm (Fig. 8). Survey length frequency information is available from the Irish and Scottish deep-water trawl surveys (Figure 9) which sample the flat grounds along the continental slope in 6 and 7. Survey data show that the length frequency on gentle slopes has several peaks between 7 and 23 cm with a further peak between 45 and 65 cm suggesting the presence of several juvenile cohorts.

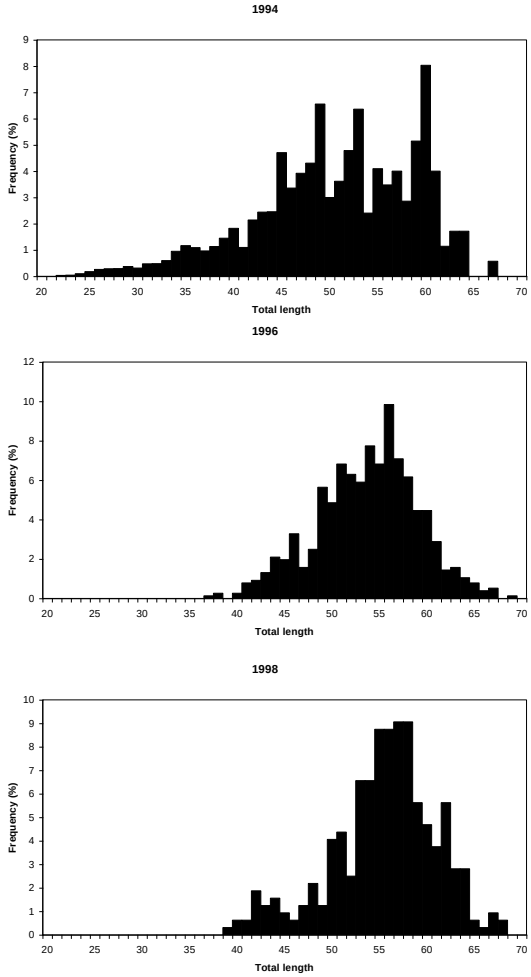


Figure 5. Length distribution of French landings of orange roughy from 1994 to 1998.

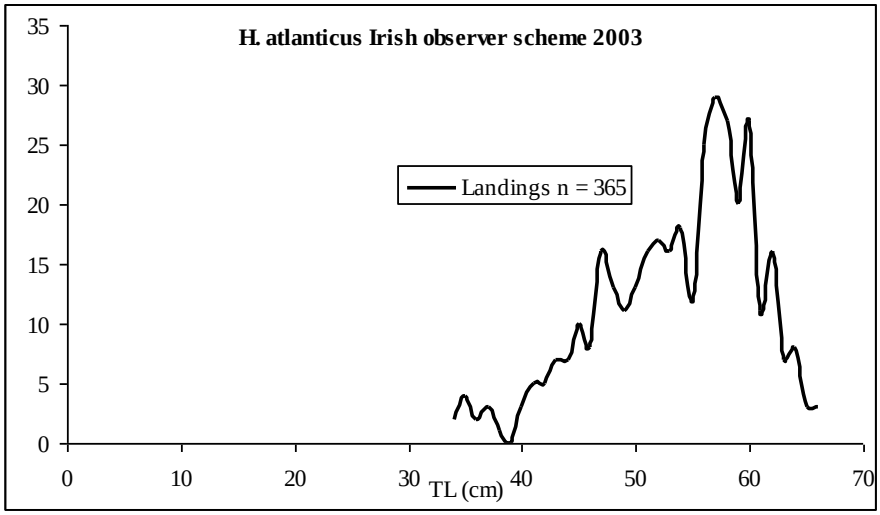


Figure 6. Length frequencies from Irish fishery in 2003 (6 and 7) from Irish Marine Institute observer scheme.

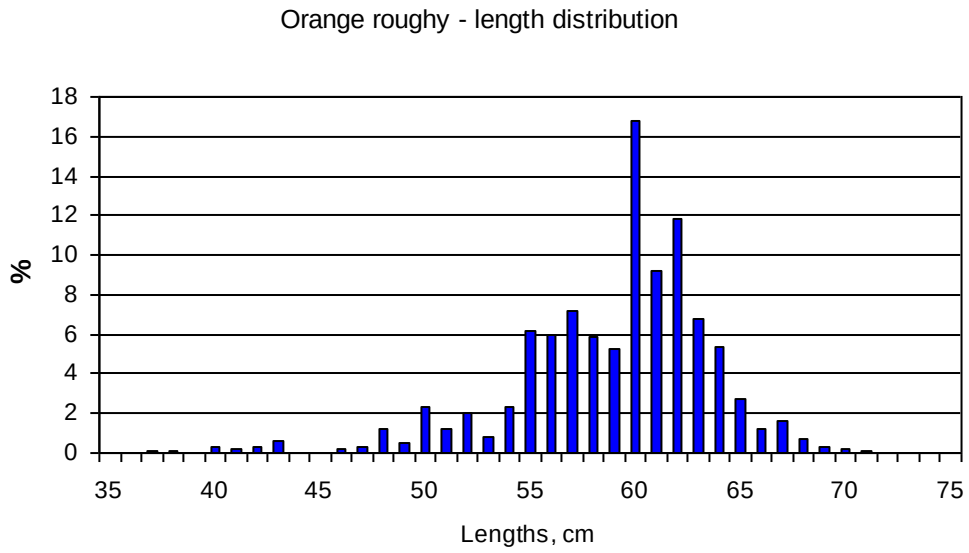


Figure 7. Orange Roughy Length frequencies from Faroese exploratory fishery in 2008 in the MidAtlantic Ridge (subareas 10 and 12).

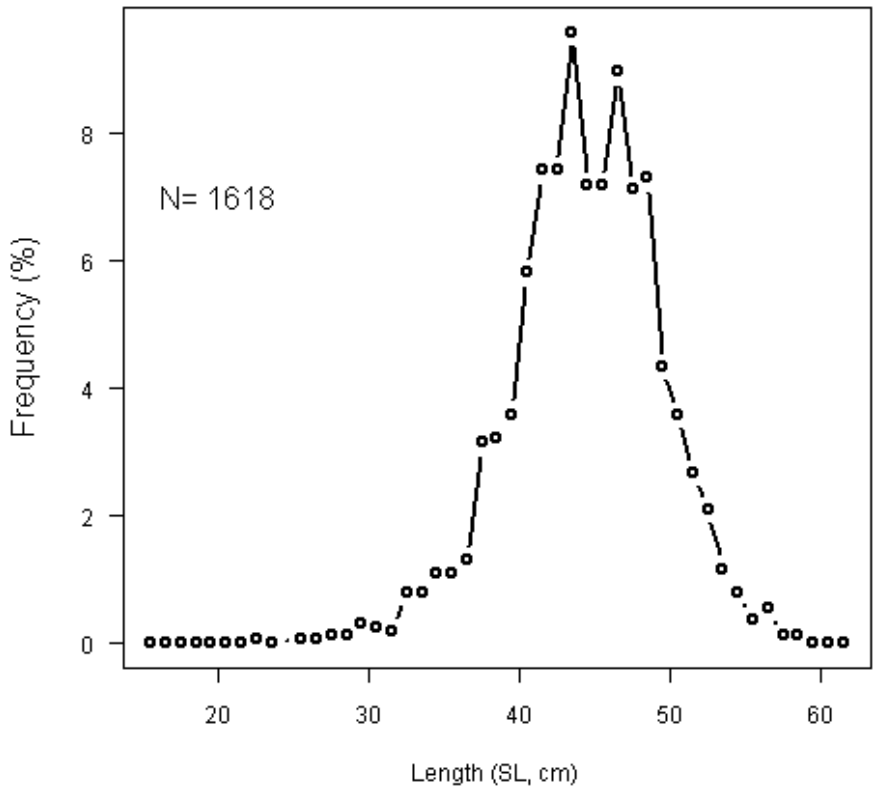


Figure 8. Length frequency from bathymetric feature trawl data sampled on the 2005 acoustic survey, 7.

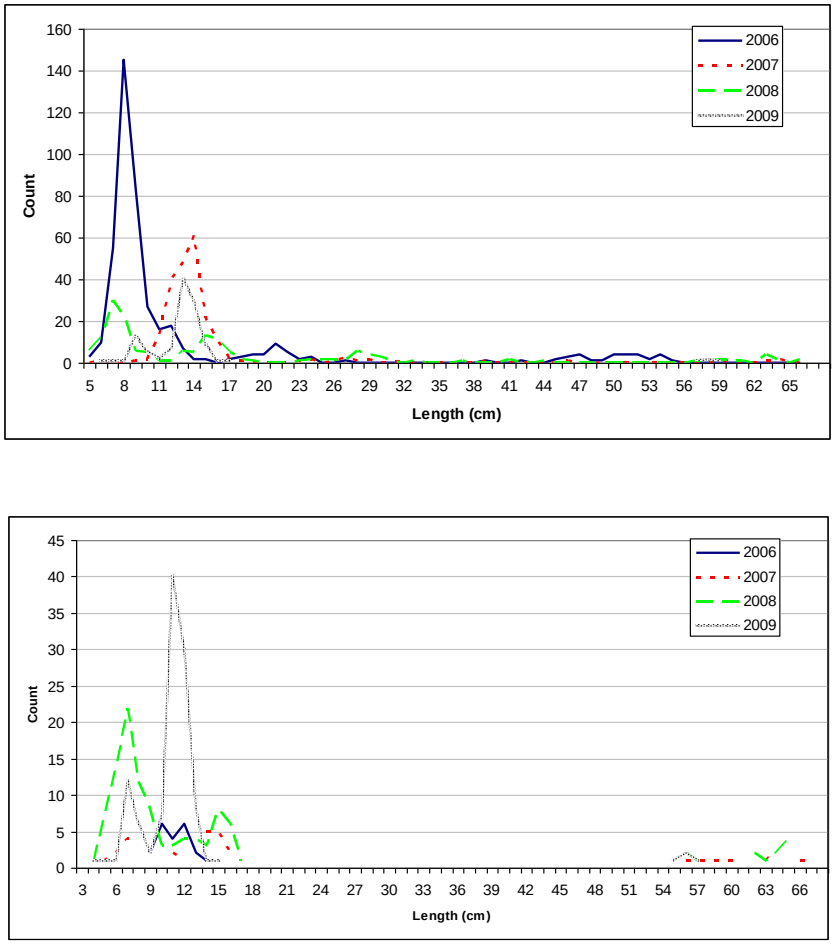


Figure 9. Length frequency of Orange Roughy caught at the Irish (upper panel) and Scottish (lower panel) deep-water survey 2006–2009.

Age compositions

Age data was available from sampling at-sea on commercial trawlers operating on the Porcupine Bank during September 2003-April 2004 and February 2005 (Sheppard and Rogan 2006). Most otolith samples were of juvenile fish (< 30 cm SL). Otoliths were prepared and sectioned according to Tracey and Horn (1999). Age estimates (6-169 years) were obtained from a total of 151 otoliths. The Von Bertalanffy growth model was fitted to the data (R^2=0.92) (Figure 9.3.6). Estimated growth parameters were: L_{∞}=47.6 cm, k=0.039 yr^{-1} and t_0=2.61 years.

Age estimates were presented by Talman *et al*. (2002) based on samples taken from the Irish developmental fishery in 2001, in 6 and 7 (BIM, WD 2002). Age estimates from sectioned otoliths ranged from 20 to 187 years (Standard Lengths 30 to 68 cm). Empirical growth curves presented by Talman *et a*l. (2002) suggests that growth slows and reaches an asymptote at about 55cm SL and 37 years. This asymptote is far greater than estimate above and the cause of this is unknown (it possibly could be TL rather than SL). The orange roughy in the area west of Ireland appear to reach the greatest age of any populations so far examined.

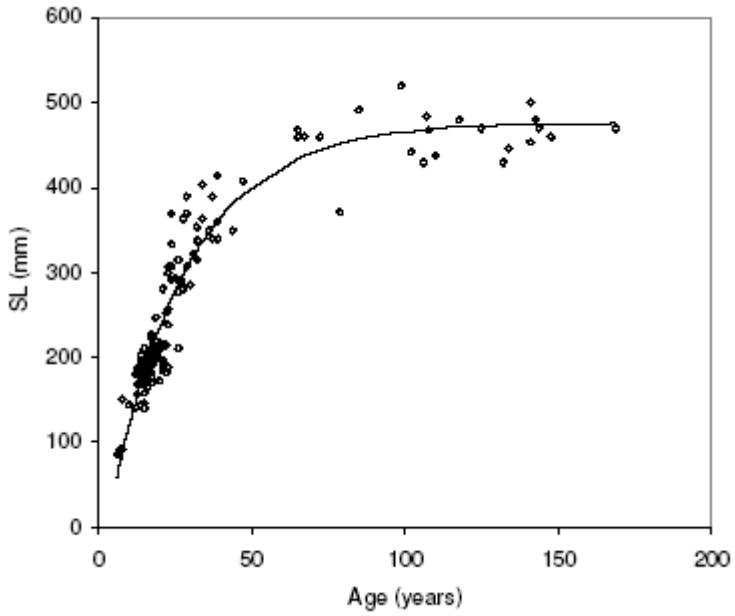


Figure 10. Age estimates and the estimated Von Bertalanffy growth curve (Sheppard and Rogan 2006 check). Note that the y axis refers to standard length rather than total length as used elsewhere.

Weight–at–age

There is not weight-at-age relationship available for orange roughy in the ICES area.

Maturity and natural mortality

Recently estimated maturity L50 was 34 cm SL for Orange Roughy collected from the flats fishery and 37 cm SL from hill aggregations on the Porcupine Bank (Sheppard and Rogan, 2006). This is similar to the estimate from the west of Ireland of 36 cm SL (Minto and Nolan, 2006). These are higher than that estimated for orange roughy in New Zealand and Australia.

B.3. Surveys

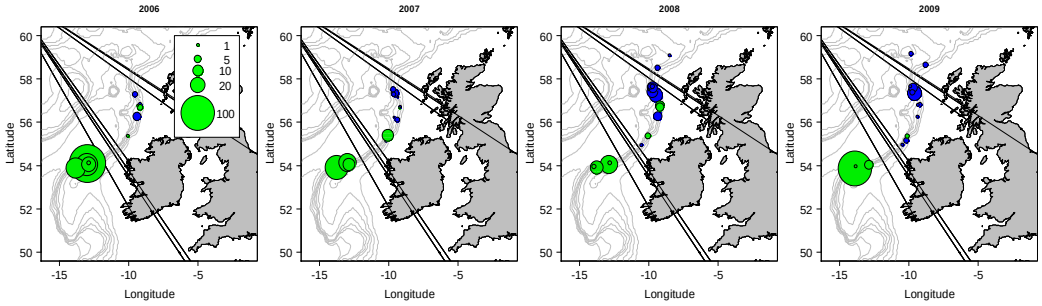
In 2005 an acoustic survey was carried out on the slopes to the west and north of the Porcupine Bank. Estimates of biomass were considered to be unreliable due to concerns over target strength.

Biological samples and multibeam echosounder and a ROV were used on selected sea-mounds to map the orange roughy habitats (O'Donnell et al, 2007).

Distribution of juvenile and adult CPUEs of Orange Roughy in 6 and 7 within the survey areas of the Scottish and Irish Deepwater survey are shown in fig. 11. Mean catch rates (number/hours) for Orange Roughy from the Irish deep-water trawl survey are shown in fig. 12 for individuals >23 cm (a.) and < 23 cm (b.) caught in the

1000 m to 1500 m depth band between 2006–2009. Data is very variable, but do indicate the entry of juveniles into the population.

a.)



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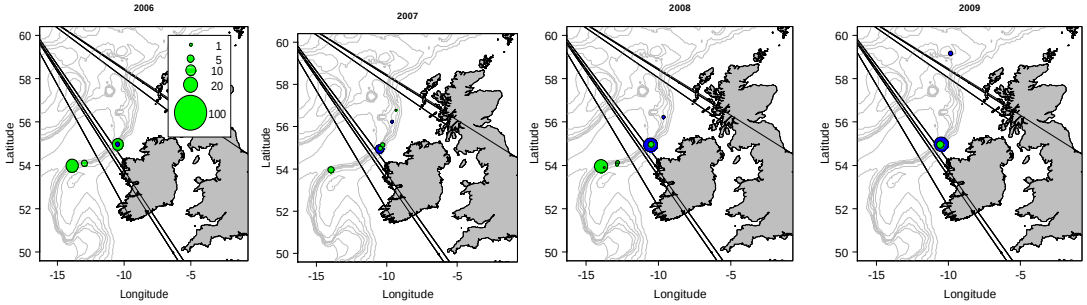

Figure 11. Cpue of a.) Orange Roughy (≤23 cm) and cpue of b.) Orange Roughy (>23 cm), 2006–2009. Combined Irish (green) and Scottish (blue) Deep-water survey data.

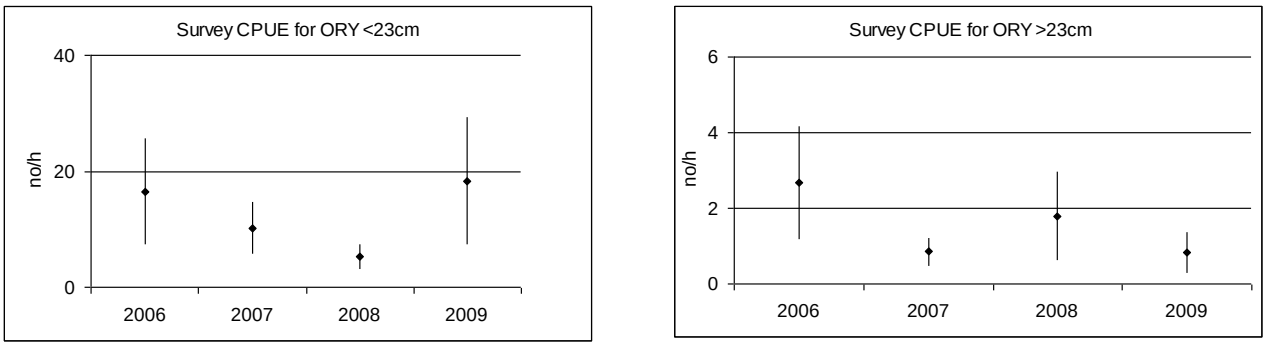

Figure 12. Mean catch rates (number/hours) for Orange Roughy >23 cm (a.) and < 23 cm (b.) caught at the Irish deep-water survey 2006–2009 in the 1000 m to 1500 m depth band (±1SE).

B.4. Commercial CPUE

Historical French CPUE series is shown in Figure 13 and 14 for subarea 6 and 7. No data is available for this cpue from 2006 onwards, as the fishery virtually ceased.

Standardised cpues for Irish deep-water trawlers targeting Orange Roughy are shown in Figure xx. These are based on personal logbooks and are calculated using the mean catch weight per haul per month for the period of January 2001 to December 2003, i.e. the main period when the Irish trawlers were participating in the fishery. In the peak fishery for Orange Roughy, the trawl is often fast on the bottom or sometimes lifted over coral and rocks. Effective fishing time can be as short as 20 minutes. Trawling time therefore does not give any good indication of effort and consequently, only catch per haul is used for the analysis. The cpue from fishery on flat ground was also worked up but the data was scarcer as it only developed as a regular fishery since the second half of 2002.

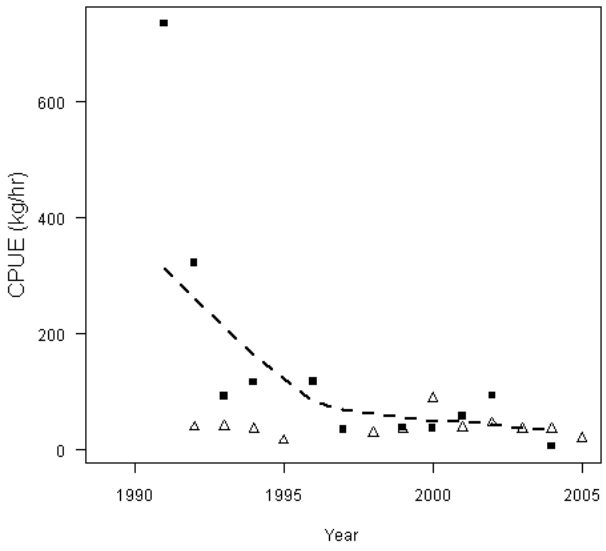

Figure 13. French cpue series 1990-2006 in Division 6.a, for 400–600 kw power vessels (open triangles) and for 1400–1600 kw vessels (solid squares). The line is a smooth curve through the latter series.

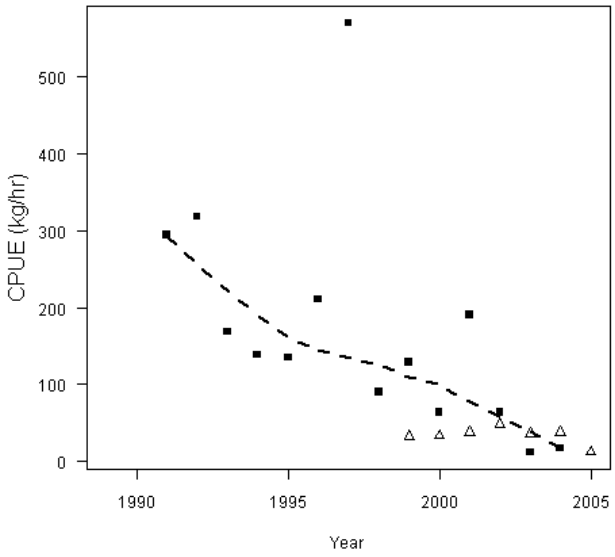

Figure 14. French CPUE series in Subarea 7 for 400-600 kw power vessels (open triangles) and for 1400-1600 kw vessels (solid squares). The line is a smooth curve through the latter series excluding the high 1997 point.

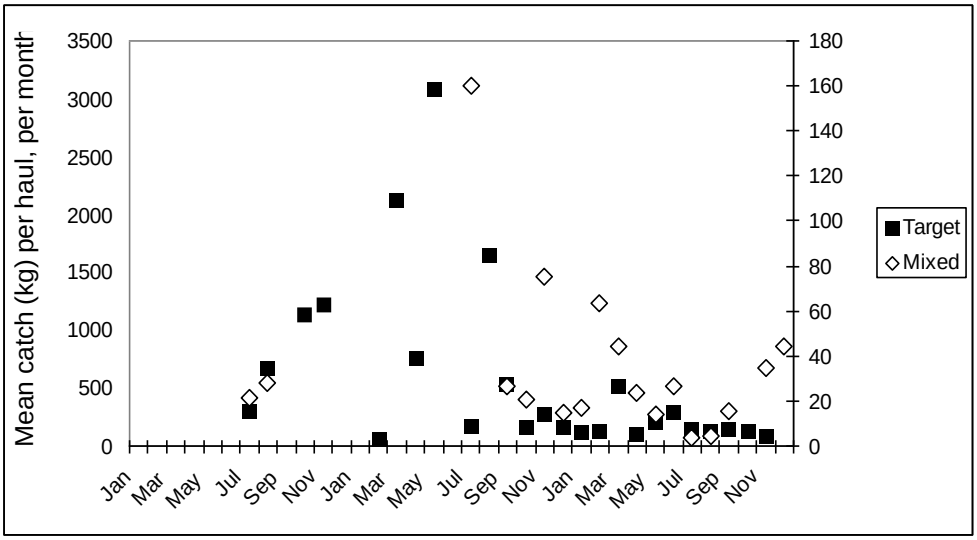

Figure 15. CPUE series for Irish deep-water trawlers targeting Orange Roughy with mean catch weight by haul per month between January 2001 and December 2003 for targeted (closed squares) and mixed fisheries hauls (open diamonds). Secondary axis corresponds to mixed fishery.

B.5. Other relevant data

C. Assessment: data and method

No assessment. Advice is based on historic landings and CPUE trends.

Model used:

Software used:

Model Options chosen:

Input data types and characteristics:

D. Short-Term Projection

No short-term projection is made for the stock.

E. Medium-Term Projections

No short-term projection is made for the stock.

F. Long-Term Projections

No long-term projection is made for the stock.

G. Biological Reference Points

Estimation of reference points for orange roughy in 6 and 7

Several methods were trialled to estimate reference points for orange roughy in all other areas. As there are no fisheries dependant or independent data available for orange roughy, the estimation of reference points was based on life-history traits. The methods explored included the DCAC method, the Gislason method, the Extended Beverton & Holt yield simple model (BHAC) and FLAdvice as recommended in WKLIFE and WKFRAME.

The DCAC method was explored for ICES Subareas 6 and 7, but not for the Mid Atlantic ridge (Subareas 10 and 12) as the ratio for catch to virgin biomass is highly uncertain. For the exploration of reference points for orange roughy based on the three latter methods, biological input parameters from Subarea 7 were used (Table 3).

Table 3. Input parameters use to explore possible refernce point for orange roughy for the DCAC method.

DATA TYPE	6	7
Accumulated Catch	7200 t	24 600 t
Natural mortality	0.05	0.035
Period of depletion	15 years	12 years
Ratio between virgin biomass and catch	0.9	0.5
Fmsy to M	0.8	0.8
Bmsy to B	0.4	0.4

Table 4. Input parameters use to explore possible refernce point for orange roughy for the the Gislason, BHAC and FLadvice.

DATA TYPE	6	METHOD IN WHICH IT IS USED
Lmax	48 cm	Gislason
AFC	15	Gislason
natural mortality M	0.045	BHAC
K<-	0.039	BHAC
Length 1st maturity Lmat	35	BHAC
L infinity L_inf	48	BHAC
Length of first capture LFC	33	BHAC
Age range	1-16	For FLadvice
L infinity L_inf	48	For FLadvice
k VB growth K	0.039	For FLadvice
LW relationship a	0.169	For FLadvice
LW relationship b	2.59	For FLadvice

Several estimates were derived from these different approaches. Based on the DCAC method for Area 6 an estimated catch of 88 tonnes would have been sustainable in the long term (ICES 2012). This was similar to the output from a stock reduction model for area 6 where sustainable catch were estimated to be around 90 tons (ICES, 2002). The output of the DCAC method suggest that in 7 an estimated catch between 350 and 500 t (depending on input parameters) would have been sustainable over the long term but this is based on uncertain assumptions of the ratio between virgin biomass and depleted biomass.

Other methods provided fishing mortality reference points, showing that in all case fishing mortality should be well below 0.1 to maintain stocks in the long-term (Table 5)

Table 5

METHOD/ESTIMATE	FMAX	F0.1	F30%SPR	F40%SPR	FMSY
BHAC (WKLIFE)	0.63	0.06	0.04		0.06
FLAdvice (WKLIFE) based on Linf and K	0.17	0.04	0.04	0.06	
FLAdvice (WKLIFE) based on Linf, K and LW parameters		0.04	0.04	0.06	

Comments on reference points derive from various methods

DCAC method: It should be noted that the DCAC approach should be considered as representing what could have been a sustainable yield on orange roughy on fishing grounds where the standing biomass was depleted to low level. In Division 6, this is likely to represent quite closely the actual depletion of the biomass along the West of Scotland slope. It is less clear if there was orange roughy on other grounds of Subarea 6, e.g. the around the Rockall Bank and whether it was depleted in all locations. In Subarea 7, there are possible remaining aggregations. However the main issue regarding this species is that, the size of populations per seamount is unknown

so that applying a TAC per Subarea may not prevent sequential depletion of aggregations..

The Gislason method which is based on L_{inf} and age of first capture is based on the assumption that body size i.e. L_{max} can be used as a proxy of vulnerability to fishing. The method is clearly not appropriate for orange roughy, probably because at the same size orange roughy is much older than the species used to calculate the relationship between size and vulnerability. Results form this method are not shown.

BHAC and FLAdvice: The outputs of these two methods are similar and suggest that orange roughy can only sustain very low *Fs*. As the fishery for orange roughy is closed in 6 and 7, this could be seen in the context of mixed fisheries considerations, in which orange roughy was a potential bycatch until 2017. The question was whether small bycatch where sustainable. With the ban of trawling deeeper than 800 m, only insignificant bycatch may occur.

H. Other Issues

H.1. Historical overview of previous assessment methods

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