Stock Annex: Haddock (*Melanogrammus aeglefinus*) in Division 7.a (Irish Sea)

Stock specific documentation of standard assessment procedures used by ICES.

Stock	Haddock
Working Group	Working Group for the Celtic Seas Ecoregion (WGCSE)
Created	
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A. General

A.1. Stock definition

Catch weights from IBTS indicate that the haddock stock in ICES area 7.a have pulses of recruitment distinct from neighbouring areas. At present landings in rectangles 33E2 and 33E3 are considered to be fish from the northern extreme of the 7.g haddock stock. These rectangles have historically been removed from the landing series of 7.a haddock.

A.2. Fishery

Directed fishing for haddock in the Irish Sea is mainly carried out by UK (Northern Ireland) midwater trawlers using 100 mm mesh codend, particularly targeting aggregations that can be detected acoustically. These conditions prevail mainly during winter and spring when the hours of darkness are longest, and the fish are aggregating on the spawning grounds in the western Irish Sea. Other demersal whitefish vessels from Northern Ireland, Ireland and to a lesser extent Scotland, using single or twin trawls with 100 mm mesh, also target haddock when abundant. (Prior to the introduction of Council technical conservation Regulation 850/98 in 2001, most whitefish vessels in the Irish Sea used 80 mm codend.) Bycatches of haddock are made in the UK (NI) and Irish *Nephrops* fisheries using single nets with 70 mm codend or twin trawls with 80 mm codend. The haddock stock is mainly distributed in the western Irish Sea and south of the Isle of Man, preferring the coarser seabed sediments around the periphery of the muddy *Nephrops* grounds. Juveniles are taken extensively in the otter trawl fisheries in these areas, leading to substantial discarding (see Section B1.2).

The nature of the fishery has been modified by the cod closure since 2000 (Council Regulation (EC) No 304/2000). Targeted fishing with whitefish trawls was prohibited inside the closure from mid-February to the end of April. Derogations for *Nephrops* fishing were allowed. Irish *Nephrops* trawlers were involved in an experiment to test inclined separator panels in 2000 and 2001, the object being to minimize the bycatch of cod. Fishing inside a small area of the western Irish Sea closed to all fishing in spring 2000 and 2001 is permitted if separator panels were used. These panels would also have allowed escapement of part of the haddock catch. A conditional national licence has been introduced by Ireland since March 2012, making the use of grids or separator panels mandatory for all TR2 boats fishing in the Irish Sea. Since October 2012, all TR2 vessels in the UK (Northern Ireland) fleet are required to use a highly selective fishing gear to reduce overall discarding of fish. Closure of the main whitefish fishing grounds in spring 2000 resulted in a shift in fishing activities of midwater trawlers and other UK(NI) whitefish vessels into the North Channel (area 7.a) and Firth of Clyde (6.a south). A subsequent closure of the Firth of Clyde in spring 2001 under the 6.a cod recovery programme (Council Regulation (EC) No 456/2001) resulted in a reduction in reported fishing activity in this region. Several rounds of decommissioning in 1995–1997, 2001 and 2003 have reduced the size of the commercial fleets. UK vessels decommissioned at the beginning of 2002 accounted for 17% of the haddock landings from the Irish Sea in 1999–2001. A further round of decommissioning in 2003 removed 19 out of 237 UK vessels that operated in the Irish Sea at the beginning of 2004, representing a loss of 8% of the fleet by number and 9.3% by tonnage.

Gear specific effort regulations (days-at-sea) was introduced in the Irish Sea in 2004. Annex V to Council Regulation (EC) No 2341/2002 regulated the maximum number of days in any calendar month of 2004 for which a fishing vessel may be absent from port in the Irish Sea. Monthly effort limitation under this Regulation is as follows: ten days for demersal trawls, seines and similar towed gears with mesh size >=100 mm, 14 days for beam trawls of mesh size >= 80 mm and static demersal nets, 17 days for demersal longlines, and 22 days for demersal trawls, seines and similar towed gears with mesh size 70–99 mm. Additional days are available for vessels meeting certain conditions such as track record of low cod catches. In particular, an additional two days are available for whitefish trawlers (mesh >=100 mm) and beam trawlers (mesh >=80 mm) which spend more than half of their allocated days in a given management period fishing in the Irish Sea, in recognition of the area closure in the Irish Sea and the assumed reduction in fishing mortality on cod. With the introduction of the landings obligation Council Regulation (EC) No 2015/812 the restriction on days at sea was removed. There is a planned phased introduction of the landings obligation for haddock for distinct fisheries during 2016–2019.

A.3. Ecosystem aspects

B. Data

B.1. Commercial catch

B.1.1. Landings

The following table gives the source of landings data for Irish Sea haddock:

	Kind of data			
Country	Caton (catch-in-weight)	Canum (catch-at-age/in-numbers)	Weca (weight-at-age in the catch)	Length composition in catch
UK(NI)	X	X	X	X
UK(E&W)	X			
UK(Scotland)	X			
UK (IOM)	X			
Ireland	X	X	X	X
France	X			
Belgium	X			

Quarterly landings and length/age composition data are supplied from databases maintained by national Government Departments and research agencies. These figures may be adjusted by national scientists to correct for known or estimated misreporting by area or species. Catches taken or reported in rectangles 33E2 and 33E3 are not believed to belong to this stock and are reallocated to haddock 7.b–k. Data are supplied through InterCatch to a stock coordinator nominated by the ICES Working Group for the Celtic Seas Ecoregion, who compiles the international landings, discards and catch-at-age data maintaining a time-series of such data with any amendments. To avoid double counting of landings data, each UK region supplies data for UK landings into its regional ports, and landings by its fleet into non-UK ports.

Quarterly landings are provided by the UK (E&W), UK (Scotland), UK (IOM), Belgium and France. The quarterly estimates of landings-at-age of sampled fleets are raised to unsampled landings to provide raised landings-at-age estimates. Raising is applied using similar métiers and seasons. This raising and allocation of age structure is applied in InterCatch.

B.1.2. Discards

Discard data are supplied through InterCatch for sampled fleets. The estimates of discards and discards-at-age from sampled fleets are raised to unsampled fleets using discard rates from similar métiers and seasons. This raising and allocation of age structure is applied in InterCatch. Current discard data are derived through sampling schemes managed by national Government Departments and research agencies. Raising to national fleets is carried out by the scientific organisation responsible for administration of data collection.

Historically the potential magnitude of discarding was evaluated (Table 6.3.1) and the proportion, by number, at-age of discarded haddock estimated for each fleet using limited data from the following sources:

- Northern Ireland self-sampling scheme for *Nephrops*. The fisher self-sampling scheme that provides discards data for 7.a whiting was altered in 1996 to record quantities of other species in the samples. The quantity of haddock discarded from the UK (NI) *Nephrops* fishery is estimated on a quarterly basis from samples of discards and total catch provided by skippers. The discard samples contain the heads of *Nephrops* tailed at sea. Using a length–weight relationship, the live weight of *Nephrops* that would have been landed as tails only is calculated from the carapace lengths of the discarded heads. The number of haddock in the discard samples is summed over all samples in a quarter and expressed as a ratio of the summed live weight of *Nephrops* in the discard samples (i.e. those represented as heads only in the samples). The reported live weight of *Nephrops* landed as tails only is then used to estimate the quantity of haddock discarded using the haddock:*Nephrops* ratio in the discard samples. Length frequencies of haddock in the samples are then raised to the fleet estimate. No otoliths were collected, but the length frequencies could be partitioned to age class based on appearance of modes and comparison with length-at-age distributions in March and October surveys. The age data from 2001and 2002 were derived using survey and commercial fleet ALKs. The UK (NI) estimates are available since 1996 but the reliability of these estimates has not been determined. Roughly 40 discard samples are collected annually. There are several limitations to these data: only a small subset of single-rig trawlers is sampled; the method of raising to the fleet discards will be affected by any inaccuracies in the reported landings of *Nephrops*; and there are no estimates of landings of whiting from these vessels with which to calculate proportions discarded-at-age. The WG has not used these data in past assessments.

- Northern Ireland observer sampling (all fleets): Length frequencies from NI (AFBI) observer trips in specified fleet métiers are raised to the trip level, summed across trips during each year or by quarter (if requested) then raised to the annual number of trips per year in the NI fleet in 7.a to give raised annual LFDs for discards. An age–length key from discards trips is then applied to give annual discards by age class and métier.
- Irish otter trawl fleet (IR-OTB). Discards are estimated by observers on Irish trawlers operating in 7.a. Estimates for this fleet are given in the Report of the ICES Study Group on Discards and Bycatch Information (ICES CM 2002 ACFM:09). The anomalous high estimate of discards for this fleet in 2001 was a result of an inappropriate raising procedure, and data for this year are not presented. No discard data were available for 2002 as a consequence of a very limited number of sampling trips (n=1). This sampling level has increased in 2003, but is still low (n=6). A re-analysis of the Irish discard data raised to the number of trips, instead of landings, was performed based on methods described by Borges *et al*., 2005 and provided to the WG in 2005.

Table 6.3.1. Haddock in 7.a: Estimates of Irish Sea haddock discards 1995–2011. Data are numbers ('000 fish) discarded by the fleet, estimated from numbers per sampled trip raised to total fishing effort by each fleet, for the range of quarters indicated. Tables (b) and (d) represent estimates from limited observer sampling of N.Ireland vessels also included within the self-sampling estimates for N.Ireland trawlers catching *Nephrops* (Table (a)). Table (f) is the total for sampled fleets and quarters, excluding missing quarters or fleets. Table (e) is the revised figures supplied to the 2005 WG.

a) Self sampling scheme: N.Ireland single trawl Nephrops vessels. Estimates are extrapolated to all N.Ireland vessels catching *Nephrops* (single and twin trawl)

	1996 Q1-4	1997 Q1-4	1998 Q1-4	1999 Q1-4	2000 Q1-4	2001 Q1-4	2002 Q1-4	2003 Q1	2004	2005	2006	2007	2008 Q2-4	2009 Q1-4	2010 Q
Age	43 trips	39 trips	48 trips	39 trips	44 trips	43 trips	35 trips	8 trips					114	136	100
0	4485	100	1552	1274	110	1083	851	0	n/a	n/a	n/a	n/a	1312	7058	3830
1	229	1209	318	342	2384	140	1073	62	n/a	n/a	n/a	n/a	601	1015	2219
2	179	88	210	69	253	199	37	28	n/a	n/a	n/a	n/a	156	651	83
3	0	0	0	0	0	0	11	0	n/a	n/a	n/a	n/a	5	253	11

(b) Observer scheme: N.Ireland vessels catching *Nephrops* (single trawl only) (*not raised to fleet level – no. of fish)

	1999 Q3-4	2000 Q1-3	2001 Q1	2006 Q3-4*	2007 Q1-4	2008 Q1-4	2009 Q1-4	2010 Q
Age	4 trips	6 trips	1 trip	9 trips	29 trips	55 trips	30 trips	36 trip
0	2185	210	0	8391	901	625	1609	924
1	22	280	1677	809	1553	295	284	763
2	0	57	1593	60	681	124	101	16
3	0	0	0	15	74	16	23	1
4	0	0	0	0	0	1	0	0

(c) Observer scheme: N.Ireland midwater trawl

	1997 Q2-4	1998 Q1-3	1999 Q3-4	2000 Q1	2001 Q1	2008 Q4	2009 Q2	2010 Q1
Age	n/a	n/a	5 trips	4 trips	2 trips	1 trip	1 trip	3 trip
0	0	0	68	0	0	0	0	0
1	178	316	96	20	0.4	7	1	33
2	19	1342	35	83	19	15	39	28
3	4	0	2	5	0	2	19	4

(d) Observer scheme: N.Ireland twin trawl (*not raised to fleet level – no. of fish)

	1997 Q2-4	1998 Q1-3	1999 Q4	2000 Q1-4	2001 Q1	2006 Q3-4*	2007 Q1-4	2008 Q1-4	2009 Q1-4	2010 Q
Age	n/a	n/a	1 trips	10 trips	2 trips	2 trip	14 trips	16 trips	18 trips	21 trip
0	34	4	26	10	0	363	369	676	3219	493
1	284	205	3	13	3	59	275	183	315	1849
2	6	382	0	10	19	9	77	70	600	277
3	0.5	0	0	0	0	0	9	6	200	39
4	0	0	0	0	0	0	0	0	1	3

Table 6.3.1. (Continued). Haddock in 7.a: Estimates of Irish Sea haddock discards 1995–2011.

(e) Observer scheme: Republic of Ireland otter trawlers

	1996 Q1-4	1997 Q1-4	1998 Q1-4	1999 Q1-4	2000 Q1-4	2001 Q1-4	2002 Q1-4	2003 Q1-4	2004 Q1-4	2005 Q1-4	2006 Q1-4	2007 Q1-4	2008 Q1-4	2009 Q1-4	2010 Q1-4	2011 Q1-4
Age	8 trips	8 trips	7 trips	4 trips	10 trips	2 trips	1 trip	9 trips	11 trips	8 trips	5 trips	16 trips	18 trips	18 trips	4 trips	6 trips
0	3808	165	565	87	182	5349	47	1169	5663	776	3966	1122	322	5759	233	885
1	713	11396	1973	58	2193	7354	31	1747	6566	2350	10140	8735	1226	5654	374	647
2	297	303	3564	59	580	140	0	1178	2301	996	3856	3995	783	334	105	311
3	0	0	0	0	0	15	0	10	225	120	132	435	44	72	57	3
4	0	0	0	0	0	0	0	0	0	0	0	1	2	0	0	0

(f) Observer scheme: Republic of Ireland GEAR TECH otter trawlers (using grids)

	2010	2011
Age	9 trips	4 trips
0	43	256
1	125	67
2	43	11
3	26	0
4	1	0

(g) Total for sampled fleets and quarters: NI self sampling scheme (a); NI midwater trawl (c); ROI otter trawl (e)

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2010
Age	51 trips	n/a	n/a	48 trips	58 trips	47 trips	36 trips	17 trips	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
0	8293	265	2117	1429	292	47	36	17	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
1	942	12783	2607	496	4597	6432	898	1169	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
2	476	410	5116	163	916	7494	1104	1809	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
3	0	4	0	2	5	358	37	1206	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
4	0	0	0	0	0	15	11	10	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table 6.3.2. Haddock in 7.a: Proportion by number-at-age discarded by sampled fleets.

		Proportion discarded			
Fleet	Period	age 0	age 1	age 2	age 3
Midwater trawl	Q2-Q4 1997		0.93	0.37	0.02
Midwater trawl	Q1-Q3 1998		0.99	0.16	0.00
Midwater trawl	Q3-Q4 1999	1.00	0.79	0.31	0.00
Midwater trawl	Q1 2000		1.00	0.44	0.04
Midwater trawl	Q1 2001		1.00	0.30	
Midwater trawl	Q4 2008	1.00	0.97	0.90	0.30
Midwater trawl	Q2 2009		-	0.44	0.14
Midwater trawl	Q1-2,4 2010	1.00	0.92	0.22	0.03
Single *Nephrops*	Q3-Q4 1999	1.00	0.94		
Single *Nephrops*	Q1-Q3 2000	1.00	0.97	0.45	
Single *Nephrops*	Q1 2001		1.00	0.49	
Single *Nephrops*	Q3-Q4 2006	1.00	1.00	0.96	0.50
Single *Nephrops*	Q1-Q4 2007	1.00	1.00	0.94	0.79
Single *Nephrops*	Q1-Q4 2008	1.00	0.99	0.78	0.18
Single *Nephrops*	Q1-Q4 2009	1.00	1.00	0.88	0.46
Single *Nephrops*	Q1-Q4 2010	1.00	1.00	0.96	0.68
Single *Nephrops*	Q1-Q4 2011	1.00	1.00	0.94	0.21
Twin trawl	Q2-Q4 1997	1.00	1.00	0.61	0.04
Twin trawl	Q1-Q3 1998	1.00	1.00	0.76	0.00
Twin trawl	Q4 1999	1.00	1.00		
Twin trawl	Q1 – Q4 2000	1.00	0.96	0.28	
Twin trawl	Q1 2001		1.00	0.12	
Twin trawl	Q3-Q4 2006	1.00	1.00	0.81	0.00
Twin trawl	Q1-Q4 2007	1.00	1.00	0.91	0.63
Twin trawl	Q1-Q4 2008	1.00	0.95	0.50	0.05
Twin trawl	Q1-Q4 2009	1.00	0.99	0.95	0.75
Twin trawl	Q1-Q4 2010	1.00	1.00	0.85	0.42
Twin trawl	Q1-Q4 2011	1.00	1.00	0.80	0.08
OTB	Q1-Q4 2007	1.00	1.00	0.93	0.65
OTB	Q1-Q4 2008	1.00	0.97	0.90	0.17
OTB	Q1-Q4 2009	1.00	1.00	0.62	0.24
OTB	Q1-Q4 2010	1.00	0.99	0.59	0.29
OTB	Q1-Q4 2011	1.00	0.99	0.63	0.03

B.2. Biological

Natural mortality estimates were derived from mean catch weights-at-age using the approach proposed by Lorenzen (1996).

Table 6.3.3. Estimates for M as calculated by Lorenz method.

age	Length	Weight	M (Lorenz)
0	6.306264	2.05752	2.44
1	18.86225	61.02887	0.918
2	29.24511	237.0379	0.621
3	37.83096	525.6647	0.494
4	44.93081	894.9961	0.424
5	50.80186	1308.702	0.38
6	55.65678	1735.73	0.35
7	59.67144	2153.132	0.329

The proportions mature-at-age was also recalculated in 2013 based mean proportion observed during the NIGFS-WIBTS-Q1 survey. A Loess smoother is applied annually to update the proportion mature at a-age.

Table 6.3.4. LOWESS smoothed proportion of female haddock mature at-age 1–3 from quarter 1 NIGFS surveys.

Year	Age -1	Age -2	Age - 3
1994	0	0.79	1 (0.99)
1995	0	0.78	1 (0.99)
1996	0	0.78	1 (0.99)
1997	0	0.77	1 (0.99)
1998	0	0.77	1 (0.99)
1999	0	0.77	1 (0.99)
2000	0	0.76	1 (0.99)
2001	0	0.76	1 (0.99)
2002	0	0.76	1 (0.99)
2003	0	0.77	1 (0.99)
2004	0	0.78	1 (0.99)
2005	0	0.79	1 (0.99)
2006	0	0.81	1 (0.99)
2007	0	0.82	1 (0.99)
2008	0	0.83	1 (0.99)
2009	0	0.84	1 (0.99)
2010	0	0.85	1 (0.99)
2011	0	0.86	1 (0.99)
2012	0	0.87	1 (0.99)
2013	0	0.88	1 (0.99)
2014	0	0.89	1 (0.99)
2015	0	0.90	1 (0.99)

F and M before spawning were set to 0 for all ages in all years.

Working Groups prior to 2001 used constant weights-at-age over years based on analysis of some early survey data. However, evidence of a decline in mean length of adult haddock over time needed to be reflected in the stock weights-at-age. Since 2001 the WG calculated stock weights by fitting a von Bertalanffy growth curve to all available survey estimates of mean length-at-age in March, with an additional vector of parameters estimated to allow for year-class effects in asymptotic length. The efficacy of using annual von Bertalanffy growth curve across year classes was investigated by comparison with random intercept mixed effect models and multiple linear regressions. The results showed a high level of agreement between the predictions of the von Bertalanffy curve and methods account for year-class effects on growth. To increase the number of observations for older age classes, the mean lengths-at-age in UK (NI) first-quarter landings are included. (Comparisons of survey and landings data demonstrated that values from landings were larger than from the survey at-ages 1 and 2 because of selectivity patterns in the fishery, but very similar for ages 3 and over.) Stock weights-at-age were calculated from the model-fitted mean lengths-at-age, using length–weight parameters calculated from all March survey samples (2001 WG)). The time-series of length weight parameters are listed below:

	Length–weight parameters		Expected weight-at-length	
Year	**a**	**b**	30 cm	**40 cm**
1993	0.01132	2.972	278	653
1994	0.00374	3.279	261	669
1995	0.00354	3.291	257	661
1996	0.00565	3.156	259	642
1997	0.00723	3.104	278	680
1998	0.00633	3.119	256	629
1999	0.00449	3.208	246	620
2000	0.00439	3.208	241	606
2001	0.00402	3.242	247	627
2002	0.00369	3.268	247	633
2003	0.00459	3.197	242	607
2004	0.00514	3.156	236	585
2005	0.00489	3.174	238	593
2006	0.00506	3.165	239	595
2007	0.00469	3.194	244	612
2008	0.00523	3.159	242	601
2009	0.00431	3.224	249	629
2010	0.00413	3.238	250	635
2011	0.00457	3.207	250	629
2012	0.00499	3.174	243	606
2013	0.00451	3.208	247	622
2014	0.00591	3.121	241	591
2015	0.00423	3.232	251	637
2016	0.00420	3.233	250	634

The following model was fitted to the length-at-age data:

$$L_{t,yc} = LI_{yc} .(1\text{-}\exp(-K(t\text{-}t_0)))$$

where LI_{yc} is the estimated asymptotic length for year class yc. Parameters were estimated using Microsoft Solver in Excel by minimizing $\Sigma(\ln(\text{observed } L_t \ / \text{ expected. } L_t))^2$.

The year-class effects demonstrate a smooth decline from the mid-1990s coincident with the rapid growth of the stock, and may represent density-dependent growth effects. The year-class parameters effectively remove the temporal trend in residuals around a single von Bertalanffy model fit without year-class effects.

To estimate mean weight-at-age for year classes prior to 1990, represented as older fish in the early part of the time-series, the year-class effect for the 1990 year class and length–weight parameters for 1993 were assumed.

B.3. Surveys

UK (Northern Ireland) October Groundfish Survey (NIGFS–WIBTS-Q4): ages 1–3, years 1992–present

The survey series commenced in its present form in 1992. It comprises 45 three mile tows at fixed station positions in the northern Irish Sea, with an additional twelve one mile tows at fixed station positions in the St George's channel from October 2001 (the latter are not included in the tuning data). The surveys are carried out using a rock-hopper otter trawl deployed from the RV Lough Foyle. The survey designs are stratified by depth and seabed type. An ALK for the whole survey is used for filling in for any length groups with no ages at a station. The effects of using strata specific and all area age–length keys were explored. The effects of this are agreed to be negligible, with greatest effect in older ages 3+ (ICES, 2016).

Mean numbers-at-age per 3-mile tow are calculated separately by stratum, and weighted by surface area of the strata to give a weighted mean for the survey or group of strata. Coefficients of variation are calculated at-age across strata and for numbers of individuals between stations. From 2002 onwards, all stations in the survey have been reduced to 1 nautical mile, with comparative tows of 1 and 3 nm conducted to use a reference calibration dataset. Analysis of this dataset has shown no effect of tow duration on the, weight or lengths of haddock catches. A high degree of agreement is observed in age tracking of the NIGFS-WIBTS-Q1, NIGFS-WIBTS-Q4 and NI-MIK survey series, providing confidence in the ability of the surveys to track stock changes and inform the assessment.

Since 2005, the RV Lough Foyle used for all surveys since 1992 has been replaced by the larger RV *Corystes*. The trawl gear and towing practices have remained the same.

UK (Northern Ireland) March Groundfish Survey (NIGFS–WIBTS-Q1): ages 1–5, years 1993–present

General description as for October Surveys above, except that 3-mile stations have been retained in all strata other than in the St Georges Channel. Since 2005, the RV Lough Foyle used for all surveys since 1993 has been replaced by the larger RV *Corystes*. The trawl gear and towing practices have remained the same. The 1992 survey had only partial coverage of the western Irish Sea and is no longer used in the assessment. An ALK for the whole survey is used for inferring age from length. The effects of using strata specific and all area age–length keys have been explored (ICES, 2016). The effects of this are agreed to be negligible, with greatest effect in older ages 3+, but it is agreed that strata specific ALKs are more appropriate. A high degree of agreement is observed in age tracking of the NIGFS-WIBTS-Q1, NIGFS-WIBTS-Q4 and NI-MIK survey series, providing confidence in the ability of the surveys to track stock changes and inform the assessment.

UK (Northern Ireland) Methot–Isaacs–Kidd Survey (NIMIK): age 0; 1994–present

The survey uses a Methot–Isaacs–Kidd frame trawl to target pelagic juvenile gadoids in the western Irish Sea at 40–45 stations. The survey is stratified and takes place in June during the period prior to settlement of gadoid juveniles. Indices are calculated as the arithmetic mean of the numbers-per-unit sea area. The survey is considered informative as an index of recruitment with and displays consistent patterns with indices from other series.

UK Fishery Partnership Surveys (UK–FSP), Western Irish Sea, in March: ages 1–5, years 2005–2013, 2015–2016

The Irish Sea roundfish survey was initiated in 2003 as a fully collaborative project between the fishing industry and Cefas scientists. It forms part of the UK Fisheries Science Partnership funded by the UK's Department for Environment, Food and Rural Affairs (Defra). The main objective of the Irish Sea roundfish survey is to develop a time-series of data to track year-on-year changes in abundance, population structure and distribution of the target species (cod, haddock and whiting). The results of the surveys provide information supporting the scientific assessment of the stocks and the management of the fisheries in the Irish Sea. The surveys were designed to achieve full coverage of potential cod, haddock and whiting habitats within the area of the main roundfish fisheries of the Irish Sea, using a stratified design to allow additional trawling effort in areas expected to have the greatest densities of cod, haddock or whiting. The survey is conducted on board a commercial fishing vessel. Fishing gear and survey methods are kept constant. In the most recent year of the highest index value in the series was observed. This coincided with a vessel change after a period of consistent vessel selection. The potential for a vessel effect to generate this high index value was explored by plot mean standardised index values, by year with index values at year -1 and age-1 appearing to correspond in the penultimate year and final year of the survey and reflecting the 2013 year class observed in other survey series.

The indices from the UK FSP survey in the western Irish Sea also show similar year-class signals to the other survey series, but are noisy with strong year effects. The survey is considered informative as an index of older age classes.

C. Historical stock development

During the 2004–2007 Working Group explored the possibility of using TSA, ICA and B-Adapt (which allows for years with missing catch data) was explored. The results of these models were unsatisfactory. Because the assessment suffers from poor data quality with a relatively short time-series, from 2004 onwards the WG presented assessments of recent stock trends based on survey data only. The 2004 assessment focused on a Time-Series Analysis (TSA), which allows the 2003 commercial catch data to be treated as missing. Since 2005 a Survey Based Assessment (SURBA) was used; which is considered to give a reliable picture of the status of the stock at least for SSB and recruitment. The current assessment method was derived at WKirish3 (ICES, 2017), during which ASAP was proposed as the main assessment method.

Software used:

ASAP V2.0 NOAA Fisheries toolbox (http://nft.nefsc.noaa.gov)

FLR with R version 2.15.3 with packages FLCore 2.2, FLAssess 2.0.1 (http://cran.r-project.org; http://flr-project.org)

ASAP is proposed as the main assessment model.

C.1. Input data types and characteristics

A plus group of 5+ was used. Age group 0 was included in the assessment data to allow inclusion of 0-group indices. However, catch numbers and selectivity-at-age 0 were set to zero in all years because catches at this age were very low or zero.

Discard estimates are included in the catch numbers and weights, therefore catch is explicitly defined here as landings + discards.

Data	Year range	Age range	Variable from year to year
Catch (tonnes)	1993–current	0–5+	Yes
Catch-at-age in numbers (thousands)	1993–current	0–5+	Yes
Weight-at-age in the commercial catch (kg)	1993–current	0–5+	Yes
Weight-at-age of the stock at spawning time (kg).	1993–current	0–5+	Yes
Weight-at-age of the stock at Jan- 1 (same as stock weights)	1993–current	0–5+	Yes
Proportion of natural mortality before spawning (Lorenzen M)	1993–current	0–5+	No
Proportion of fishing mortality before spawning (XSA only)	1993–current	0–5+	No
Proportion mature-at-age	1993–current	0–5+	No
Natural mortality	1993–current	0–5+	No

C.2. Model options

ASAP

Note that ASAP does not accommodate inclusion of data for age 0. Therefore the ages in ASAP are offset by 1 year. All age settings above refer to the real age, not the age group used by ASAP.

Option	Setting
Use likelihood constant	Yes
Mean F (Fbar) age range	2–4
Fleet selectivity block 1	Assymtotpic
Fleet selectivity block 2	Age coefficineits (age 0 - 5) (0.2;0.5;0.8;1;0.7;0.5)
Fleet selectivity block 3	Age coefficients (age 0 - 5) (0.3;0.6;0.7;8;0.6;0.4)
Discards	Included in catch (not specified separately from landings)
Index units	4 (numbers)
Index month	NIGFS-Q1 (3); NIGFS-Q4 (10); NIMIK (7); UKFSPW(3)
Index selectivity linked to fleet	-1 (not linked)
Index age range	NIGFS-Q1 (1-4); NIGFS-Q4 (0-3); NIMIK (0); UKFSPW(2-5)
Index Selectivity (NIGFS-Q1)	Double logistic
Index Selectivity (NIGFS-Q4)	Asytotpic
Index Selectivity (NIMIK)	NA (age 0 only)
Index Selectivity (UK-FSPW)	Aysmytotic
Index CV & ESS (NIGFS-Q1)	Observed strata CV (lower limit 0.1); ESS = 50
Index CV & ESS (NIGFS-Q4)	Observed strata CV (lower limit 0.1); ESS = 50
Index CV & ESS (NIMIK)	Observed station CV (lower limit 0.1); ESS = 50
Index CV & ESS (UK-FSPW)	CV = 0.7; ESS = 10
Phase for F-Mult in 1st year	1
Phase for F-Mult deviations	2
Phase for recruitment deviations	3
Phase for N in 1st Year	1
Phase for catchability in 1st Year	3
Phase for catchability deviations	-5 (Assume constant catchability in indices)
Phase for unexploited stock size	1
Phase for steepness	-5 (Do not fit stock–recruitment curve)
Catch total CV	1993–2000 (0.175); 2003–2006 (0.2); 2007–2015 (0.15)
Catch effective sample size	1993–2000 (50); 2003–2006 (1); 2007–2015 (50)
Lambda for recruit deviations	0 (freely estimated)
Lambda for total catch	1
Lambda for total discards	NA (discards included in catch)
Lambda for F-Mult in 1st year	0 (freely estimated)
Lambda for F-Mult deviations	0 (freely estimated)
Lambda for index	1 for both indices in the model
Lambda for index catchability	0 for all indices (freely estimated)
Lambda for catchability devs	NA (phase is negative)
Lambda N in 1st year deviations	0 (freely estimated)
Lambda devs initial steepness	0 (freely estimated)
Lambda devs unexpl stock size	0 (freely estimated)

Tuning data

Type	Name	Year range	Age range
Survey	NIGFS-Q1	1993–present	0–5
Survey	NIGFS-Q4	1993–present	
Survey	NIMIK	1993–present	
Survey	UKFSPW	2007–present (ex 2014)	

D. Short-term projection

Model used: Multifleet Deterministic Projection. Landings and discards are modelled as separate fleets.

Software used: FLAssess

Option	Setting
Initial stock size	Long-term GM (omitting last two years) Stock numbers-at-age 1 and older from model
Natural mortality	Lorenzen M, as in model
Maturity	As in final year of assessment
F and M before spawning	0 for all ages in all years
Stock / catch weights-at-age	Average last 3 years
Exploitation pattern	Average last 3 years
Intermediate year assumptions	F in the last year – check retrospective pattern for evidence of bias
Stock–recruit model	None, long-term GM recruitment (omitting last two years)
Fbar range	2–4
Rescale to last year	No

E. Medium-term projections

F. Yield and biomass per recruit

No stock–recruit relationship exists for this stock; recruitment is characterised by sporadic extreme recruitment events.

G. Biological reference points

B_{lim} was set to the SSB in 1993, from which the fishery developed, an SSB of 2300 t in 1993. The S–R plot for Irish Sea haddock shows no obvious S–R relationship (Figure 9), mainly because the recruitment is highly variable. The S–R pairs from 1993:2012 were not used initially as the 2013 recruitment event and 2015 SSB were considered to be highly influential. The fitted relationship, compared to the selecting B_{lim} at 2300 t provides a B_{lim} of 4035 t, a value which has only been exceeded on eight occasions. However, the fitted segmented regression in a much better fitted given an Akaike Information Criterion weight of 94%. Whilst the selected B_{lim} of 2300 t is used proposed as a more realistic value for the stock the modelled relationship is used for further MSY simulations (ICES, 2017).

The entire time-series is used for MSY simulations (1993–2105). Fcv is 0.22 (F error in last year) and SSBcv as 0.15 (SSB error in last year). B_{pa} was calculated as B_{lim} combined with the assessment error; B_{lim} x exp(1.645 x σ); σ = 0.15 as 3093 t. $MSYB_{trigger}$ is set to B_{pa} as the stock has not been fished at or below F_{MSY} for more than five years. F_{MSY} median point estimates is 0.27 (0.273). The upper bound of the F_{MSY} range giving at least 95% of the maximum yield was estimated to 0.35 (0.351) and the lower bound at 0.19 (0.192) (Figure 5.4.2). $F_{p.05}$, without assessment error of $B_{trigger}$ as estimated 0.40 (0.0445) and therefore the upper bound does not need to be restricted because of precautionary limits. F_{lim} is estimated to be 0.47 (0.474) as F with 50% probability of SSB <B_{lim} with F_{pa} as 0.34 calculated as F_{lim} combined with the assessment error; F_{lim} x exp(-1.645 x σ); σ = 0.22.

H. Other issues

The use of specified selectivity blocks may require review at annual assessment working groups. With advice and management for haddock or other species it is possible that the character of the fishery may change. The current model includes a final selectivity block with only partial selectivity for older ages. In recent years 2013–present it has been observed that targeted fishing of haddock has increased, due to the strength of the 2013 year class. As this year class has matured and the cohort progressed full selection of the older fish may need to be taken into consideration in model configuration, at present this selectivity period is too short to be robustly parameterised.

I. References

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