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SCIENTIFIC COUNCIL MEETING – JUNE 2004

Report of the 3rd Meeting of the NAFO Working Group on Reproductive Potential

by

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The 3rd Meeting of the NAFO WG on Reproductive Potential was held at the Northeast Fisheries Science Center, National Marine Fisheries Service, Woods Hole, MA, 15-18 October 2003. A total of 13 of the 19 Working Group members were in attendance. Ed Trippel (Canada) (Chair), Gudrun Marteindottir (Iceland), Loretta O'Brien (USA), Joanne Morgan (Canada), Jay Burnett (USA), Tara Marshall (UK), Nathalia Yaragina (Russia), Yvan Lambert (Canada), Chris Chambers (USA), Jonna Tomkiewicz (Denmark), Peter Wright (UK), Gerd Kraus (Germany) and Fran Saborido-Rey (Spain). Additionally, Pauline King (Ireland), Catriona Clemmesen (Germany), Paul Rago (USA), Lisa Hendrikson (USA), and Katherine Sosebee (USA) participated in the meeting bringing the total to 18 from 9 countries. Local arrangements were provided by Jay Burnett and Loretta O'Brien (Woods Hole Institute) which were greatly appreciated.

Through the efforts of the ToR Co-Leaders, other WG Members and participants achieved significant progress was made at this meeting on the second set of ToRs. A brief summary of progress and future plans of each ToR are given below.

ToR 1: Co-Leaders: Jonna Tomkiewicz (Denmark) and Jay Burnett (USA)

Complete inventory of available data in standardized format on reproductive potential for fish stocks of the North Atlantic and Baltic Sea.

Members: everyone

This task is a follow up of the previous ToR 1: Explore and review availability of information and existing data on reproductive potential by areas and species. The approach of ToR 1 has been to produce an inventory of the availability and quality of data through a series of tables. These tabulate, in a standardised form, the availability of data and information relevant for estimating stock reproductive potential and stock-recruitment relationships. The tables are not designed to include actual data, but to list data and studies published in journals, reports etc. or unpublished data existing in national laboratories. In 2003, tabulated information for 53 North Atlantic fish stocks was published in the NAFO Scientific Council Studies (Morgan et al. 2003). The tabulated information is available on the NAFO web site on a stock basis, which facilitates that assessment WG members and researcher can identify exisisting data available for estimation stock reproductive potential (http://www.nafo.int/publications/frames/puFrSC37.html).

A sub-set of these tables was used to explore and review the availability of information and existing data on reproductive potential for demersal Northwest Atlantic fish stocks (Tomkiewicz et al. 2003). For these 42 stocks, information about stock size and age composition as well as, data on sex ratio, maturity and weight at length or age were often available for two or more decades, whereas fecundity data were scarce. Only a few studies of parental and environmental influences on egg and larval survival and stock recruitment analyses existed, but realised egg production data from ichthyoplankton surveys were common. Data and information on gadoids and flatfishes generally were comprehensive, while both quantity and quality of data on redfish and grenadiers often had constraints. For most stocks, data were available for considering natural variability in more parameters, which could be used to improve spawning stock estimates (e.g. female-only spawning stock) or to develop alternative indices, whereas establishment of egg production time series or more advanced SRP indices requires fecundity studies.

In order to accomplish the present ToR 1, the WG is collaborating with the ICES Study Group on Growth, Maturity and Condition in Stock Projections (SGGROMAT). The objective is to extend the tabulated information to comprise pelagic and demersal fish stocks important to the commercial fisheries in the North Atlantic, the Baltic Sea and the western Mediterranean Sea (ICES 2004). In this context, table design have been updated and the guidelines how to fill in tables have been revised accordingly and a new example has been elaborated (North Sea herring). The main focus of the revision was to allow the incorporation of information relevant to indeterminate spawners. Secondly, the review of data availability for the Northwest Atlantic stocks identified a need for further specification of certain variables and studies. The revised guidelines and new example are presented in Appendix A and B. Additional stocks to be considered also have been identified and include a total of 159 stocks (Table 1). These stocks include elasmobranch, gadoid, flatfish, some other demersal stocks and a variety of pelagic fish stocks. In addition to these, the existing tables document the data availability for 53 stocks including 22 gadoid, 17 flatfish, 9 redfish, 4 pelagic and 1 other stock, for which 48 are from NAFO area and 5 from ICES area (Table 2). However, these tables need to be updated to the format of the new ones for the review in order to reflect the same level of information. The number of stocks available for the review of the general data availability for North Atlantic stocks thus will add up to 212 provided that all tables are filled in.

Substantial progress on filling in the tables of available information has already been made (see table below). At present, tables for 173 stocks are in progress or have been completed. For the remaining 39 stocks further efforts will be made to appoint contributors. A need for circulating tables in progress among colleagues working with a particular stock has been identified. This is particularly relevant in ICES fishing areas where several institutes or national laboratories often have monitoring and research programs addressing the same stock.

Areas:	Stocks identified	Contributor lacking	Tables in progress	Establ. tables in circulation	NAFO version exist	Updated/ completed
Northeast Atlantic and Baltic Sea (ICES areas)						
Baltic Sea, Kattegat and Skagerrak	24		12	11	1	
Barents Sea, Celtic Sea, English Channel	16	2	10	3	1	
Iberian Sea, Southern Shelf	14	2	12			
Iceland and Greenland	12	9	2		1	
Irish Sea	9	9				
North Sea	15	1	4	6	2	2
West of Scotland, Rockall	5	4	1			
Northwest Atlantic (NAFO areas)						
USA + Canadian areas	106	12	27	1	48	18
Western Mediterranean Sea (GFCM areas)	11		7			4
Total	212	39	75	21	53	24

The main work of ToR 1 will be conducted intersessionally via correspondence with an update on progress filling in tables and intial planning of the review during the next WG meeting. A tentative work plan and timetable for the remaining including the review of the data availability for exploited North Atlantic fish stocks is given below. The resulting inventory of data and information for estimating reproductive potential could be placed on NAFO website or as part of the data inventory on ICES website the ICES and be maintained as a resource for use in stock assessments and research as recommended by the ICES SGGROMAT (ICES 2004).

Activity	Deliverables	Year	Month
Circulate and complete tables for identified stocks	Data inventory for ca. 200 stocks in ICES, NAFO and Mediterranean fishing areas	2004	10
Analyse the information available as recorded in the tables	Relevant tables analysed	2005	6
Review quantity and quality of available data	Manuscript reviewing the availability and application of information		10

References:

ICES, 2004. Report of the Study Group on Growth, Maturity and Condition in Stock Projections. ICES CM 2004/D2.

Morgan,M.J., Burnett,J., Tomkiewicz,J. and Saborido-Rey,F. 2003 The availability of data for estimating reproductive potential for selected stocks in the North Atlantic. Scientific Council Studies 37, Dartmouth: Northwest Atlantic Fisheries Organization. 378 p.

Tomkiewicz, J., Morgan, M.J., Burnett, J. and Saborido-Rey, F. 2003 Available information for estimating reproductive potential of Northwest Atlantic groundfish stocks. J. Northw. Atl. Fish. Sci. 33: 1-21.

Table 1: New species, stocks and areas identified

	Species	Scientific names	Stock	Area
1	Barndoor skate	*Dipturus laevis*	Northwest Atlantic	NAFO 5
2	Porbeagle shark	*Lamna nasus*	Northwest Atlantic	NAFO Subarea 3-6
3	Little skate	*Leucoraja erinacea*	Northwest Atlantic	NAFO 5-6
4	Winter skate	*Leucoraja ocellata*	Northwest Atlantic	NAFO 5-6
5	Smooth skate	*Malacoraja senta*	Northwest Atlantic	NAFO 5
6	Thorny Skate	*Raja radiata*	Northwest Atlantic	NAFO 3LNOPs
7	Thorny skate	*Raja radiata*	Northwest Atlantic	NAFO 5
8	Thorny skate	*Raja radiata*	West Greenland	NAFO SA 1
9	Spiny dogfish	*Squalus acanthias*	Northwest Atlantic	NAFO 5-6
10	Witch flounder	*Glyptocephalus cynoglossus*	Gulf of St. Lawrence	NAFO Div. 4RST
11	American plaice	*Hippoglossoides platessoides*	Eastern Scotian Shelf	NAFO 4VW
12	American plaice	*Hippoglossoides platessoides*	Southern Gulf of St. Lawrence	NAFO Div. 4T
13	American plaice	*Hippoglossoides platessoides*	West Greenland	NAFO SA 1
14	Atlantic halibut	*Hippoglossus hippoglossus*	Northwest Atlantic	NAFO 5
15	Atlantic halibut	*Hippoglossus hippoglossus*	Scotian shelf/southern Grand Bank	NAFO Div. 4VWX3NOPs
16	Megrim	*Lepidorhombus sp.*	Northern Shelf	ICES Div. VI
17	Megrim	*Lepidorhombus sp.*	Southern Shelf Megrim	ICES Div. VIIb,c,e-k, VIIIa,b,d
18	Megrim	*Lepidorhombus sp.*	Southern Shelf Megrim	ICES Div. VIIIc, IXa
19	Yellowtail flounder	*Limanda ferruginea*	Southern Gulf of St. Lawrence	NAFO Div. 4T
20	Dab	*Limanda limanda*	Baltic dab	ICES SD 22-32
21	Flounder	*Platichtyus flesus*	Kattegat, Skagerrak flounder	ICES Div. IIIa
22	Flounder	*Platichtyus flesus*	Baltic flounder in SD 22	ICES SD 22
23	Flounder	*Platichtyus flesus*	Baltic flounder in 24-25	ICES SD 24-25
24	Flounder	*Platichtyus flesus*	Baltic flounder in SD 26	ICES SD 26
25	Flounder	*Platichtyus flesus*	Baltic flounder in SD 28	ICES SD 28
26	Flounder	*Platichtyus flesus*	Botnian Sea flounder	ICES SD 29-30
27	Flounder	*Platichtyus flesus*	Baltic flounder in SD 32	ICES SD 32
28	Winter flounder	*Pleuronectes americanus*	Southern Gulf of St. Lawrence	NAFO Div. 4T
29	Plaice	*Pleuronectes platessa*	Skagerrak, Kattegat plaice	ICES Div. IIIa
30	Plaice	*Pleuronectes platessa*	Irish Sea plaice	ICES Div. VIIa
31	Plaice	*Pleuronectes platessa*	English Channel (east)	ICES Div. VIId
32	Plaice	*Pleuronectes platessa*	Western Channel Plaice	ICES Div. VIIe
33	Plaice	*Pleuronectes platessa*	Celtic Sea Plaice	ICES Div. VIIf and g
34	Plaice	*Pleuronectes platessa*	South of Ireland Plaice	ICES Div. VIIh-k

	Species	Scientific names	Stock	Area
35	Plaice	*Pleuronectes platessa*	Baltic plaice	ICES SD 22-32
36	Plaice	*Pleuronectes platessa*	North Sea plaice	ICES Subarea IV
37	Turbot	*Pstta maxima*	Skagerrak, Kattegat turbot	ICES Div. IIIa
38	Turbot	*Pstta maxima*	Baltic turbot	ICES SD 22-32
39	Greenland Halibut	*Reinhardtius hippoglossoides*	NEA	ICES Div. I-II
40	Greenland halibut	*Reinhardtius hippoglossoides*	Greenland	ICES V, XIV
41	Greenland halibut	*Reinhardtius hippoglossoides*	Greenland	NAFO 0+1
42	Greenland halibut	*Reinhardtius hippoglossoides*	Gulf of St. Lawrence	NAFO Div. 4RST
43	Common sole	*Solea solea*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
44	Sole	*Solea solea*	Skagerrak, Kattegat sole	ICES Div. IIIa
45	Sole	*Solea solea*	Irish Sea sole	ICES Div. VIIa
46	Sole	*Solea solea*	English Channel	ICES Div. VIId
47	Sole	*Solea solea*	Western Channel Sole	ICES Div. VIIe
48	Sole	*Solea solea*	Celtic Sea Sole	ICES Div. VIIf and g
49	Sole	*Solea solea*	South of Ireland	ICES Div. VIIh-k
50	Sole	*Solea solea*	North Sea sole	ICES Subarea IV
51	Sole	*Solea solea*	Bay of Biscay Sole	ICES VIII a and b
52	Fourspot flounder	*Hippoglossina oblonga*	Northwest Atlantic	NAFO 5-6
53	Windowpane flounder	*Scophthalmus aquosus*	Northwest Atlantic	NAFO 5-6
54	Cod	*Gadus morhua*	Norwegian Coastal Cod	ICES Div. I-II
55	Cod	*Gadus morhua*	Iceland	ICES Div. Va
56	Cod	*Gadus morhua*	West of Scotland	ICES Div. VIa
57	Cod	*Gadus morhua*	Celtic Sea Cod	ICES Div. VII e – k
58	Cod	*Gadus morhua*	Irish Sea cod	ICES Div. VIIa
59	Cod	*Gadus morhua*	Greenland	ICES Div. XIV +NAFO 1
60	Cod	*Gadus morhua*	Western Baltic cod	ICES SD 22-24
61	Cod	*Gadus morhua*	Sydney Bight	nafo div. 4vn, may-dec
62	Haddock	*Melanogrammus aeglefinus*	NEA Haddock	ICES Div. I-II
63	Haddock	*Melanogrammus aeglefinus*	Iceland	ICES Div. Va
64	Haddock	*Melanogrammus aeglefinus*	West of Scotland	ICES Div. VIa
65	Haddock	*Melanogrammus aeglefinus*	Rockall	ICES Div. VIb
66	Haddock	*Melanogrammus aeglefinus*	Irish Sea haddock	ICES Div. VIIa
67	Haddock	*Melanogrammus aeglefinus*	Grand Bank	NAFO Div. 3LNO
68	Whiting	*Merlangius merlangus*	West of Scotland	ICES Div. VIa
69	Whiting	*Merlangius merlangus*	Irish Sea whiting	ICES Div. VIIa
70	Whiting	*Merlangius merlangus*	Southern shelf whiting	ICES Div. VIIe-k
71	Whiting	*Merlangius merlangus*	North Sea whiting	ICES Subarea IV, Div. VIId
72	Saithe	*Pollachius virens*	NEA Saithe	ICES Div. I-II
73	Saithe	*Pollachius virens*	Iceland	ICES Div. Va
74	Saithe	*Pollachius virens*	North Sea, West of Scotland, Rockall, and Skagerrak & Kattegat	ICES Subarea IV, VI and Div. IIIa
75	Norway pout	*Trisopterus esmarkii*	North Sea, Skagerrak & Kattegat	ICES Subarea IV, Div. IIIa
76	Poor cod	*Trisopterus minutus*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6

	Species	Scientific names	Stock	Area
77	Sand lance	*Ammodytes americanus*	Northwest Atlantic	NAFO 5-6
78	Sandeel	*Ammodytes tobianus*	North Sea	ICES Subarea IV
79	Spotted wolfish	*Anarhichas minor*	West Greenland	NAFO SA 1
80	Spotted wolffish	*Anarhichas minor*	Newfoundland	NAFO SA 2+3
81	Atlantic wolffish	*Anarhichas lupus*	Northwest Atlantic	NAFO 5
82	Atlantic wolffish	*Anarhichas lupus*	West Greenland	NAFO SA 1
83	Northern wolffish	*Anarhichas sp.*	Newfoundland	NAFO SA 2+3
84	Striped wolffish	*Anarhichas sp.*	Newfoundland	NAFO SA 2+3
85	Wolffishes	*Anarhichas spp.*	Scotian shelf/Georges Bank/Gulf of St. Lawrence	NAFO SA 4 + Div. 5YZe
86	Cusk	*Brosme brosme*	Northwest Atlantic	NAFO 5-6
87	Cusk	*Brosme brosme*	Georges Bank	NAFO Subareas 4 and 5
88	Lumpfish	*Cyclopterus lumpus*	Southern Newfoundland	NAFO Div. 3P
89	White seabream	*Diplodus sargus*	Gulf of Lions	GFCM 7
90	Anglerfish	*Lophius budegasa*	Southern Anglerfish	ICES Div. VIIb-k,
91	Anglerfish	*Lophius budegasa*	Southern Anglerfish	ICES Div. VIIIc, Ixa
92	Anglerfish	*Lophius piscatorius*	Southern Anglerfish	ICES Div. VIIb-k,
93	Anglerfish	*Lophius piscatorius*	Southern Anglerfish	ICES Div. VIIIc, Ixa
94	Anglerfish	*Lophius sp.*	Northern Shelf	ICES div.IV, VI IIIa
95	Monkfish	*Lophius sp.*	Northwest Atlantic	NAFO 5
96	Monkfish	*Lophius sp.*	Northwest Atlantic	NAFO 6
97	Monkfish	*Lophius sp.*	Grand Bank/Southern Newfoundland	NAFO Div. 3LNOPs
98	Monkfish	*Lophius sp.*	Scotian shelf/northwest Georges Bank	NAFO Div. 4VWX5Zc
99	Silver hake	*Merluccius bilinearis*	Northwest Atlantic (2 stocks)	NAFO 5YZe & NAFO 5Zw6
100	Silver Hake	*Merluccius bilinearis*	Scotian Shelf	NAFO Div. 4VWX
101	Hake	*Merluccius merluccius*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
102	Hake	*Merluccius merluccius*	Northern Hake	ICES Div. II-VIII
103	Hake	*Merluccius merluccius*	Southern Hake	ICES Div. VIIIc and IXa
104	Red mullet	*Mullus sp.*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
105	Striped red mullet	*Mullus sp.*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
106	Axillary seabream	*Pagellus acarne*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
107	Scup	*Stenotomus chrysops*	Northwest Atlantic	NAFO 5-6
108	Black sea bass	*Stereolepis gigas*	Northwest Atlantic	NAFO 5-6
109	Red hake	*Urophycis chuss*	Northwest Atlantic (2 stocks)	NAFO 5YZe & NAFO 5Zw6
110	White Hake	*Urophycis tenuis*	Southern Gulf of St. Lawrence	NAFO Div. 4T
111	White Hake	*Urophycis tenuis*	Grand Bank/St. Pierre Bank	NAFO Div. 3LNOPs
112	White Hake	*Urophycis tenuis*	Northwest Atlantic	NAFO Div. 4VWX5Z
113	Ocean pout	*Zoarces americanus*	Northwest Atlantic	NAFO 5-6
114	redfish	Redfish sp.	NEA (Sebastes mentella)	ICES Div. I-II
115	redfish	Redfish sp.	NEA (Sebastes marinus)	ICES Div. I-II
116	Golden redfish	Redfish sp.	Dermersal fishery (Iceland, Faroes, Greenland waters)	ICES Div. V, VI, XII, XIV
117	Deep-water redfish	Redfish sp.	Dermersal fishery (Iceland, Faroes, Greenland waters)	ICES Div. V, XIV
118	Deep water redfish	Redfish sp.	Irminger pelagic fishery	ICES Div. XII, Va, XIV
119	Redfish spp.	Redfish spp.	Unit 1	NAFO Div. 4RST- 3P4Vn(Jan-

	Species	Scientific names	Stock	Area
				May)
120	Redfish spp.	Redfish spp.	West Greenland	NAFO SA 1
121	Herring	*Clupea harengus*	Norwegian spring spawning	ICES Div. I, II, V
122	Herring	*Clupea harengus*	Spring spawning herring 22-24, IIIa (Rügen herring)	ICES Div. IIIa, SD 22-24
123	Herring	*Clupea harengus*	North Sea autumn spawners	ICES Div. IV, VIId, IIIa
124	Herring	*Clupea harengus*	Icelandic summer spawning	ICES Div. Va
125	Herring	*Clupea harengus*	West of Scotland, autumn spawners	ICES Div. VIa (N)
126	Herring	*Clupea harengus*	Ireland autumn-spring spawners	ICES Div. VIa (S), VIIb,c
127	Herring	*Clupea harengus*	Irish Sea, autumn spawners	ICES Div. VIIa (N)
128	Herring	*Clupea harengus*	Celtic Sea & VIIj	ICES Div. VIIg, VIIj
129	Herring	*Clupea harengus*	Central Baltic herring	ICES SD 25-29, 32 (minus Gulf of Riga)
130	Herring	*Clupea harengus*	Gulf of Riga herring	ICES SD 28 (Part)
131	Herring	*Clupea harengus*	Botnian Sea herring	ICES SD 30
132	Herring	*Clupea harengus*	Botnian Bay herring	ICES SD 31
133	Herring	*Clupea harengus*	East and Southeast Newfoundland	NAFO Div. 3KLPs
134	Herring	*Clupea harengus*	West Coast of Newfoundland	NAFO Div. 4R
135	Herring	*Clupea harengus*	Quebec north shore	NAFO Div. 4S
136	Herring	*Clupea harengus*	Southern Gulf of St. Lawrence	NAFO Div. 4T
137	Herring	*Clupea harengus*	SW Nova Scotia/Bay of Fundy	NAFO Div. 4VWX
138	Anchovy	*Engraulis encrasicholus*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
139	Anchovy	*Engraulis encrasicholus*	Gulf of Lions	GFCM 7
140	Anchovy	*Engraulis encrasicholus*	Iberian Region (east)	ICES Subarea IXa
141	Anchovy	*Engraulis encrasicholus*	Bay of Biscay, Iberian Region (north)	ICES Subarea VIII
142	Capelin	*Mallotus villosus*	Barents Sea	ICES Div. I
143	Capelin	*Mallotus villosus*	Iceland-East Greenland-Jan Mayen area	ICES Div. V, XIV, Div IIa
144	Capelin	*Mallotus villosus*	Northeast NF Shelf/northern Grand Bank	NAFO 2J3KL
145	Capelin	*Mallotus villosus*	Southern Grand Bank	NAFO Div. 3NO
146	Capelin	*Mallotus villosus*	Gulf of St. Lawrence	NAFO Div. 4RST
147	Blue whiting	*Micromesistius poutassou*	Iberian Mediterranean	GFCM 1, 2, 3, 5, 6
148	Blue whiting	*Micromesistius poutassou*	“Atlantic”	ICES Div. I-IX, XII, XIV
149	Sardine	*Sardina pilchardus*	Gulf of Lions	GFCM 7
150	Sardine	*Sardina pilchardus*	Iberian Region	ICES Div. VIIIc and IXa
151	Mackerel	*Scomber scombrus*	Northeast Atlantic	ICES Subareas IV, Vb, VI, VII, VIII
152	Brill	*Scophthalmus rhombus*	Baltic brill	ICES SD 22-32
153	Sprat	*Sprattus sprattus*	Kattegat-Skagerrak sprat	ICES Div. IIIa
154	Sprat	*Sprattus sprattus*	North Sea	ICES Div. IV
155	Sprat	*Sprattus sprattus*	Baltic sprat	ICES SD 22-32
156	Horse mackerel	*Trachurus trachurus*	Western horse mackerel	ICES Div. Iia, IIIa (western part), Iva, Vb, VIa, VIIa-c, VIIe-k and VIIIabde
157	Horse mackerel	*Trachurus trachurus*	North Sea horse Mackerel	ICES Div. IIIa (excluding western Skagerrak) Ivbc, VIId
158	Horse mackerel	*Trachurus trachurus*	Southern Horse Mackerel (Iberian Region)	ICES Div. VIIIc and IXa
159	Butterfish		Northwest Atlantic	NAFO 5-6

Table 2. Completed species and stocks for the northwest Atlantic (see www.nafo.int)

	Species group	Species	Scientific names	Stock	Area
1	Flatfish	American plaice	*Hippoglossoides platessoides*	Flemish Cap	NAFO 3M
2	Flatfish	American plaice	*Hippoglossoides platessoides*	Labrador and Northeast Newfoundland	NAFO 2+3K
3	Flatfish	American plaice	*Hippoglossoides platessoides*	Grand Bank	NAFO 3LNO
4	Flatfish	American plaice	*Hippoglossoides platessoides*	Newfoundland South Coast	NAFO 3Ps
5	Flatfish	American plaice	*Hippoglossoides platessoides*	Gulf of Maine/mid Atlantic	NAFO 5+6
6	Flatfish	Greenland halibut	*Reinhardtius hippoglossoides*	Labrador – Eastern Newfoundland	NAFO 2+3KLMNO
7	Flatfish	Witch flounder	*Glyptocephalus cynoglossus*	Labrador and Northeast Newfoundland	NAFO 2J3KL
8	Flatfish	Witch flounder	*Glyptocephalus cynoglossus*	Southern Grand Bank	NAFO 3NO
9	Flatfish	Witch flounder	*Glyptocephalus cynoglossus*	Newfoundland South Coast	NAFO 3Ps
10	Flatfish	Witch flounder	*Glyptocephalus cynoglossus*	Gulf of Maine/Georges Bank	NAFO 5+6
11	Flatfish	Yellowtail flounder	*Limanda ferruginea*	Grand Bank	NAFO 3LNO
12	Flatfish	Yellowtail flounder	*Limanda ferruginea*	Georges Bank	NAFO 5Ze
13	Flatfish	Yellowtail flounder	*Limanda ferruginea*	Southern New England	NAFO 5Zw
14	Flatfish	Yellowtail flounder	*Limanda ferruginea*	Cape Cod	US State areas 514
15	Flatfish	Winter flounder	*Pseudopleuronectes americanus*	Georges Bank	NAFO 5Z
16	Flatfish	Winter flounder	*Pseudopleuronectes americanus*	Coastal-south New England/mid-Atlantic	NAFO 5+6
17	Flatfish	Summer flounder	*Paralichthys dentatus*	Mid Atlantic- Georges Bank	NAFO 5+6
18	Gadoid	Cod	*Gadus morhua*	Flemish Cap	NAFO 3M
19	Gadoid	Cod	*Gadus morhua*	Northern	NAFO 2J3KL
20	Gadoid	Cod	*Gadus morhua*	Southern Grand Bank	NAFO 3NO
21	Gadoid	Cod	*Gadus morhua*	Newfoundland South Coast	NAFO 3Ps
22	Gadoid	Cod	*Gadus morhua*	Northern Gulf of St. Lawrence	NAFO 4RS3Pn
23	Gadoid	Cod	*Gadus morhua*	Southern Gulf of St. Lawrence	NAFO 4TVn (J-A)
24	Gadoid	Cod	*Gadus morhua*	Eastern Scotian Shelf	NAFO 4VSW
25	Gadoid	Cod	*Gadus morhua*	Bay of Fundy/Western Scotian Shelf	NAFO 4X
26	Gadoid	Cod	*Gadus morhua*	Georges Bank	NAFO 5Z + 6
27	Gadoid	Cod	*Gadus morhua*	Gulf of Maine	NAFO 5Y
28	Gadoid	Cod	*Gadus morhua*	North Sea	ICES IV
29	Gadoid	Cod	*Gadus morhua*	Baltic	ICES SD 25-32
30	Gadoid	Cod	*Gadus morhua*	Northeast Arctic	ICES 1+2
31	Gadoid	Cod	*Gadus morhua*	Icelandic	ICES Va
32	Gadoid	Haddock	*Melanogrammus aeglefinus*	Eastern Scotian Shelf	NAFO 4TVW
33	Gadoid	Haddock	*Melanogrammus aeglefinus*	Bay of Fundy/Western Scotian Shelf	NAFO 4X
34	Gadoid	Haddock	*Melanogrammus aeglefinus*	Georges Bank	NAFO 5Z + 6
35	Gadoid	Haddock	*Melanogrammus aeglefinus*	North Sea	ICES IV
36	Gadoid	Pollock	*Pollachius virens*	Scotian Shelf/Bay Fundy/Georges Bank	NAFO 4ZWX + 5ZC
37	Gadoid	White hake	*Urophycis tenuis*	Gulf of Maine / Georges Bank	NAFO 5+6
38	Gadoid	Roughhead grenadier	*Macrourus berglax*	Labrador-eastern Newfoundland	NAFO 2+3
39	Gadoid	Roundnose grenadier	*Coryphaenoides rupestris*	Labrador – eastern Newfoundland	NAFO 2+3

	Species group	Species	Scientific names	Stock	Area
40	Redfish	Redfish	*Sebastes fasciatus*	Flemish Cap	NAFO 3M
41	Redfish	Redfish	*Sebastes mentella*	Flemish Cap	NAFO 3M
42	Redfish	Redfish	*Sebastes sp.*	Flemish Cap	NAFO 3M
43	Redfish	Redfish	*Sebastes sp.*	Labrador-Northeast Newfoundland	NAFO 2+3K
44	Redfish	Redfish	*Sebastes sp.*	Eastern Grand Bank	NAFO 3LN
45	Redfish	Redfish	*Sebastes sp.*	Southwestern Grand Bank	NAFO 3O
46	Redfish	Redfish	*Sebastes sp.*	Unit 2	NAFO 3Ps4VsW-3Pn4Vn (J-D)
47	Redfish	Redfish	*Sebastes sp.*	Gulf of Maine/Georges Bank	NAFO 5
48	Other	Herring	*Clupea harengus*	Mid Atlantic/Gulf Maine/Georges Bank	NAFO 5+6
49	Other	Mackerel	*Somber scombrus*	Northwest Atlantic	NAFO 2-6
50	Other	Bluefish	*Pomatomus saltatrix*	Mid-Atlantic/Gulf of Maine	NAFO 5+6
51	Other	Striped Bass	*Morone saxatlis*	Coastal/mid-Atlantic/Gulf of Maine	NAFO 5+6
52	Other	Thorny skate	*Raja radiata*	Flemish Cap	NAFO 3M

Appendix A. Guidelines to fill in tables on stock reproductive potential

NAFO Working Group on Reproductive Potential &
ICES Study Group on Growth, Maturity and Condition in Stock Projections

GUIDELINES TO FILL IN TABLES ON STOCK REPRODUCTIVE POTENTIAL

INTRODUCTION

The purpose of the tables is to provide an overview of available information and existing data that can be applied to estimate stock reproductive potential. Unpublished as well as published data may be available for this purpose and, by recording identified stock characteristics (e.g. stock size, maturity, fecundity, etc.) and data sources in a systematic fashion, the potential for estimating the total, realised or viable egg/larval production can be evaluated for different stocks. The tables, including information about available data and their sources will be published or listed on the NAFO/ICES web-sites so that readers, e.g. assessment Working Group members, can avail themselves of information for a specific stock and locate the origin of the information.
The tables were not designed to include actual data, but rather to reference existing data and studies published in journals, reports, etc. or to identify persons who might provide information relative to data, which may exist in national laboratories but have not been analysed or published. The file containing this information consists of five tables: 1) Data Availability; 2) Data Basis, Format and Quality; 3) Studies of Stock Reproductive Potential (SRP); 4) Data Sources; and 5) Contributors. The first table provides on a yearly scale an overview of the availability of basic data to estimate the reproductive potential of a given stock inclusive ichthyoplankton data. Table 2 provides more details about the available data and adds information about compatibility of different data sets (e.g. age-based versus length-based data) and their quality (e.g. differences in accuracy due to differences in methodology, sampling intensity, experimental design, etc.). This table includes more variables than Table 1, and some variables have been divided into sub-levels to specify different data types. Table 3 refers to existing studies that estimate reproductive potential or evaluate stock-recruitment relations. In both Tables 2 and 3, a reference number links the identified data and studies with their sources in Table 4, where the full reference to journals, reports etc. or for unpublished data, the name and address of the contact persons and laboratories is given. An additional table, Table 5, identifies the persons, who have contributed the table and the date of their submission of the tables. An example of a completed table is provided, i.e. North Sea Herring – autumn spawners.
The listed variables are intended to primarily cover aspects related to parental, environmental and anthropogenic influences on the stock reproductive potential, i.e. at the basic level estimating the total egg production, to the ultimate level of estimating the viable larvae production. The influences of e.g. the ambient environment on egg and larval survival during the recruitment process have had a lower priority but may be very important to stock-recruitment relations; options to record information of this type exist in both Table 2 and 3.

2. FILLING IN TABLES

The template file (SRP Table Templates revised 200300917.dot) is protected, and should be opened as “read only”. The file includes the tables 1-5, which consist of text and form fields indicated by shading. Only the form fields can be filled in. The tabulator function allows subsequent movement from one form field to next. The mouse allows free movement to previous fields, preceding fields and to other pages. Two types of form fields are applied, i.e. text and drop-down form fields. Numbers or text of variable length can be filled in the text fields with standard formats. The drop-down fields offer different choices, but no text can be added. A help function providing an explanatory text is available for each form field and appears when positioning the cursor on the form field and pressing F1. To obtain help for drop-down form fields, click first on the field (the form field occurs) and then on the arrow to the right before pressing F1. The help function includes generally both an explanation and an example. The example of a completed table, i.e. Herring - North Sea autumn spawners - ICES IV, IIIA and VIID, may also serve as a guide to fill in the tables. Filled-in files should be saved as a word document (default) under a name identifying the stock i.e. "Common name of species - stock - management code.doc" (as in the example: "Herring - North Sea autumn spawners - ICES IV, IIIA and VIID").

Table 1

The form fields in the header of Table 1 specify the fish species, area and stock. The latter two are applied as headers in subsequent tables, but the records should only be filled in once, i.e. in Table 1. The corresponding text boxes in Tables 2-5 will be updated automatically when using print preview, printing or closing the file. The person(s) initially reviewing the literature and creating the table should be referenced in the lower header of Table 1, and the date of finalising the tables should be included. If the tables are updated later, the name of the person(s) providing new data or reviewing the tables as well as the date should be recorded in addition.

The review of a specific stock should aim at covering all data and information that can be used to quantify the total or realised egg production inclusive ichthyoplankton data. This implies that highest priority should be given to identification of quantitative measures that can be used as parameter estimates. The review should preferably extend as far back in time as possible. In this overview table, three different options exist in the drop-down form fields. Option 1: "blank" which is default indicates that no information is available. Option 2: v is selected in the form field if proper information about a given variable is available. Option 3: (v) is chosen from the form field if e.g. no applicable estimates are available, but basic data or information exist although not analysed or published. The reason for choosing Option 3 should be specified under comments in Table 2. Correction of v or (v) entered in a form field that should be blank is made by choosing the first field in the drop down list, which is "blank". The availability of data or information about the specific variables should be recorded on a yearly basis back to 1960. If information before 1960 exists, particular years can be included or data availability can be registered on decadal basis, e.g. 1950s to record specific information about the variables.

Table 2

The form fields specifying the fish species, area and stock will be filled in automatically when the file is updated. The text fields in the header to be filled in include information about "Reproductive Strategy", "Timing of Spawning" and "Optimal Time for Maturity Sampling" as well as their references. This information is intended to provide the reader with some criteria to evaluate the data quality. The data types and analytical methods needed to estimate the total egg production and other SRP indices depend on the type of reproductive strategy. The timing of spawning is important in relation to the timing of fecundity sampling for the given species and stock. The optimal time for maturity sampling is normally during the pre-spawning period when fish that will participate in spawning will have initiated the gonadal maturation process, but before e.g. spawning migration has started.

The table: "Data Basis, Format and Quality" provides the opportunity to enter detailed information about data or studies for specific variables. The variable column lists different categories and sub-categories, which may be utilised in the estimation of the reproductive potential of a stock. The list categories, which may be utilised in the estimation of the reproductive potential of a stock. The list is not meant to be all encompassing, but to specify the data basis, format and quality of important variables making an evaluation of the compatibility and applicability of data possible as well as identifying data sets potentially complementing each other. In the event that the listed categories do not suffice, information can be added under "Other parameters" at the end of the table – specifying under "Notes on method, sampling coverage, etc." the kind of information; if sub-categories are incomprehensive, the information can similarly be entered under the sub-category "Other". For each data source, the following information should be entered: the year range, the data basis, data origin, sampling frequency and the reference number referring to the source of the study (should be given in full in Table 4). Under "Notes on methods, sampling coverage, etc.", additional information about the particular data source can be added. The help function (F1) provides information about the data to be entered in the specific columns and form fields.

Table 3
In some cases, studies of the reproductive potential of the stock may have been performed and estimates of egg or larvae production may be available. This information should be included in Table 3. The headers will be updated automatically. The table lists different subject-related categories to include information about the reproductive potential and stock-recruitment relationships as well as about processes affecting stock reproduction and critical life stages. For each study, a brief description of its focus should be filled in as well as the year range covered and the reference number referring to its source (and provided in full in Table 4).

Table 4
This table references the sources of data or other information referenced in Tables 2 and 3. The headers will be filled in automatically as in previous tables. For each reference number applying to the studies listed in the proceeding tables, the data source should be filled in. The following system should be used (the North Sea Herring tables provide examples):
Journal papers: Names and initials of all authors, year. Title of paper. Journal name (abbreviated), volume number (issue number): first and last page numbers of the paper.
Monographs: Names and initials of all authors, year. Title of the monograph. Publisher, location of publisher.
Edited volume papers: Names and initials of all authors, year. Title of paper. In: Names and initials of the volume editors (eds.), title of the edited volume. Publisher, location of publisher, first and last page numbers of the paper.
Conference proceedings papers: Names and initials of all authors, year. Title of paper. Name of the conference. Publisher, location of publisher, first and last page numbers of the paper.
Unpublished theses, reports, etc.: Names and initials of all authors, year. Title of item. All other relevant information needed to identify the item (e.g., technical report, Ph.D. thesis, institute).
Unpublished data: Name and initials of contact person, affiliation, and postal address.
If the number of references exceeds 50, additional rows are available to fill in reference numbers and references. It is possible to fill in more than 1 reference per row.

Table 5
This table identifies the persons, who have contributed with information referenced in Tables 1-4. The headers will be updated automatically. For each contributor the full name and affiliation including postal address should be filled in as well as the date of submission of the tables. If more

contributors created the first version or updated tables in collaboration, their names can be listed below each other under the same date.

Filled in tables
Please forward filled-in files to either:

Fran Saborido-Rey - fran@iim.csic.es
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We thank you for your contribution.

Appendix B. Example of filled in tables on stock reproductive potential

NAFO Working Group on Reproductive Potential &
ICES Study Group on Growth, Maturity and Condition in Stock Projections

INFORMATION ON STOCK REPRODUCTIVE POTENTIAL

TABLE 1: DATA AVAILABILITY *(press **F1** on form fields for help)*

COMMON NAME:	HERRING	**SPECIES:**	*Clupea harengus*
AREA:	NORTH SEA (ICES IV, IIIA AND VIID)	**STOCK:**	NORTH SEA AUTUMN SPAWNERS
ENTERED BY:	MARK DICKEY-COLLAS 2003-07-10	**LAST UPDATE:**	PETER MUNK 2003-05-09

Data availability

Year	Stock size	Stock composition	Age	Weight	Condition	Sex ratio	Maturity	Fecundity	Egg/larval abundance
2005									
2004									
2003	√	√	√	√	√	√	√		√
2002	√	√	√	√	√	√	√		√
2001	√	√	√	√	√	√	√		√
2000	√	√	√	√	√	√	√		√
1999	√	√	√	√	√	√	√		√
1998	√	√	√	√	√	√	√		√
1997	√	√	√	√	√	√	√		√
1996	√	√	√	√	√	√	√		√
1995	√	√	√	√	√	√	√		√
1994	√	√	√	√	√	√	√		√
1993	√	√	√	√	√	√	√		√
1992	√	√	√	√	√	√	√		√
1991	√	√	√	√	√	√	√		√
1990	√	√	√	√	√	√	√		√
1989	√	√	√	√	√	√	√		√
1988	√	√	√	√	√	√	√		√
1987	√	√	√	√	√	√	√		√
1986	√	√	√	√	√	√	√		√
1985	√	√	√	√	√	√	√	√	√
1984	√	√	√	√	√	√	√	√	√
1983	√	√	√	√	√	√	√		√
1982	√	√	√	√	√	√	√	√	√
1981	√	√	√	√	√	√	√		√

1980	v	v	v	v	v	v	v		v
1979	v	v	v	v	v	v	v		v
1978	v	v	v	v	v	v	v		v
1977	v	v	v	v	v	v	v		v
1976	v	v	v	v	v	v	v		v
1975	v	v	v	v	v	v	v		v
1974	v	v	v	v	v	v	v		v
1973	v	v	v	v	v	v	v		v
1972	v	v	v	v	v	v	v		v
1971	v	v	v	v	v	v	v		v
1970	v	v	v	v	v	v	v		v
1969	v	v	v	v	v	v	v		v
1968	v	v	v	v	v	v	v		v
1967	v	v	v	v	v	v	v		v
1966	v	v	v	v	v	v	v	v	v
1965	v	v	v	v	v	v	v	v	v
1964	v	v	v	v	v	v	v	v	v
1963	v	v	v	v	v	v	v		v
1962	v	v	v	v	v	v	v	v	v
1961	v	v	v	v	v	v	v	v	v
1960	v	v	v	v	v	v	v		v
1959	v	v	v	v	v	v	v		v
1950s	v	v	v	v	v	v	v	v	v
1940s	v	v	v	v	v	v	v		v
1930s	v	v	v			v	v	v	
1920s	v	v	v						
1910s	v	v							v
1900s	v	v							
1887								v	

TABLE 2: DATA BASIS, FORMAT AND QUALITY

COMMON NAME:	HERRING		
AREA:	NORTH SEA (ICES IV, IIIA AND VIID)		
STOCK:	NORTH SEA AUTUMN SPAWNERS		
REPRODUCTIVE STRATEGY:	SYNCHRONOUS DETERMINATE TOTAL SPAWNER	**REF. NO.:**	20, 33, 22
TIMING OF SPAWNING:	AUTUMN/WINTER	**REF. NO.:**	24
OPTIMAL TIME FOR MATURITY SAMPLING:	AUG/SEP	**REF. NO.:**	5

Data basis, format and quality

Variables	Year range	Data basis	Data origin	Sampling frequency	Notes on method, sampling, coverage, etc.	Ref. No.
Stock size:	1903-1972 1961-2002 1989-2003	AL LWA LWA	CL CL, S S	M M SUMMER	VPA - annual estimates ICA - annual estimates Acoustic - calibrated	2,26 1 1
Stock composition:	1903-1972 1961-2002 other issues	LA LWA	CL CL, S	M M	Cohort analysis - annual ICA - annual estimates	2 1 4,21, 22,6,31
Age determination:	1930-1972 1960-2002	LA LWS	CL CL, S	M JUN-DEC	Otoliths Otoliths with regular exchanges	2, 28 1
Weight:						
A. Round weight	1920-2003 1950-2003 1980-2003	SAL SAL SAL	CL CL S	M M Q3	Individual weights Individual weights Acoustic, individual	28 30 1,29
B. Gutted weight						
C. Estimated weight	1960-2003	AL	CL	Q	Annual L/W relationships by area	29
D. Other						
Condition and energy indices:						
A. Morphometric (K, Kn, etc.)	1920-2003 1950-2003 1980-2003	SLWA SLWA SLWA	CL CL S	M M Q3	Individual sampling, K Individual sampling, K Acoustic survey, individual sampling, K	28 30 1,29
B.Physiological (HSI, GSI etc.)						
C. Biochemical (lipids, proteins, etc.)	1956-1957	SWLA	CL	M	Study of protein and fat metabolism and allocation	36
D. Other (parasitism, etc.)						

Sex ratio:	1940-2002 1980-2002	LWA LWA	CL S	M SUMMER	Landings Acoustic surveys	28, 30 29
Maturity:						
A. Ogives or spawning prob.	1935-1971 1955-1961 1955-1973 1960-2002 1980-2003	LA LWAS LA LWA LWA	CL CL CL CL S	Q3 Q3 Q3 Q3 SEP	AL Macrosc., AL-mat key Macrosc., AL-mat key Macrosc., AL-mat key Macrosc., AL-mat key	19,13 35 5 1,28,30 1,29
B. First time spawners	1903-1972 1960-2002	LA LWA	CL CL	A A	Macrosc. AL-mat key Macrosc. AL-mat key	2 1
C. Skip of spawning						
D. Other						
Fecundity:						
A. Potential total fecundity	1887 1933 1950-1953 1954-1957 1954-57, 1964-66, 1957-1958 1961 1962, 1965-1966 1982 1984-1985	L L AL ALW ALW ALW AL ALW L AL	L CL CL CL CL CL CL CL S CL	(Late summer all)	Mostly length-based with some weight, coverage good in most cases. No year effects detected, age effect found by some (older fish less fecund relative to length)	14 16 27 15 19 17,18 13 12 11 32
B. Batch fecundity						
C. Atresia						
D. Other						
Egg/larval abundance:	1903-1905 1964-1975 1953-1971 1958-1973 1960s 1972-2003 1976-2003	Early larval stages larvae ½Y	S S S S S S S	A A A A A A A	National ichthyoplankton surveys of various areas of the North Sea at hatching time Int. co-ord. since 1972 Int. co-ord. survey - directed to larvae ½ year	25,34 7 8 3 39 1 23
Spawning:						
A. Population spawning period	1910, 1970-2003 1950s- 1990s	Egg/larvae? gonadal maturity	S CL	A M	Ichthyoplankton surveys, good coverage Based on targeted fisheries	25,7,8, 3,1 24,31,3 7
B. Individual spawning period	1960s	SL	CL	A	Many fisheries target spawning events so coverage is good	20,33
C. Spawning frequency						
D. Other						

Egg viability:						
A. Egg quality	1964-1966 1984-1985	ALW AL	CL CL	Q3-4 Q3-4	Egg size and weight Egg size and weight	19 32
B. Fertilisation success						
C. Egg mortality	1955-1956	Density	EW	Wild obs	Mortality of eggs in mats	40
D. Other						
Larval viability:						
A. Hatching success						
B. Larvae quality	1987-88 1995 1993-1994	Env. parents & env. parents & env.	S EC EC	4 single occassions 512 larv. 1 single exp. 398 larv. captive, single occassion	Sample size: 100s, Spatial growth diff. Sample size: 100s, effects on otoliths Samples size 100s, hieracy of larvae and effect on population	42 44 41
C. Mortality						
D. Other						
Other parameters:						

TABLE 3: STUDIES OF STOCK REPRODUCTIVE POTENTIAL

COMMON NAME: HERRING

AREA: NORTH SEA (ICES IV, IIIA AND VIID)

STOCK: NORTH SEA AUTUMN SPAWNERS

Studies of stock reproductive potential (SRP)			
Subject	**Brief description**	**Year range**	**Ref. No.**
Estimated potential egg production:	Egg production estimates with worries about first time spawners.	1950-1964	31
Estimated realised egg production:	Larval survey of Downs herring.	1951-1972	8
Estimated viable egg or larvae production:	Larval production in relation to temperature.	1951-1972	8
Existing SRP indices:	From larval abundance to spawning potential using fixed fecundity.	1951-1972	8
Parental influences on SRP:	Differences in survival and growth of offspring originating from different spawning areas utilised by different stock components.		46

Environmental influences on SRP:	Larval production in relation to temperature Larval growth to juvenile based on temp, food and density dependent effects	1951-1972 1960-1980	8 24
Anthropogenic effects on SRP:			
Stock-recruitment relationships:	Linear SSB to recruit relationship in some components Different recruitment patterns in components of stock Recruitment strengths Paulik diagrams	1940-1985 1950-1970 1967-1981 1977-2002	6 38, 43 10 9
Critical life stages:	Larvae to metamorphosis	1950-2002	9, 31
Other studies:	Studies of reproductive strategies of herring Conservatism in herring	1960-1990 1960-1990	22 45

TABLE 4: DATA SOURCES

COMMON NAME: HERRING

AREA: NORTH SEA (ICES IV, IIIA AND VIID)

STOCK: NORTH SEA AUTUMN SPAWNERS

Data sources
Reference number and literature citation or for unpublished data the contact person
1. ICES, 2003. Report of the Herring Assessment Working Group. ICES C.M. 2003/ACFM:12.
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19.	Zijlstra, J.J.,1973. Egg weight and fecundity in the North Sea herring (Clupea harengus). Neth. Jour. Sea Res., 6 (1-2): 173-204.
20.	Blaxter, J.H.S. and Hunter, J.R., 1982. The biology of clupeoid fishes. Adv. Mar. Biol., 20: 1-223.
21.	ICES, 1965. The North Sea Herring. ICES Cooperative Report 4, 57 pp.
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28.	Unpublished data: Dr. Beatriz Roel, CEFAS Lowestoft Laboratory, Pakefield Road, Lowestoft Suffolk NR33 0HT, UK.
29.	Unpublished data: Dr John Simmonds, FRS Marine Laboratory, PO Box 101, 375 Victoria Road, Aberdeen, AB11 9DB, UK.
30.	Unpublished data: Dr. M. Dickey-Collas, RIVO, P.O. BOX 68, 1970 AB IJmuiden, The Netherlands.
31.	Cushing, D.H. and Bridger, J.P., 1966. The stock of herring in the North Sea, and changes due to fishing. Fishery Investigations, London, Ser. II, 25 (1): 1-123.
32.	Almatar, S.M. and Bailey, R.S., 1989. Variation in the fecundity and egg weight of herring (Clupea harengus L.). Part I. Studies in the firth of Clyde and northern North Sea. Cons. int. Explor. Mer, 45:113-124.
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TABLE 5: CONTRIBUTORS

COMMON NAME:	HERRING
AREA:	NORTH SEA (ICES IV, IIIA AND VIID)
STOCK:	NORTH SEA AUTUMN SPAWNERS

List of contributors	
Date:	**Name and affiliation of contributor:**
2003-07-10	Mark Dickey-Collas, Netherlands Institute for Fisheries Research, P.O. Box 68, 1970 AB IJmuiden, The Netherlands
2003-09-05	Peter Munk, Danish Institute for Fisheries Research, Kavalergården 6, DK-2920 Charlottenlund, Denmark

ToR 2: Co-Leaders: Yvan Lambert (Canada) and Gerd Kraus (Germany)

Explore the use of correlation analysis to estimate the reproductive potential of fish stocks having limited data availability.

Members: Hilario. Murua (Spain), Nathalia Yaragina (Russia), Gudrun Marteinsdottir (Iceland), Peter Wright (UK), Peter Witthames (UK)

Rationale: In data moderate or poor stocks, alternative means need to be investigated that can generate reliable estimates of reproductive potential (e.g., use of condition factor, age diversity, etc.). These alternative indices can be evaluated by determining whether they give improved recruitment predictions compared to spawning stock biomass. Recommendations will be given describing the data that are required to improve annual estimates of reproductive potential in the future.

It is suggested in light of results obtained from the review performed within the last set of ToRs that the effort for this ToR should focus on the estimation of fecundity. It was established by Tomkiewicz et al. (ToR1, J. Northw. Atl. Fish. Sci. 33: 1-21) that data on fish age, weight, maturity and sex ratios had been extensively collected but that possibilities for estimating potential egg production/ reproductive potential were constrained by scarcity of fecundity data. However, it was determined that predictive models to estimate potential fecundity could be developed as potential fecundity was strongly related to different biological/environmental variables (Lambert et al., TOR3, J. Northw. Atl. Fish. Sci. 33: 115-159). As determination and verification of correlations with potential fecundity for data poor stocks would not directly be possible, a comparative study on different stocks of a species covering a large range of environmental conditions was suggested. It is proposed to apply multivariate methods to detect common or stock / habitat specific variables related to fecundity / reproductive potential. The results may then apply to data poor stocks living in similar environmental conditions.

The following workplan is used to address this ToR:

1- Identify promising proxies of fecundity/ reproductive potential from TOR3 (1st mandate of the working group) to be used in correlation analysis
2- Define potential explanatory variables
   - Stock level
     -Stock identity (as a genetic variable)
     -Water temperature (different time windows)
     -Prey abundance/availability
     -Growth and surplus production per capita (indicators of the productivity of the ecosystem)
     -Spawning stock biomass anomaly (indicator of historic abundance of stocks)
     -Feeding patterns (time periods, duration)
     -Seasonal energy cycle (amplitude, indicator of the importance of accumulating energy reserves for maturation)
     -Average condition and HIS (different time windows)
   - Individual level
     -Length, weight, condition (K), liver index, egg size etc…
3- Define how each variable is best expressed or could be standardized
4- Select multivariate statistical methods (i.e. Cluster analysis, Principal component analysis, or discriminant function analysis) to group similar fecundity data and identify most important explanatory variables of fecundity
5- Identify candidate stock and species
6- Create databases including all standardized data
7- Built one or more fecundity models based on selected multivariate methods
8- Validate the use of selected models

ToR 3: Co-Leaders: Hilario Murua (Spain) and Gerd Kraus (Germany)

Model the inter-annual and inter-stock variability in size-dependent fecundity for stocks having multi-year estimates.

Rationale: Over the past decade, fecundity data have been collected intermittently for several gadoid stocks. For two cod stocks (Baltic and Northeast Arctic cod) inter-annual variability in size-specific fecundity is significantly correlated with prey availability. Such relationships are useful for hindcasting fecundity for these stocks. Stocks lacking fecundity data have on occasion extrapolated fecundity models from data-rich stocks, a practice that is unverified and potentially misleading. Consequently, fecundity data for cod stocks should be compiled and the degree of inter-annual and inter-stock variation in size-specific fecundity assessed.

ToR3 may not be best suited for peer reviewed publications. For the majority of stocks having multi-year estimates of fecundity, fecundity models which are applicable to predict spatio-temporal variations in fecundity are established. Most of these are already published in primary literature. Interannual and inter-stock variability will likely be addressed in ToR2. Therefore, it is suggested to address ToR3 only with a summary report on existing fecundity models not to be published in the primary literature.

ToR 4: Co-Leaders: Tara Marshall (UK) and Joanne Morgan (Canada)

Explore how the current use of biological reference points and medium-term projections can be adapted to include new information on reproductive potential.

Introduction

Given the intrinsic importance of reproductive potential to stock/recruit (S/R) relationships, and by extension the setting of biological reference points (BRPs) and stock projections, the alternative measures of reproductive potential that are currently being developed for some stocks merit serious consideration by assessment working groups and fisheries managers. The use of these alternative measures in the assessment process should not depend on the alternatives explaining a higher proportion of the variability in the S/R relationship. Assuming they do not result in increased uncertainty in the S/R relationship, the alternative measures should be judged according to whether they are more precise by definition and whether they deviate substantially from SSB.

Resistance to using these alternative measures directly in stock assessment often focuses on several perceived impediments. Data availability is considered to be a limiting factor for many stocks. However, the work already completed by the WG has indicated that there are substantial amounts of relevant data that are available (e.g., length structure, sex ratios, Tomkiewicz et al 2003, J. Northw. Atl. Fish. Sci. 33:1-21). It is commonly felt that the alternative measures cannot be integrated with the BRP framework that is currently used to formulate management advice. However, several of the case studies included here illustrate there are no technical obstacles to determining analogous reference points for the alternative measures of spawning stock size. Furthermore, software tools have been or are being developed to facilitate both the estimation of these alternative measures and their application in standard techniques.

More fundamentally, it is apparent that there are large differences between regional fisheries bodies in their capacity to adopt new approaches. Many NAFO stocks already use highly customized approaches for assessing stocks. This makes it easier to incorporate new approaches. For ICES stocks the prevailing ethic is to apply a standardized set of methods to all stocks. Consequently, data-rich stocks are limited to using approaches that can be applied in data-poor situations. In such cases, the integration of new knowledge into stock management will require greater flexibility than typically exists.

Several presentations were made at the meeting on the topic of how current management can be adapted to use information on reproductive potential. These presentations are summarized here as case studies for Icelandic cod, Northeast Arctic cod, cod in NAFO Div. 3NO and spiny dogfish. Progress in the development and implementation of supporting software is briefly summarized. Lastly, several recommendations for future work are given.

Case studies

Icelandic cod

The Icelandic cod stock has gone through great changes during the last century. Since 1955, the fishable stock has declined from more than 2.3 million tonnes to less than 600 thousand tonnes in 2000 and the SSB has gradually declined from 1.3 million tonnes towards historical low levels at approximately 200 thousand tonnes in 1993 and 2000 (Fig. 1). Along with decreasing stock size the recruitment has also declined significantly (Fig. 1). Recruitment has been low or exceptionally low since 1985, compared to the 1955-1990 average of 207 million 3-yr-old cod. Furthermore, since the middle of this century, the time interval between strong year classes has increased and below average recruitment has been observed more and more frequently (Marteinsdóttir and Thorarinsson, 1998).

Today the Icelandic cod stock is near a historic low. The poor state of the stock today is both caused by overestimation in the stock size leading to too high TAC as well as low recruitment from 1985 to 1996, especially in 1991, 1994 and 1996. Declining stock size has also resulted in impaired size and age distributions. In recent years much fishing effort has been directed towards large cod, caused by a combination of high price for the cod and high price of rental quota in the Icelandic quota system. This effort has led to severe reduction in the number of old and especially large cod.

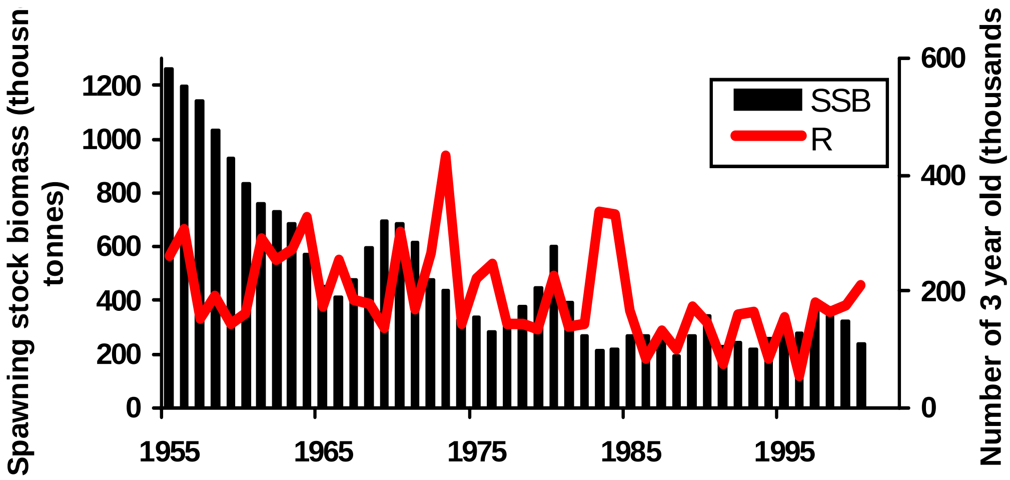


Fig. 1. Spawning stock biomass and recruitment of cod in Icelandic waters during 1955-2000

For stock management purposes, cod in Icelandic waters are assumed to belong to a single stock. One of the central problems for stock management is the apparent lack of a S/R relationship. Although the declines in stock size and recruitment coincide, the relationship between recruitment and SSB is weak and uncertain (Baldursson et. al. 1996). Strong year classes have been generated during periods of exceptionally low stock sizes, as in 1973 and 1983/1984 when some of the largest cohorts on record were produced (Fig. 1). However, the accumulation of low year classes during the period from 1985-1998 has improved this relationship by demonstrating that a higher number of below average year classes are produced when the SSB is below the average of 490 thousand tonnes compared to when it is above the average (Fig. 2; χ^2=119.1).

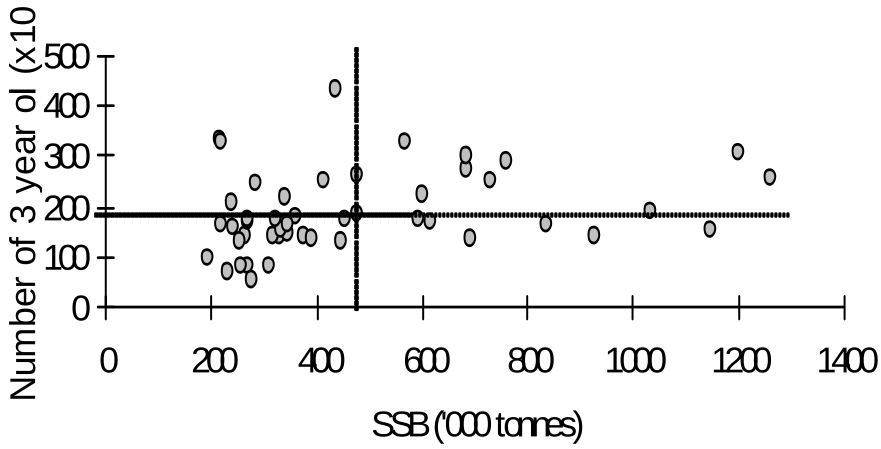


Fig. 2. Recruitment and SSB of the Icelandic cod stock during 1955-2000.

Other modelling attempts have shown that a greater proportion of the variation in recruitment can be explained by including information on biomass and age diversity (Eq. 1; Marteinsdóttir and Thorarinsson 1998). The age diversity of the mature fish (H) is estimated as:

$$\mathrm{H} = (n\log_{10}(n) - \sum_{i=1}^{k} \mathrm{f_i}\log_{10}(\mathrm{f_i}))/n \qquad \text{Eq. 1}$$

where k is the number of age groups, n is the total number of mature fish in all age groups, and f_i is the number of mature fish in each age group (Marteinsdóttir and Thorarinsson, 1998). H was significantly related to recruitment ($r^2 = 0.18$ and 0.2 for nonlinear and linear approach, $p < 0.001$; Fig. 3).

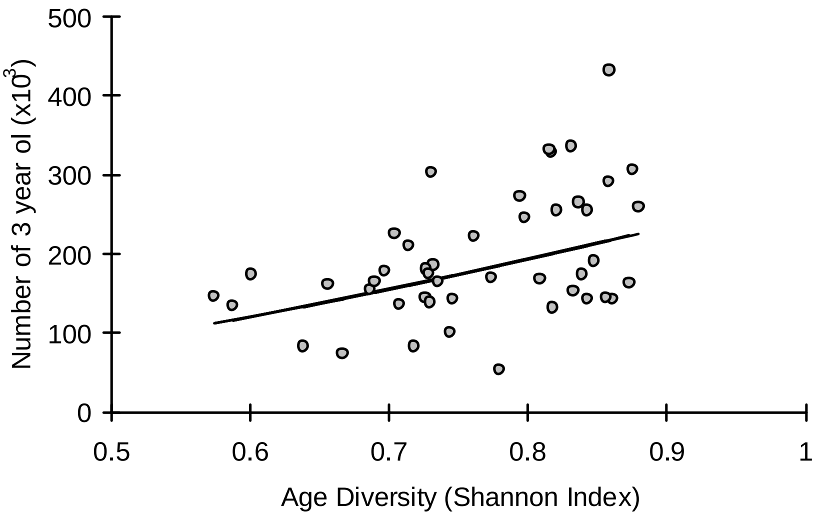


Fig. 3. Relationship between age diversity and recruitment in Icelandic cod.

Contrary to the assumption that cod in Icelandic waters originate mainly from spawning sites located in waters off the south coast, recent evidence indicates that the surviving juvenile population may in fact originate from multiple spawning sites located all around the country (Marteinsdottir et al., 2000; Begg and Marteinsdottir, 2000; Begg and Marteinsdottir 2003). As such, the contribution of the main spawning grounds in the south in relation to the smaller spawning grounds at the west, north and east coasts, appears to be highly variable and to depend on the strength of the northbound current and inflow of Atlantic water into the northern nursery regions.

Presently attempts are being made to identify the different spawning populations in order to estimate the relative contribution of each unit to recruitment and the fishable stock (METACOD, an ongoing EU project to be completed in 2005). In a first attempt to partition the spawning stock into smaller geographical units, the stock around Iceland has been divided into north and south components (Fig. 4).

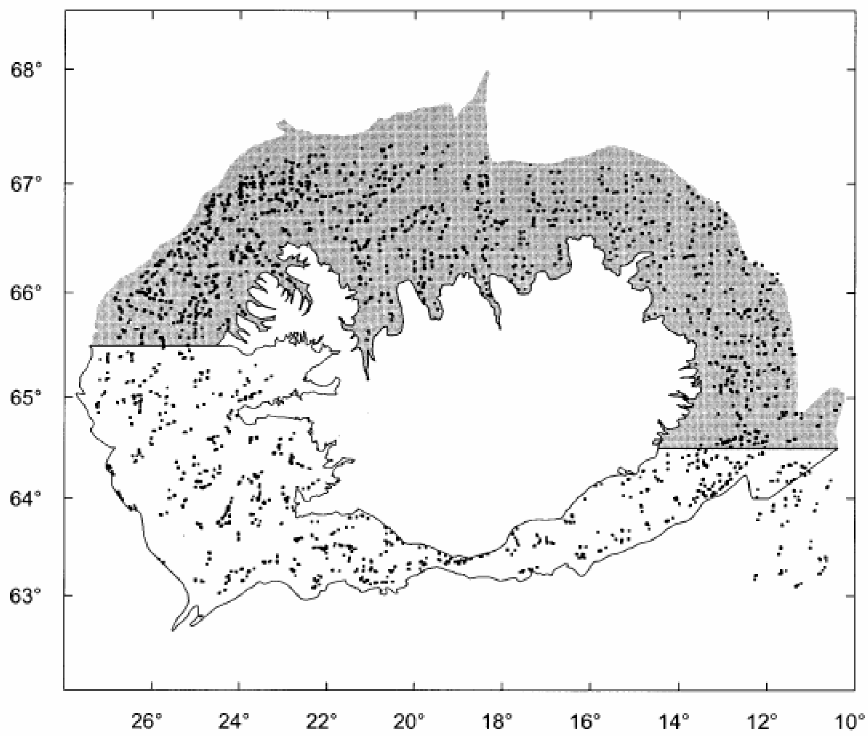


Fig. 4. Location of sampling sites in the spring ground fish survey showing the south/north division used to disaggregate the Icelandic cod stock.

Total egg production (TEP) for each area was estimated for the years 1955 to 2000 according to:

$$TEP = \sum N_{y,l} * W_{y,l} * M_{y,l} * P_{g,y,,l} * X_{y,l} * F \qquad \text{Eq. 2}$$

$N_{y,l}$ = Number of cod in each length class l in each year Y

$W_{y,l}$ = Expected weight based on mean length -weight relationship of cod sampled in the ground fish survey (1993-2003).

For south cod < 91 cm: $W = 0.00715 * L^{3.05632}$

For south cod > 90 cm: $W = 0.00026 * L^{3.81374}$

For north cod < 91 cm: $W = 0.00508 * L^{3.1406}$

For north cod > 90 cm: $W = 0.00112 * L^{3.4797}$

$M_{y,l}$ = proportion mature in length class l and year *y* based on a relationships derived for the survey data (1985-2003):

For south cod: $M\% = 1/(1+e^{-(-6.372246 + 0.1001868*L)})$

For north cod: $M\% = 1/(1+e^{-(-7.47252 + 0.09921118*L)})$

$P_{g,y,l}$ = proportion of cod in area (north or south) at length l and year y based on division of the total spawning stock abundance estimated with a VPA.

$X_{y,l}$ = Proportion females at length l and year *y* (based on survey data estimated for each 20 cm length interval)

F = number of eggs produced per unit weight = $3.3736 * w^{1.56}$; where w = total weight (based on fecundity estimates from 1998)

Number of repeat spawners at each length and year was estimated as 1- $M_{y,l}$.

Length distributions for each area were based on measurements collected from landed catch from line, gill nets, trawls and Danish pouch. The preliminary results reported here are based on reconstructured length distributions for the south component only, as the data for the northern area is still being assmbled. Consequently, these results may change as new data from the earlier part of the period, 1955-1970 are being entered into the data base.

Preliminary results

Length distribution of mature cod decreased significantly during 1955-2000 (Fig. 5). Similarly, mean age of mature cod decreased from 9 to nearly 5 years during the same time period (Fig. 5).

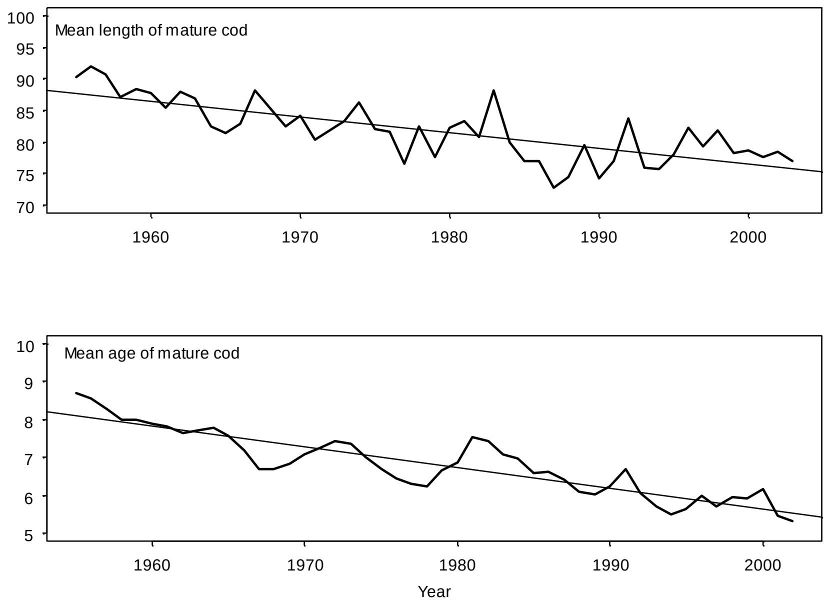


Fig. 5. Mean length of cod in the South region ($r^2 = 0.55$, $p < 0.001$) based on reconstructed length distributions of landed catch (line, trawl, gill nets and danish pouch) and mean age of mature cod ($r^2 = 0.80$, $p < 0.001$) based on numbers at age from the 2003 VPA..

Currently, the proportion of large and old cod being is a small fraction of what it was during the middle of last century (Fig. 6).

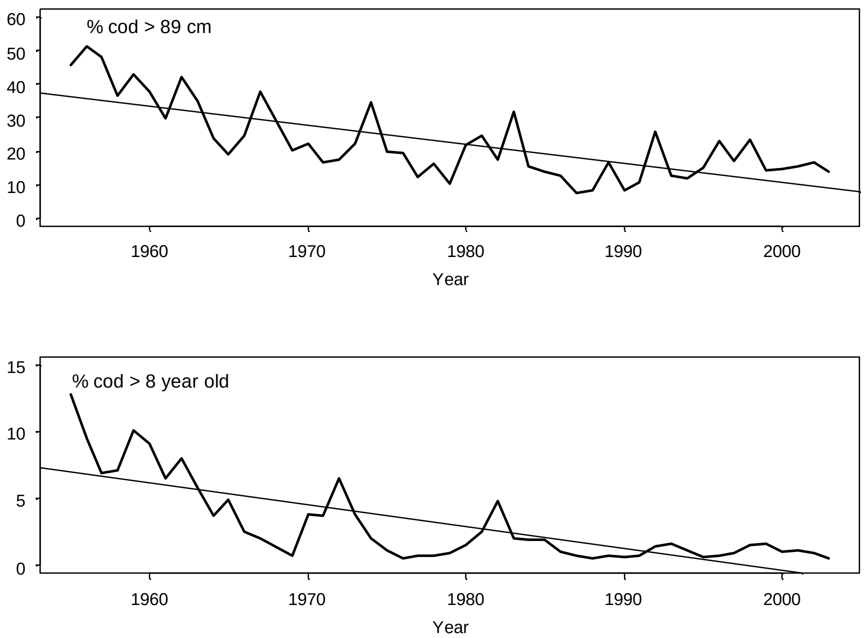


Fig. 6. Proportion of cod > 89 cm (based on reconstructured length distributions; r^2 = 0.53) and proportion of cod > 8 years old (bases on numbers at age from the 2003 VPA; r^2 = 0.81)

The estimated TEP appeared to follow the spawning stock biomass closely (Fig. 7 and 8), displaying a similar oscillation in amplitude with gradually declining peaks during 1955-2000. However, the relative difference between TEP and SSB was considerably less around the middle of last century compared to the more recent time Today, TEP is relatively low in comparison to spawning stock biomass, presumably due to the fact that the eggs are being produced by much younger and smaller fish than in the earlier years. Consequently, the TEP of repeat spawning females is exceptionally low during the recent years or since 1985 (Fig. 8).

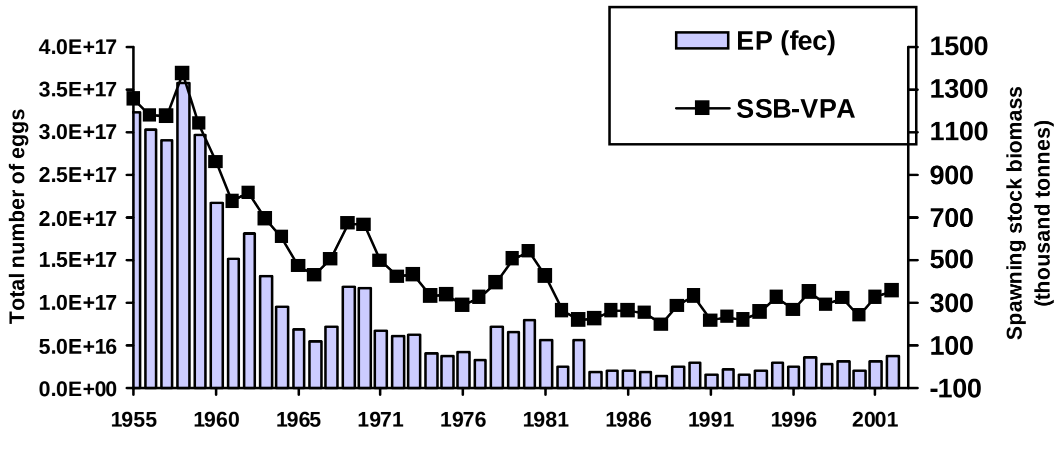


Fig. 7. Number of eggs produced by the southern component in 1955-2002 and the SSB estimated with VPA.

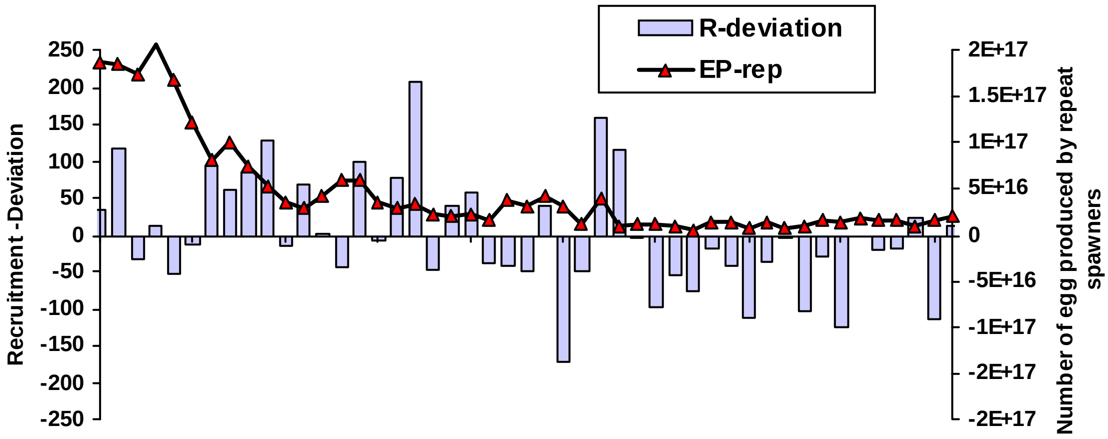


Fig. 8. Recruitment variation (deviation of number of 3 year old estimated with VPA) during 1955-2002 and TEP of repeat spawners

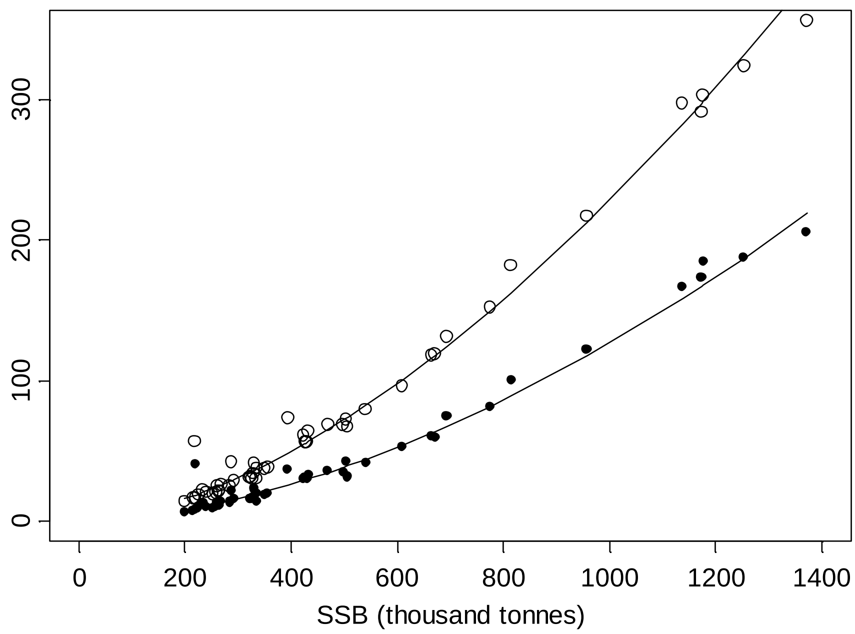


Fig. 9. Relationship between SSB (VPA) and estimated TEP of all spawning females (open circles) and repeat spawning femlaes (closed circles).

As reviewed in Marshall et al (1998) and Marteinsdottir and Begg (2002) on of the main assumptions behind the estimation and use of S/R relationships is the proportionality of the SSB and TEP. However, with respect to the Icelandic cod stock as well as the Northeast Arctic cod stock (Marshall et al., 1998), this assumption does not appear to be valid. As such, the relationship between TEP and SSB is not linear (Fig. 9). Assuming a linear relationship would result in an underestimation of TEP when SSB is large and an overestimation when SSB is small.

Another basic assumption behind the use of the stock-recruitment relationships is that it should pass through the origin (see review in Marshall et al. 1998). For the SSB-recruitment relationship, this assumption is often based on restricted data because SSB has rarely been measured close to zero (see Fig. 10a and also Marshall et al., 1998). As such, the relationship between recruitment and TEP gives a much more satisfactory results as the relationship does clearly approach the origin. These findings further confirm the observations on Northeast Arctic cod by Marshall et al (1998).

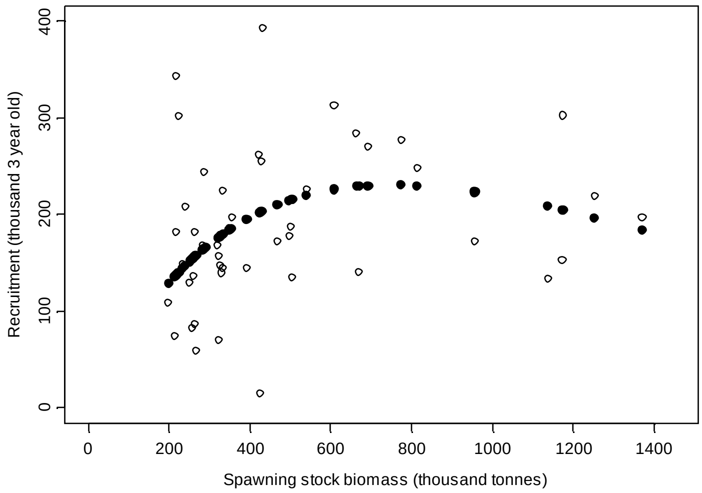


Fig. 10. The relationship between recruitment and spawning stock biomass. Expected recruitment based on a Ricker model is shown with closed circles.

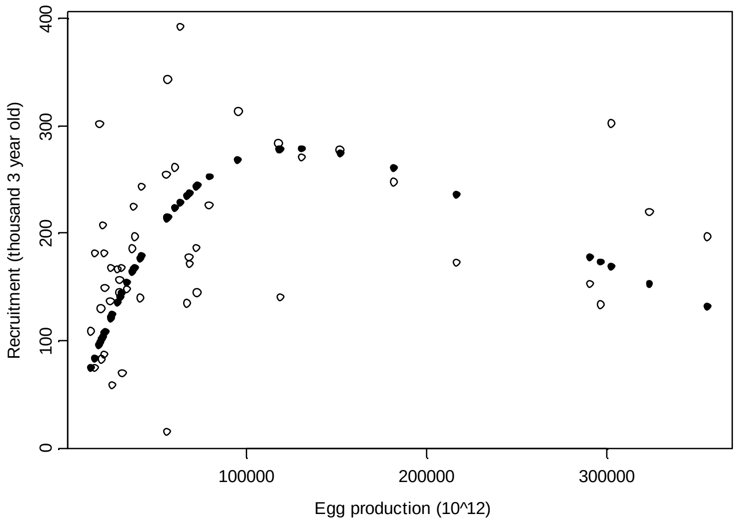


Fig. 10b. The relationship between recruitment and TEP. Expected recruitment based on a Ricker model is shown with closed circles.

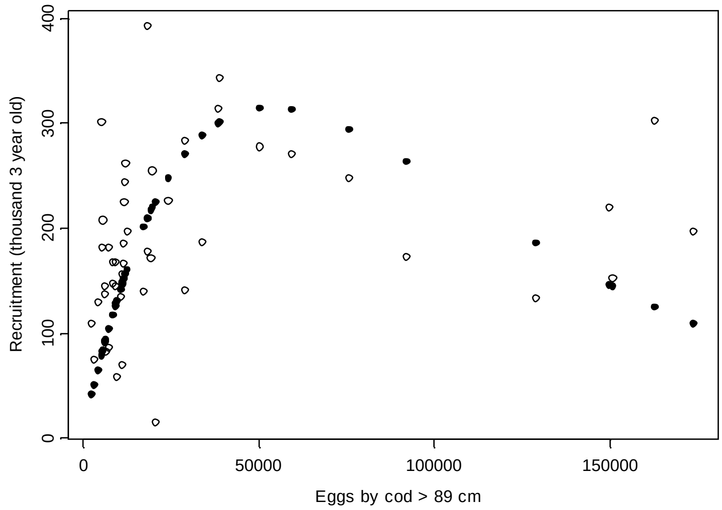


Fig. 10c. The relationship between recruitment and TEP by cod females > 89 cm. Expected recruitment based on a Ricker model is shown with closed circles.

Table 1. Results from the fitting of a Ricker model to the recruitment (R=number of 3 year old) and SSB (VPA based) and estimated TEP.

	Residual SS	β	St. error
R vs SSB	$257 * 10^3$	0.0013	0.00019
R vs EP	$270 * 10^3$	$7.8*10^6$	$7.7*10^7$
R vs EP by cod > 89cm	$315*10^3$	$1.8*10^5$	$1.8*10^6$

Northeast Arctic cod

The assumption implicit in the S/R model is that female-only SSB (FSB) is equal to half of the SSB. For species that exhibit strongly dimorphic growth, maturation and mortality this is a very dubious assumption. Recently, the estimation of length-based sex ratios and female-only maturity ogives have allowed SSB to be partitioned into FSB. Values of FSB/SSB deviate considerably from 0.5, reaching maximum values approaching 0.7 and minimum values approaching 0.2 (Fig. 11). Furthermore, the temporal trends vary systematically with variation in the mean length of the spawning stock (Fig. 11). Stocks having a higher proportion of large cod have higher proportions of females simply because of the earlier maturation and mortality of males.

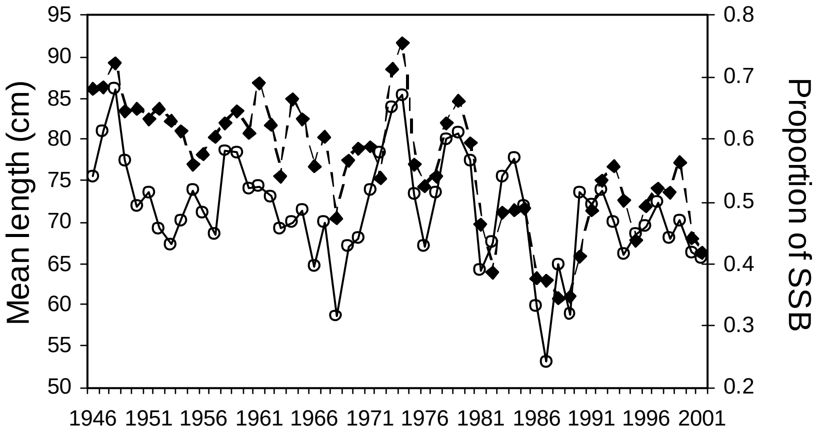


Fig. 11. a) the mean length of the spawning stock (solid diamonds, dashed line) and female-only SSB (open circles, solid line).

A second assumption of the S/R model is that SSB is proportional to TEP by the stock, i.e., TEP/SSB is constant. A recently developed fecundity model for Northeast Arctic cod (Report of the Study Group on Growth, Maturity and Condition in Stock Projections 2003, ICES ACFM C.M. 2003/D:01) was used to develop a time series of TEP for Northeast Arctic cod. Over the assessment time period (1946-2001) TEP/SSB varies by a factor of 3 (Fig. 12). Peak values were observed in the seventies and since the early 1980's values have been near or below the long term mean. This indicates that the reproductive potential of the stock has been relatively low over the past two decades. If TEP is standardized by FSB rather than SSB then the magnitude of the fluctuation is reduced (Fig. 12). This latter standardization is intuitively more sensible because the number of mature females is common to both TEP and FSB, the difference between them resulting from the replacement of a weight term in FSB by the fecundity term in TEP.

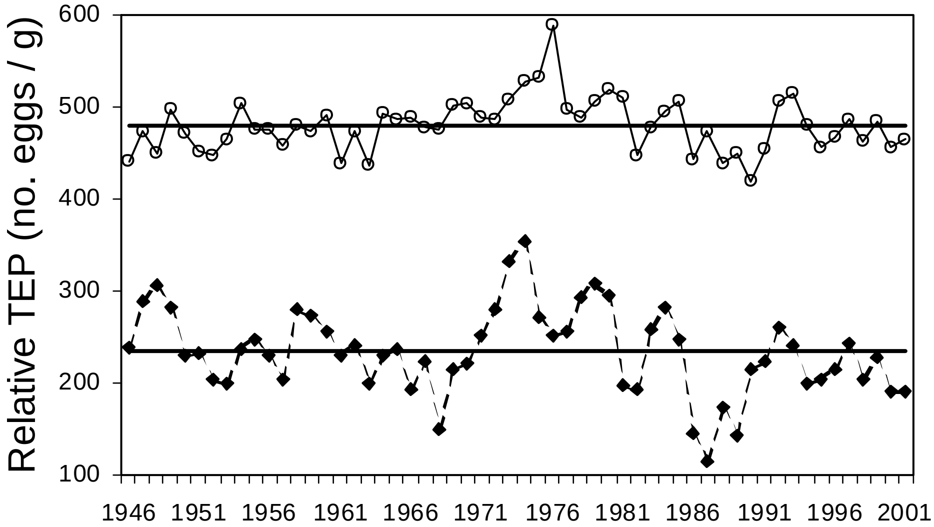


Fig. 12. Time series of relative total egg production standardized by SSB (solid diamonds, dashed line) or by female-only SSB (open circles, solid lines). The arithmetic average of each time series is indicated by the horizontal lines.

The observations that: a) there is considerable deviation from the assumption that FSB is half the SSB (Fig. 10); and b) the proportionality assumption is better satisfied using FSB as an index of reproductive potential (Fig. 12) are both strong arguments for using FSB rather than SSB as the independent variable in the S/R plot for this stock. The S/R relationship for Northeast Arctic cod is highly variable for the full time period (1946-present) but shows a strong signal for the recent time period (since 1980). Accordingly, the S/R relationship that used SSB as an index of spawning stock size was compared to the relationship that used FSB (Fig. 13). To allow a non-zero intercept, a modified Ricker model was fit to the data (Recruitment = α (SSB - γ) e $^{-\beta(SSB-\gamma)}$). This model is a standard Ricker curve shifted along the spawner axis and γ represents the value at which the curve cuts the spawner axis. An estimate of γ that is significantly greater than 0 suggests depensation, whereas, a value of γ that is less than 0 suggests compensation. The most important difference between the two S/R relationships was in the behaviour near the origin. The empirical relationship which used SSB had a positive γ, suggesting depensation, whereas, the empirical relationship which used FSB had a negative value of γ, suggesting compensation. This is a fundamental distinction and establishing which is a more accurate description of cod population dynamics is essential to establishing effective BRPs. Work is continuing on this issue.

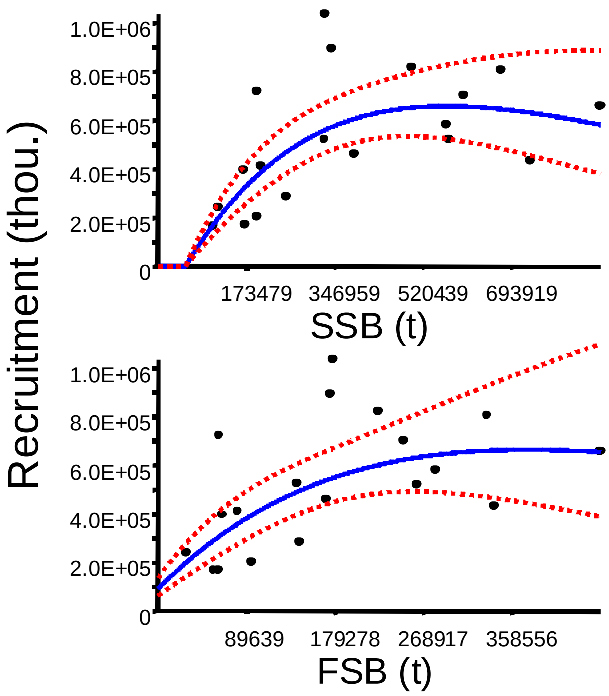
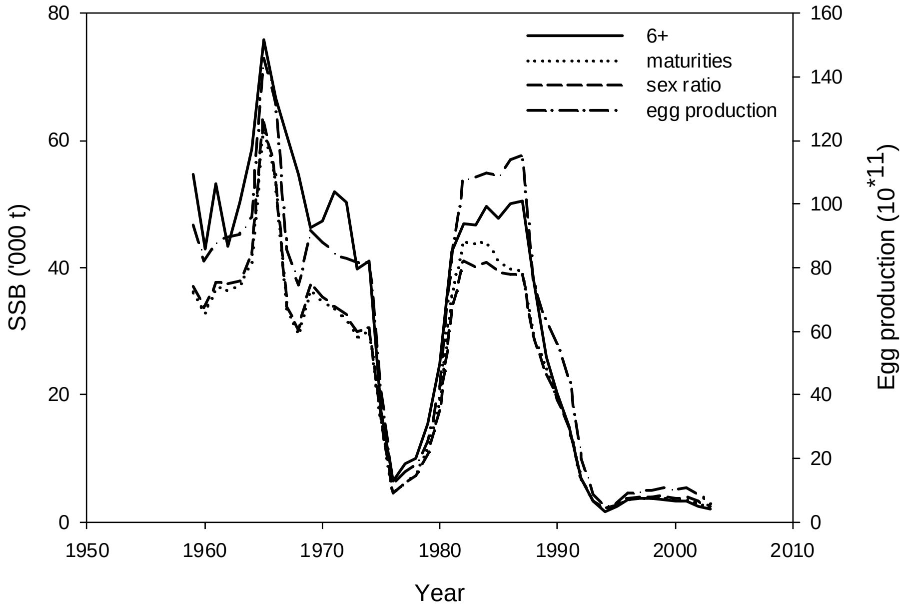


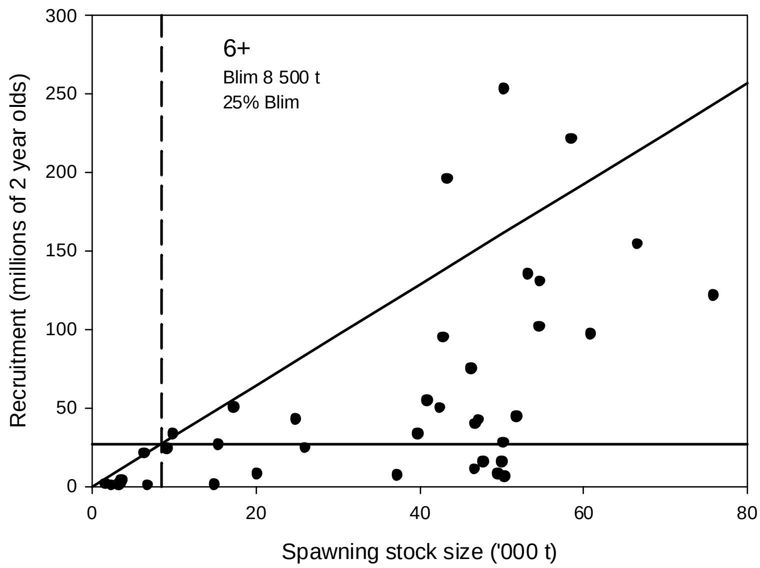
Fig. 13. Stock/recruit relationships for Northeast Arctic cod. Only the 1980 to 1998 year classes are represented. The models shown are the Brickman and Frank model plus confidence intervals estimated as twice the std. errors.

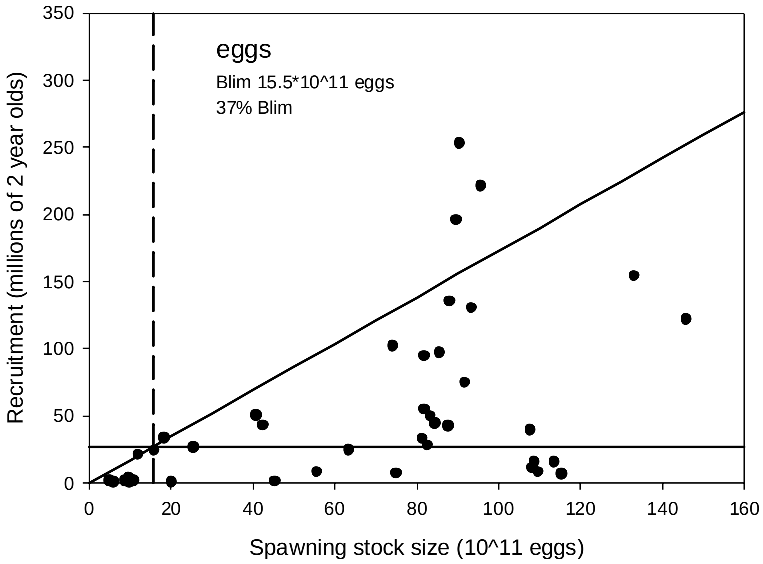
Cod in 3NO

For this population there have been significant changes in maturity at age, sex ratio and mean length at age. Four indices of spawning stock size (SSS) were produced to explore the effect of these changes. The first index was simply one half of the 6+ biomass. A second index applied estimates of female proportion mature at age to one half of the biomass at age. The third index used the female proportion mature at age and the estimated sex ratio at age. The final index of SSS was an estimate of egg production. In this case the female numbers at age was multiplied by the number of eggs produced at age. Total egg production was estimated by applying a constant fecundity/length relationship to the mean length at age. These estimates of SSS showed broadly similar trends over time but there were important differences. For instance the 6+ estimate of SSS was the highest at the beginning of the time series while the egg production estimate of SSS was the highest during the 1980's. Differences in temporal pattern will lead to differences in the stock recruit scatter produced using the different measures of SSS.

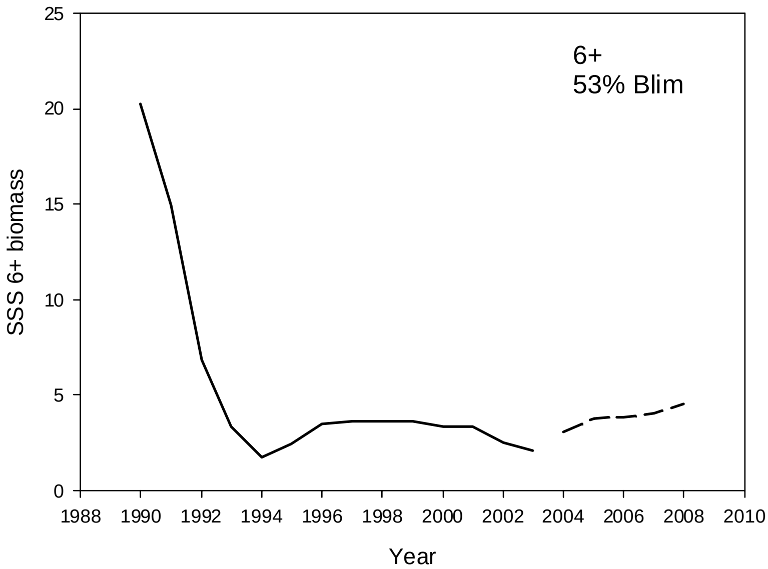


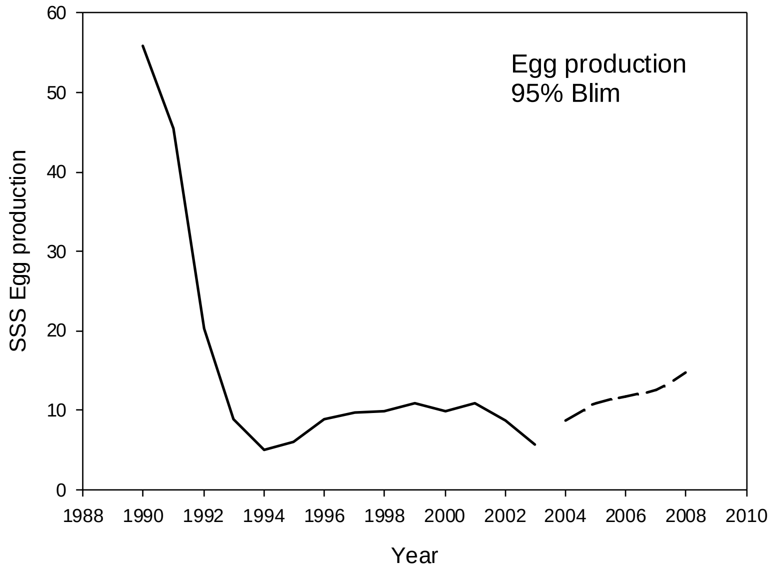
Two of the estimates of SSS (6+ and egg production) were used to estimate B_{lim} reference points using a modified Serebryakov method. B_{lim} can easily be estimated using either index of SSS. However the level of B_{lim} and more importantly the current level of the index relative to B_{lim} is different. It should be noted that neither of these estimates of B_{lim} are being suggested for actual application to the stock. The Serebryakov method is very sensitive to the addition of data close to the origin (NAFO Scientific Council Reports 2003). These have been calculated simply to illustrate that it is possible to estimate B_{lim} with a variety of types of estimates of SSS. The important aspect is to find the best estimate of SSS for a stock.





Population numbers at age were projected at F=0 using the same assumptions as in the June 2003 assessment of this stock. The 6+ and egg production estimates of SSS were then calculated over the 5 year projection period. Both estimates of SSS show an increase over the projection period but the rate of increase in egg production is greater than that for 6+ biomass. This aspect requires further exploration.





Spiny Dogfish

Spiny dogfish (*Squalus acanthias*) in the Northwest Atlantic have been sampled for maturity and fecundity since 1998. Reproductive potential data have been used in the stock assessment in various ways. First, female SSB is used in estimating reference points. Fecundity data, in terms of number of pups per female at length has also been used in population projections. In the last stock assessment, it was noted that small females produce smaller pups than large females. It is thought that these may have a lower survival rate than the larger pups. Therefore, a new set of projections was run with a survival function to take this into account.

Software development

In order to routinely incorporate estimates of reproductive potential into stock assessment new software must be developed. This requirement has stimulated the development of a suite of software having two main aims: a), to improve projections by assessment WG; and b) to provide a framework in which to evaluate biological processes affecting growth and reproductive potential. The code was developed using Northeast Arctic cod as a case study, and within a Fortran-95 programming environment with a Winteracter front-end and NAG statistical and numerical library routines. There are three modules: historical modelling (StockAN), recruitment modelling (RecAN), and projections (MedAN). The models fitted in StockAN were outlined at the recent meeting of the ICES Study Group on Growth, Maturation and Condition in Stock Projections (Report of the Study Group on Growth, Maturity and Condition in Stock Projections 2003, ICES ACFM C.M. 2003/D:01), while a wide variety of recruitment model-fitting options are provided in RecAN. Development of MedAN has not yet begun. An egg production model that has been produced by the STEREO project will be integrated as a separate module and a growth model is also in development. The software will be modularised as far as possible, in order to simplify expansion and modification.

Implementation

The incorporation of data on reproductive potential in NAFO stock assessments will likely be a gradual process consisting of several steps including introducing scientists to the benefits of incorporating such information, providing them with supporting software and assistance in the interpretation of the results. Case studies that are specific to NAFO stocks, e.g., 3NO cod, would be most pertinent but applications to other stocks with longer time series of data that measure reproductive potential would also be helpful in illustrating the benefits of incorporating such data in stock assessments (see Icelandic and Northeast Arctic cod examples given above).

Recommendations

Temporal changes in total egg production appear to be more dynamic than temporal changes in spawning stock biomass. This feature of the population dynamics should be investigated further along with the implications for estimation of biological reference points and stock projections.

The impact of different indices of spawning stock size on the behaviour of stock/recruit relationships near the origin should be explored along with the implications for the estimation of biological reference points.

For many stocks little or no data exists to develop a fecundity model that can be used to hindcast age- or length-specific fecundity. A sensitivity analysis of estimates of total egg production to variability in the fecundity model should be undertaken. Stocks having relatively good fecundity data sets (e.g., Icelandic cod, Northeast Arctic cod) could give guidance on how to model uncertainty in this term. Models which incorporate maternal effects on egg quality could also be included in this sensitivity analysis.

Representatives of the Working Group on Reproductive Potential should make presentations to the NAFO Scientific Council on the practical aspects of implementing this knowledge in assessments, e.g., estimation of alternative indices, determination of biological reference points and software.

Given the anticipated rate of progress on these issues the NAFO Scientific Council should consider sponsoring (or co-sponsoring with ICES) a workshop to explore the effects of incorporating data on reproductive potential on stock assessments.

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ToR 5: Co-Leaders: Peter Wright (UK) and Chris Chambers (USA)

Explore the consequences of fishery-induced changes in the timing and location of spawning to reproductive success.

The topic of consequences of fishery-induced changes in the timing and location of spawning to reproductive success is being evaluated by decomposing it into three components: theory, retrospective analyses using select data sets, and evaluation of consequences via cohort simulation. The focus of work in the first year is directed at the timing of spawning. The first of the three components is being considered in a literature review of spawning time and evidence for selection on birth date. Data sets relevant to spawning time will be collated before the next WG meeting. Regarding the latter component, a simulation framework is being developed in which key parameters are being varied to determine their effects on offspring fitness and population size. These key parameters are spawning characteristics (frequency distribution of spawning, size and age structure of females, and the dependency of fecundity and egg quality on female attributes), egg and larval characteristics (life-stage duration, growth, and mortality), and the intensity/selectivity of fishing mortality on adults.

ToR 6: Co-Leaders: Fran Saborido-Rey (Spain) and Joanne Morgan (Canada)
Provide recommendations for the collection of required data in existing research surveys, sentinel fisheries and captive fish experiments that are required to improve annual estimates of reproductive potential for stocks varying in data availability.

Members: Anders Thorsen (Norway), Rick Rideout (Canada), Ed Trippel (Canada), Jonna Tomkiewicz (Denmark) and Jay Burnett (USA).

Initial planning for this ToR was completed. This included an outline of the structure of the report to be produced as well as decisions on the type of information that will need to be included.

Type, quantity and quality level of data to be collected to estimate reproductive potential will be listed. A classification of the relevance of each variable will be provided relative to the capability of obtaining the specific data and its relevance for the estimation of stock reproductive potential for species with different reproductive strategy. Basic recommendations on procedures for data collection will be provided as well.

We acknowledge that sampling strategy will be different depending on the fecundity type of the target species. Therefore, two different guidelines will be provided, i.e. for determinate and indeterminate species. Within each approach, variables that should be collected will depend on the data source: research surveys, commercial fisheries and captive fish experiments. However, the paper will not produce a detailed sampling protocol but a focus on what would need to be collected to estimate reproductive potential. Examples will be given, as well pros and cons of collecting each variable

ToR 7: Co-Leaders: Loretta O'Brien (USA) and Nathalia Yaragina (Russia)

Explore the effects of the environment on Stock Reproductive Potential and how these relate of ToRs 2, 3 and 4.

ToR 2: Explore the use of correlation analysis to estimate the reproductive potential of fish stocks having limited data availability.
ToR 3: Model the inter-annual and inter-stock variability in size-dependent fecundity for stocks having multi-year estimates.
ToR 4: Explore how the current use of biological reference points and medium-term projections can be adapted to include new information on reproductive potential.

We will apply scenario modelling to determine how SRP responds in different environments (e.g, high, medium, or low temperatures, high or low age diversity). Life history models will provide a measurement of SRP, which can be compared within a stock and among stocks, however, other simulation models will be explored, e.g. generalized additive model. The effect of environment on SRP of about 20 stocks will be investigated using the final model (8 cod, 3 haddock, 3 herring, 2 American plaice, anchovy, sprat, redfish, and skate). In addition, a latitudinal study comparing growth and production of 3 populations of Atlantic silverside will be conducted.

FUTURE ACTIVITIES

Scientific Council approved the progress of the WG and its future directions in completing the second set of ToRs. A Workshop to illustrate how reproductive data can be further integrated into NAFO stock assessments was recommended (this might best be scheduled to coincide with an upcoming Annual Meeting of Scientific Council in September). The format for publication of results for the second set of ToRs will likely include both peer and non-peer reviewed outlets and has yet to be determined for each specific ToR.

The 4th Meeting of the NAFO Working Group on Reproductive Potential will be held at FAO Headquarters in Rome, Italy on October 20-23, 2004. Invitations to interested FAO staff to take part in the meeting will be made. Local arrangements will be organized by Fran Saborido-Rey (Spain) and Jorge Csirke, Chief of Marine Resources, Fishery Resources Division, FAO (Italy).