ICES Diadromous Fish Committee
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Report of the ICES/EIFAC Working Group on Eels (WGEEL)

22–26 November 2004
Galway, Ireland

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

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1 Introduction

At the 91st Statutory Meeting of ICES (2004) and the 24th meeting of EIFAC (2004) it was decided that:

The **ICES/EIFAC Working Group on Eels** [WGEEL] (Chair: W. Dekker, Netherlands) will meet in Galway, Ireland from 22–26 November 2004 to:

a) report on appropriate rebuilding goals for recovery of eel stocks/populations and advise on the factors which would affect their implementation;
b) specify practical monitoring requirements to evaluate progress towards the objectives of a stock recovery plan;
c) specify the scientific and management actions needed for implementation of a stock recovery plan;
d) assess trends in recruitment, stock and fisheries indicative for the status of the stock;
e) continue work to expand the data bases and knowledge on eels in Europe and North America, to provide a more complete basis for recovery of these stocks/populations.

17 people attended the meeting, from seven countries (see Annex 1).

The current Terms of Reference and Report constitute one step in an ongoing process of documenting the status of the European eel stock and fisheries and compiling management advice. As such, the current Report does not present a comprehensive overview, but should be read in conjunction with previous reports (ICES, 2000; 2002a; 2003; 2004).

In the past meetings of the Working Group, attention focused on documenting the poor status of the stock, listing available options for management, and advising on management action. Within ICES, those meetings were organised under the Advisory Committee on Fisheries Management ACFM, with the aim to respond to requests for management advice. The current meeting was organised under ICES Diadromous Fish Committee DFC, to continue and extend several developments which will eventually contribute to a stock recovery plan. The current report focuses predominantly on the structures and tools required for sustainable management of the stock. For EIFAC, this re-direction of the working groups objectives still fits within the scope of the group.

The structure of this report does not strictly follow the order of the Terms of Reference for the meeting, since different aspects of subjects where covered under different headings and a rearrangement of the Sections by subject was considered preferable. Section 2 presents updates of the data series on recruitment, stock and yield. In addition, new information is presented on the seasonality of the eel fisheries, and the spatial and temporal consistency in the seasonality. Section 3 discusses the objectives of sustainable management, and the various complications arising in practical implementation of this objective. Section 4 discusses current and required approaches in modelling eel stock dynamics, in relation to the objectives (Section 3) and to monitoring. Section 5 discusses monitoring of eel stocks and fisheries, and considers the relevance of ongoing, wider-scoped monitoring programmes for the specific purpose of eel stock management. Finally, Section 6 summarises the conclusions, and presents the recommendations. Appendices at the end of the report present elaborations of specific material. In particular, Annex 2 discusses the ongoing review of landings statistics; Annex 3 provides a short presentation of current modelling approaches; and finally Annex 4 contains the individual Country Reports, as submitted to the working group meeting.

The first Term of reference considers rebuilding goals. The conceptual aspects of this discussion are dealt with in Section 3, while the technical details of deriving adequate goals are discussed in Section 4. The second Term of Reference is dealt with in Section 5. Scientific and management actions (ToR c) are detailed in Sections 3, 4 and 5. Section 2 presents the most recent data updates, indicated in ToR d, but also extends our knowledge (ToR e), specifically with regard to the fishing season for the different life stages, throughout Europe.

2 Trends in Recruitment, Stock and Yield

2.1 Trends in recruitment

There are relatively few data sets, which provide information on the recruitment of the European eel, and those there are relate to various stages (pigmentation, behaviour) of the recruitment into continental habitats (Dekker, 2002). Available time-series from 19 river catchments in 12 countries have been examined for trends, with data from 10 rivers available for 2003 (Table 2.1.1). The data analysed were derived from both fishery-dependent sources (i.e. catch records) and fishery-independent surveys across much of the geographic range of the European eel, and cover varying time intervals.

Downward trends are evident over the last two decades of all time-series, reflecting the rapid decrease after the high levels of the 1970s. Through the 1980s, the trend continued downwards, possibly with the exception of the Erne in northwestern Ireland in which no trend was apparent. In the 1990's most series have shown fairly stable low levels, with a historical minimum recorded in 2001. The levels of recruitment in 2004 appear to be similar to that in previous years and do not show a substantial recovery from the 2001 historical minimum for the whole stock.

In northern areas, no glass eels are found to recruit into the rivers, while the transition to the yellow eel stage happens long before the immigration into fresh water. Figure 2.1.2 presents the results of these data series. In the mid-1990s, a moderate recovery in glass eel recruitment occurred (Figure 2.1.1). The data on yellow eel recruitment recently showed an increasing trend, apparently related to the temporary recovery of the glass eel in the mid-1990s.

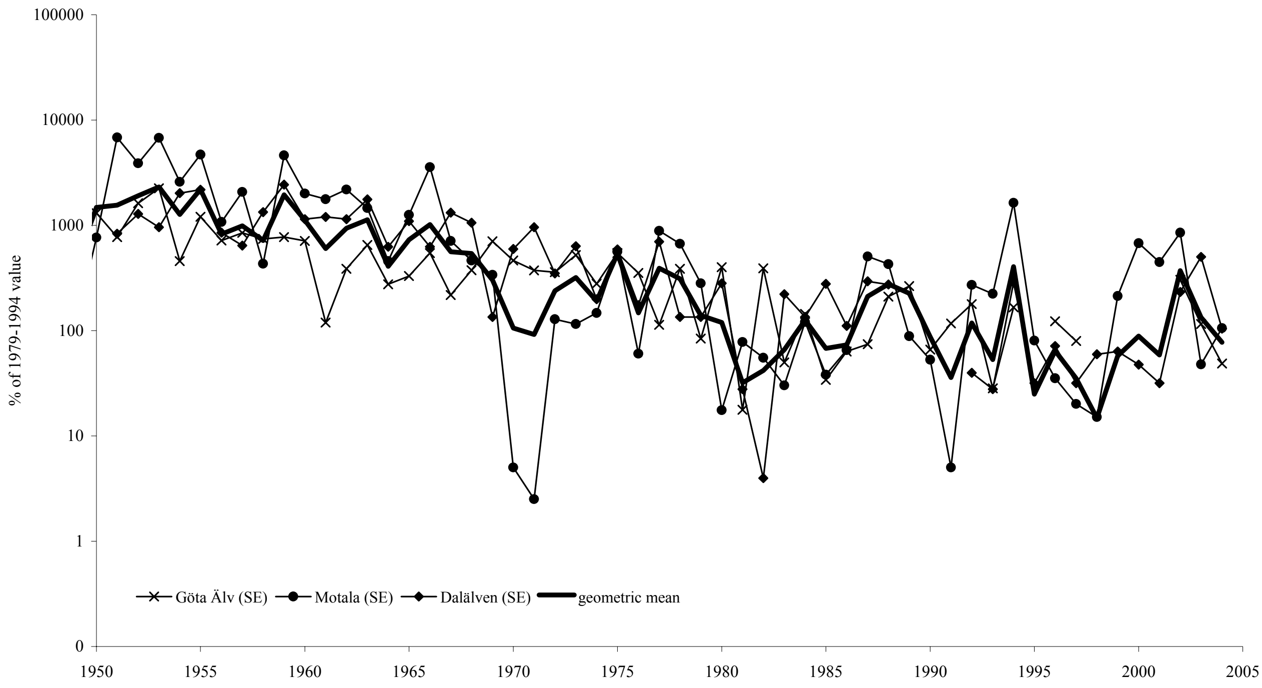

Figure 2.1.2. Time-series of monitoring yellow eel recruitment (older than one year) in European rivers, for which data are reported for 2004. Each series has been scaled to the 1979–1994 average.

Table 2.1.1 Recruitment data series. Part 1. Scandinavia and British Isles. The data units vary between data series; details are specified in Annex 4.

	N	S	S	S	S	DK	D	N.Irl.	Irl	Irl	UK
	Imsa	Göta Älv	Viskan	Motala	Dalälven	Vidaa	Ems	Bann	Erne	Shannon	Severn
1950		2947		305			875				
1951		1744		2713	210		719				
1952		3662		1544	324		1516				
1953		5071		2698	242		3275				
1954		1031		1030	509		5369				
1955		2732		1871	550		4795		167.00		
1956		1622		429	215		4194				
1957		1915		826	162		1829				
1958		1675		172	337		2263				
1959		1745		1837	613		4654		244.00		
1960		1605		799	289		6215	7409	1229		
1961		269		706	303		2995	4939	625		
1962		873		870	289		4430	6740	2469		
1963		1469		581	445		5746	9077	426		
1964		622		181.6	158		5054	3137	208		
1965		746		500	276		1363	3801	932		
1966		1232		1423	158		1840	6183	1394		
1967		493		283	332		1071	1899	345		
1968		849		184	266		2760	2525	1512		
1969		1595		135	34		1687	422	600		
1970		1046		2	150		683	3992	60		
1971		842	12	1	242	787	1684	4157	540		
1972		810	88	51	88	780	3894	2905			
1973		1179	177	46	160	641	289	2524			
1974		631	13	58.5	50	464	4129	5859	794		
1975	42945	1230	99	224	149	888	1031	4637	392		
1976	48615	798	500	24	44	828	4205	2920	394		
1977	28518	256	850	353	176	91	2172	6443	131	1.02	
1978	12181	873	533	266	34	335	2024	5034	320	1.37	
1979	2457	190	505	112	34	220	2774	2089	488	6.69	40.1
1980	34776	906	72	7	71	220	3195	2486	1352	4.50	32.8
1981	15477	40	513	31	7	226	962	3023	2346	2.15	32.0
1982	45750	882	380	22	1	490	674	3854	4385	3.16	30.4
1983	14500	113	308	12	56	662	92	242	728	0.60	6.2
1984	6640	325	21	48	34	123	352	1534	1121	0.50	29.0
1985	3412	77	200	15.2	70	13	260	557	394	1.09	18.6
1986	5145	143	151	26	28	123	89	1848	684	0.95	15.5
1987	3434	168	146	201	74	341	8	1683	2322	1.61	17.7
1988	17500	475	92	170	69	141	67	2647	3033	0.15	23.1
1989	10000	598	32	35.2		9	13	1568	1718	0.03	13.5
1990	32500	149	42	21		5	99	2293	2152	0.47	16.0
1991	6250	264	1	2			52	677	482	0.09	7.8
1992	4450	404	70	108	10		6	978	1371	0.03	17.7
1993	8625	64	43	89	7		20	1525	1785	0.02	20.9
1994	525	377	76	650	72		52	1249	4400	0.29	22.3
1995	1950		6	32	8		40	1403	2400	0.40	36.0
1996	1000	277	1	14	18		20	2667	1000	0.33	25.7
1997	5500	180	8	8	8		5	2533	1038	2.12	16.9
1998	1750		5	6	15		4	1283	782	0.28	20.0
1999	3750		2	85	16		3	1345	1100	0.02	18.0
2000	1625		14	270	12		4	563	900	0.04	7.6
2001	1875		2	178	8		1	250	699	0.003	5.4
2002		685	26.2	338.8	58.6		-	1000	112	0.16	5.1
2003		261	44.13	19	126.7		-	1010	580	0.378	19
2004		125	5.0	42	26.4		-	308	269	0.057	10

Table 2.1.1 Recruitment data series; continued. Part 2: Mainland Europe. The data units vary between data series; details are specified in Annex 4.

	NL	B	F	F	F	F	F	E	P/E	IT
	DENO-EVER	IJZER	VILAINE	LOIRE	GIRONDE (CPUE)	GIRONDE (YIELD)	ADOUR	NALON	MINHO	TIBER
1950	6.92			86						
1951	13.84			166						
1952	89.37			121						
1953	13.97			91				14,529		
1954	20.99			86				8,318		
1955	28.82			181				13,576		
1956	7.58			187				16,649		
1957	17.20			168				14,351		
1958	55.22			230				12,911		
1959	30.26			174				13,071		
1960	22.87			411				17,975		
1961	39.62			334				13,060		
1962	91.79			185				17,177		
1963	131.13			116				11,507		
1964	40.95	3.7		142				16,139		
1965	85.94	115.0	5.0	134				20,364		
1966	20.63	385.0	4.0	253				11,974		
1967	31.46	575.0	9.0	258				12,977		
1968	21.66	553.5	12.0	712				20,556		
1969	18.37	445.0	10.0	225				15,628		
1970	41.43	795.0	8.0	453				18,753		
1971	18.49	399.0	44.0	330				17,032		
1972	33.20	556.5	38.0	311				11,219		
1973	24.22	356.0	78.0	292				11,056		
1974	27.97	946.0	107.0	557				24,481	1.642	
1975	36.07	264.0	44.0	497				32,611	10.578	11.00
1976	29.33	618.0	106.0	770				55,514	20.048	6.70
1977	62.94	450.0	52.0	677				37,661	36.637	5.90
1978	41.66	388.0	106.0	526				59,918	24.334	3.60
1979	57.84	675.0	209.0	642	19.7	286.2		37,468	28.435	8.40
1980	28.92	358.0	95.0	525.5	25.9	404.8		42,110	21.32	8.20
1981	24.72	74.0	57.0	302.7	20.0	332.2		34,645	54.208	4.00
1982	15.59	138.0	98.0	274	15.0	123.3		26,295	16.437	4.00
1983	10.43	10.0	69.0	259.5	13.6	80.3		21,837	30.447	4.00
1984	14.02	6.0	36.0	182.5	19.2	82.0		22,541	31.387	1.80
1985	15.08	13.0	41.0	154	9.6	64.5		12,839	20.746	2.50
1986	15.83	26.0	52.6	123.4	10.6	45.2	8	13,544	12.553	0.20
1987	6.17	33.0	41.2	145	14.0	82.4	9.5	23,536	8.219	7.40
1988	4.43	48.0	46.6	176.6	10.9	33.0	12	15,211	8.001	10.50
1989	3.04	30.0	36.7	87.1	7.2	80.0	9	13,574	9.000	5.50
1990	3.66	218.2	35.9	96	5.6	48.1	3.2	9,216	6.000	4.40
1991	1.12	13.0	15.4	35.7	7.7	64.0	1.5	7,117	9.000	0.80
1992	2.96	18.9	29.6	39.3	3.7	41.7	8	10,259	10.000	0.60
1993	2.96	11.8	31.0	90.5	8.2	69.4	5.5	9,673	7.600	0.50
1994	4.93	17.5	24.0	94.6	8.7	45.8	3	9,900	4.700	0.50
1995	6.98	1.5	29.7	132.5	8.2	73.2	7.5	12,500	15.200	0.30
1996	7.82	4.5	22.4	80.8	4.8	30.7	4.1	5,900	8.700	0.10
1997	12.70	9.8	22.6	70.8	6.5	50.5	4.6	3,656	7.400	0.10
1998	2.27	2.3	17.5	60.7	4.3	25.0	1.5	3,273	7.400	0.13
1999	3.53		15.3	86.9	7.5	44.1	4.3	3,815	3.800	0.06
2000	1.73	17.85	14.2	79.9	6.6	25.1	10	1,330	1.200	0.07
2001	0.57	0.7	8.1	30	1.9	9	4	1,285	1.100	0.04
2002	1.15	1.4	16.0	41	4.9	36.8	6	1,569		0.02
2003	1.54	0.539	8.9	55				1,231		0.02
2004	1.52	0.381	7.0	20				506		0.03

2.2 Trends in stock and Yield

The FAO maintains a database of eel fishing landings. Additionally, ICES maintains a database of landings of marine, Atlantic eel fishing landings. Since the data in the ICES database exclude the inland yield, preference is given to the FAO data. However, in the past years, major inconsistencies between the FAO and Working Group estimates were observed, indicating a major revision of the databases is required. In the period before the meeting, official data and previous working group estimates have been circulated, and inconsistencies discussed in detail. The Country Reports, listed in Annex 4 present full details on the information available in different countries. In order to sort out the differences between official databases and working group estimates, a special meeting was organised after the working group meeting. During this meeting, the reasons behind data inconsistencies were analysed. See Annex 2 for details. It was concluded that a major review of the official data was not yet within reach, due to the many inconsistencies within and between countries. The data review was referred back to the Working Group, with the specific recommendation to further this process, by requesting individual countries to address the problems listed in Annex 2, in their national reports to the Working Group for the coming year. Following this revision, the Working Group should then consider whether to recommend revisions to the national data series, as reported to FAO and ICES.

2.3 Trends in re-stocking

Data were obtained from a number of countries, separate for glass eels and for young yellow eels. The size of 'young yellow eel' varies between countries. Most data available were on a weight base. Weights were converted to numbers, using estimates of average individual weights of the eels re-stocked. These were 3.5 g for Denmark, 33 g for the Netherlands, 20 g for (eastern) Germany, and 90 g for Sweden. An overall number of 3000 glass eels per kg was applied.

An overview of data available up to 2004 is compiled in Tables 2.3.1 and 2.3.2

Table 2.3.1 Re-stocking of glass eel. Numbers of glass eels (in millions) re-stocked in (eastern) Germany (D east), the Netherlands (NL), Sweden (S), Poland (PO), Northern Ireland (N.Irl.) and Belgium (Flanders).

	D EAST	NL	SE	PO	N.IRL.	FLANDERS
1945					17.0	
1946		7.3			21.0	
1947		7.6				
1948		1.9				
1949		10.5				
1950	0.0	5.1				
1951	0.0	10.2				
1952	0.0	16.9		17.6		
1953	2.2	21.9		25.5		
1954	0.0	10.5		26.6		
1955	10.2	16.5		30.8	0.5	
1956	4.8	23.1		21.0		
1957	1.1	19.0		24.7		
1958	5.7	16.9		35.0		
1959	10.7	20.1		52.5	0.7	
1960	13.7	21.1		64.4	25.9	
1961	7.6	21.0		65.1	16.7	
1962	14.1	19.8		61.6	27.6	
1963	20.4	23.2		41.7	28.5	
1964	11.7	20.0		39.2	10.0	
1965	27.8	22.5		39.8	14.2	
1966	21.9	8.9		69.0	22.7	
1967	22.8	6.9		74.2	6.7	
1968	25.2	17.0			12.1	
1969	19.2	2.7			3.1	
1970	27.5	19.0			12.2	
1971	24.3	17.0			14.1	
1972	31.5	16.1			8.7	
1973	19.1	13.6			7.6	
1974	23.7	24.4			20.0	
1975	18.6	14.4			15.1	
1976	31.5	18			9.9	
1977	38.4	25.8			19.7	
1978	39.0	27.7			16.1	
1979	39.0	30.6			7.7	
1980	39.7	24.8			11.5	
1981	26.1	22.3			16.1	
1982	30.6	17.2			24.7	
1983	25.2	14.1			2.9	
1984	31.5	16.6			12.0	
1985	6.0	11.8			13.8	
1986	23.8	10.5			25.4	
1987	26.3	7.9			25.8	
1988	26.6	8.4			23.4	
1989	14.3	6.8			9.9	
1990	10.65	6.1	0.7		13.3	
1991	2.01	1.9	0.3		3.5	
1992	6.36	3.5	0.3		9.4	
1993	7.62	3.8	0.6		9.9	0.8
1994	7.6	6.2	1.7		16.4	0.5
1995	0.99	4.8	1.5		13.5	0.5
1996	0.05	1.8	2.4		11.1	0.5
1997	0.38	2.3	2.5		10.9	0.4
1998	0.3	2.5	2.1		6.2	0.0
1999	0.0	2.9	2.3		12.0	0.8
2000	0.0	2.8	1.3		5.4	0.0
2001		0.9	0.8		3.04	0.2
2002		1.6	1.4		6.6	0
2003		1.6	0.6		9.2	4.5
2004		0.3	0.8		3.0	0

Table 2.3.2 Re-stocking of young yellow (bootlace) eel. Numbers of young yellow eels (in millions) re-stocked in (eastern) Germany (D east), the Netherlands (NL), Sweden (S), Denmark (DK) and Belgium (Flanders).

	D EAST	NL	SE	DK	FLANDERS
1945					
1946					
1947		1.6			
1948		2.0			
1949		1.4			
1950	0.9	1.6			
1951	0.9	1.3			
1952	0.6	1.2			
1953	1.5	0.8			
1954	1.1	0.7			
1955	1.2	0.9			
1956	1.3	0.7			
1957	1.3	0.8			
1958	1.9	0.8			
1959	1.9	0.7			
1960	0.8	0.4			
1961	1.8	0.6			
1962	0.8	0.4			
1963	0.7	0.1			
1964	0.8	0.3			
1965	1.0	0.5			
1966	1.3	1.1			
1967	0.9	1.2			
1968	1.4	1.0			
1969	1.4	0.0			
1970	0.7	0.2			
1971	0.6	0.3			
1972	1.9	0.4			
1973	2.7	0.5			
1974	2.4	0.5			
1975	2.9	0.5			
1976	2.4	0.5			
1977	2.7	0.6			
1978	3.3	0.8			
1979	1.5	0.8			
1980	1.0	1.0			
1981	2.7	0.7			
1982	2.3	0.7			
1983	2.3	0.7			
1984	1.7	0.7			
1985	1.1	0.8			
1986	0.0	0.7			
1987	0.0	0.4		1.6	
1988	0.0	0.3		0.8	
1989	0.0	0.1		0.4	
1990	0.1	0.0	0.8	3.5	
1991	0.1	0.0	0.9	3.1	
1992	0.1	0.0	1.1	3.9	
1993	0.2	0.2	1.0	4.0	0.2
1994	0.2	0.0	1.0	7.4	0.1
1995	0.7	0.0	0.9	8.4	0.1
1996	0.9	0.2	1.1	4.6	0.1
1997	1.5	0.4	1.1	2.5	0.1
1998	1.2	0.6	0.9	3.0	0.1
1999	1.1	1.2	1.0	4.1	0.1
2000	1.0	1.0	0.7	3.8	0.0
2001		0.1	0.4	1.7	0.0
2002	0.4	0.1	0.3	2.4	
2003		0.1	0.3	2.2	
2004		0.1	0.1		

2.4 Trends in aquaculture

Aquaculture of the European eel ranges from highly industrialised, indoor facilities in northern Europe, through extensive culture in artificial ponds in southern Europe, to re-stocking of foreign glass eel in semi-natural outdoor waters for fisheries in northern Europe. All aquaculture depends entirely on seed stock derived from the wild population, since artificial reproduction fails in the young larval stage. Additionally, aquaculture plants are used for quarantine of foreign glass eel to be re-stocked in outdoor waters (e.g. Sweden) and transport of partly grown eels between aquaculture and fisheries occurs in and between countries (France, Italy). Obviously, the distinction between aquaculture and fisheries is hard to define.

There is no consistent long running time series for aquaculture production. Data are available from FAO, from the Federation of European Aquaculture Producers, from previous meetings of the working group and from Kamstra (1999). An overview of the estimates is compiled in Table 2.4.1

The aquaculture production in Europe is concentrated in Denmark, the Netherlands and Italy. The aquaculture in Denmark and the Netherlands is technically highly developed and produces an increasing part of the total, while Italy has intensive as well as extensive culture systems, the latter having a declining production. Data show an upward trend in the period before 2000, followed by a stable level.

Table 2.4.1. Aquaculture production of European eel in Europe and Japan. Compilation of production estimates (tonnes) derived from reports of previous WG meetings, FAO, FEAP and others. Data for Sweden and the Netherlands have been revised.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Japan		3000															10000			
Sum EU	1950	2229	3448	4729	5517	5159	6667	6098	6818	7721	7689	8935	9031	10646	11059	10839	10510	8435		
Czech. Rep.									2	4	4	3	3	3	1	1	1	1		
Hungary					90	39	73	33		50		50			19	19				
Croatia								7	5	5	7	6	7							
Yugoslavia	44	52	48	49	19	10	5	1	8	2	9	5	5	5	6	6	5	4		
Macedonia									1	0	70	83	60	72	60	50	32			
Turkey																				
Greece			6	4	10	54	94	132	337	341	659	550	312	500	500	300	600	735		
Italy	2600	2800	4200	4600	4250	4500	3700	4185	3265	3000	2800	3000	3000	3100	3100	3100	2750	2500	1900	
Tunisia							150	151	250	260	108	158	147	108						
Algeria					72	53	22	1	0	22	20	17	17	17	22	15	18	20		
Morocco							35	41	68	85	55	55	56	42	27	28	60	28		
Portugal	60	60	590	566	501	6	270	622	505	979	200	110	200	200	200	200				
Spain	15	20	25	37	32	57	98	105	175	134	214	249	266	270	300	425	200	259		
Belgium/Lux.					30	30	125	125	125	125	150	140	150	150	40	20	50	55		
Netherlands				100	300	200	600	900	1100	1300	1450	1540	2800	2450	3250	3500	3800	4000	4000	*4200*
Germany										100	100	100	150	150	150	150	300	160		
UK				20	30	0	0				25		25							
Ireland																	100			
Denmark	18	40	200	240	195	430	586	866	748	782	1034	1324	1568	1913	2483	2718	2674	2000	1880	2050
Sweden	12	41	51	90	203	166	157	141	171	169	160	139	161	189	204	222	273	200	167	170
Norway										120	200	200	200	200						

2.5 Seasonality in eel fishing

In previous reports of the working group, season closure has been advised as a potential management measure to restrict the impact of fishing. Effective season closures have been applied locally in several areas. In recent discussions between managers and stakeholders, however, universal season closures have been mentioned, implemented over larger (or even continent-wide) areas. The Working Group realised that the spatial consistency of fishing seasons had not been addressed before. It was therefore decided to compile data on fishing seasons, for each of the life stages separately. Since no specific request was received to advice on the effect of potentially uniform season closures, no interpretation of the data is presented.

2.5.1 Seasonality in glass eel fishing

Most data presented are from fisheries; the Dutch data refer to experimental fishing, while the Irish data are derived from non-commercial fishing for local stock enhancement.

Glass eel fisheries all around Europe show a temporal distribution from October till May. The catch distribution follows a south to north gradient. In the southern areas the season starts in November (Basque country) whereas only in March, in northern areas (Northern Ireland). It ends around February in the south, while in May in the north (Table 2.5.1.1). All the intermediary areas follow a regular progressive evolution of the season from these two extreme patterns (Figure 2.5.1.1).

Table 2.5.1: Seasonality in glass eel fishing. Catch per month, in percentage of annual total.

Country	Area	Lat.	Oct	Nov	Dec	Jan	Feb	Mar	April	May	Jun
NIR(UK)	Bann estuary	55.4	0	0	0	0	0	40	60	0	0
NIR(UK)	Irish Sea Estuaries	54	0	0	0	0	0	40	60	0	0
NL	L.Ijsselmeer (CPUE)	53	0	0	0	0	0	9	55	36	0
IR	Erne & Shannon	53	0	0	0	0	33	33	33	0	0
FR	Vilaine estuary marine fishermen	48	0	0	5	22	44	27	1	0	0
FR	Loire	47	0	0	14	26	35	23	3	0	0
FR	Loire estuaire et aval fluvial fishermen	47	0	0	3	27	39	24	5	1	0
FR	Gironde zone mixte	45	0	3	6	13	42	33	2	0	0
FR	Pibalour estuaire maritime	45	0	4	19	30	27	19	1	0	0
FR	Adour fluvial fishermen	44	0	23	27	27	19	4	0	0	0
ES	Basque Country	43	0	12	39	35	12	2	0	0	0

The mean length of the fishing season is about 4 months, but it last up to 5 months in the southern regions and down to only 2 months in the northern areas.

Modes in catch quantities usually occur in a single month, in which more than 30% of the total catch is taken (exception in the Adour: 27.4%). This month is December in the south (Basque Country and Adour), January in the Gironde estuary, February in the Gironde, in the Loire and in the Vilaine, in April in IJsselmeer, in the Irish Sea estuaries and in the Bann estuary.

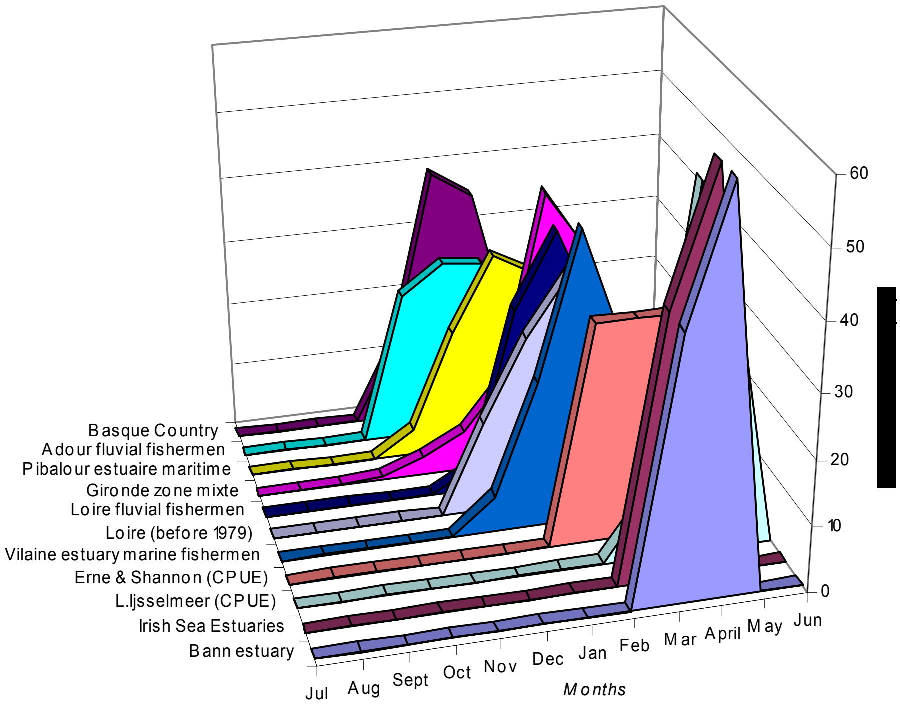

Figure 2.5.1.1. Glass eel seasonality pattern.

2.5.2 Seasonality in yellow eel fishing

All the data processed are related to fisheries, except for experimental fishing in Burrishoole (Ireland) in a yearly sampling from March to October showing a fisheries independent distribution with a maximum value of 18% of the total catch in June and July (Table 2.5.2; Figure 2.5.2).

The fisheries all around Europe have a seasonal pattern following an initial period of increasing catch, a period of maximum catch for a few months, finally decreasing towards the end of the year. This final decrease is not seen in the Swedish stat area n 23, probably because of yellow eel bycatches taken in the silver eel fishery during the winter season.

There is no strong latitudinal influence on the seasonality of yellow eel fisheries. In general, the fisheries start in April in all the studied countries. In river systems where there are several kind of fisheries such as for glass eel, lamprey and shad, there is an inter-relationship among them: the yellow eel fishery becomes important when the others finish. This might explain the delay between the Gironde estuary and the Gironde upstream zone-mixte.

There are two different patterns on yellow eel fisheries: the unimodal distribution with a short mode lasting just a month which represents more than 25% of the total catch, increasing to the 40% in the northern areas (see Sweden, ICES Stat area 27). This mode occurs from May to September. It seems that there is a geographical pattern, having an early maximum generally in the south and a later one in July in the North, and a temporal variation in IJsselmeer showing an evolution from an early pick in the beginning of the season (May) to the end of the season (September) with a transitional period in between those years.

Where the maximum values are distributed over more than one month (from 2 months to 4 months) each month takes between 14% and 21%. This usually includes July and/or August. The end of the season may occur abruptly or can take a longer time, starting usually from September or October.

Table 2.5.2. Seasonality in yellow eel fishing. Catch per month, in percentage of annual total.

Country	Area	Lat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SE	ICES stat area 30	62	0	0	0	0	16	29	35	15	5	0	0	0
SE	ICES stat area 27	58	0	0	0	1	9	18	43	13	9	6	0	0
SE	ICES stat area 20	57	0	0	0	1	7	18	25	16	18	14	2	0
SE	ICES stat area 21	56	0	0	0	0	16	20	19	14	15	13	3	0
DK	Freshwater	55	0	0	0	7	17	6	17	21	25	5	1	0
DK	Coastal ICES stat area 21 to 24	55	0	0	0	3	13	8	19	21	14	14	6	2
DK	Fjord	55	0	0	1	13	13	10	21	22	10	6	2	1
NIR(UK)	L Neagh	55	0	0	0	0	10	20	20	20	20	10	0	0
SE	ICES stat area 23	55	0	0	0	1	8	10	9	11	10	24	25	1
SE	ICES stat area 25	55	0	0	0	3	11	13	19	29	12	9	4	1
IR	Burrishoole saline	54	0	0	6	8	14	18	19	16	12	8	0	0
DE	shallow lakes	52	1	0	1	10	9	12	21	18	11	8	8	1
NL	L.Ijsselmeer, early season	52	0	0	0	13	24	16	10	13	13	9	1	0
NL	L.Ijsselmeer, average season	52	0	0	0	6	17	16	18	19	16	7	1	0
NL	L.Ijsselmeer, late season	52	0	0	0	4	6	7	11	16	32	23	1	0
FR	Rhin	50	0	0	1	4	6	13	24	23	9	9	6	4
FR	Loire estuaire fluvial fishermen	47	0	0	3	6	18	14	14	18	16	7	4	0
FR	Gironde zone mixte	46	1	3	4	6	7	15	16	15	18	13	3	1
FR	Dordogne amont	45	0	1	3	11	34	27	10	5	3	3	2	1
FR	Dordogne aval	45	0	0	12	6	19	24	19	15	4	1	0	0
FR	Garonne amont	45	0	0	0	0	0	5	23	23	21	13	13	2
FR	Gironde estuaire	45	0	1	4	11	22	20	11	8	9	8	5	1
FR	Garonne aval	45	0	0	0	0	0	0	28	16	32	19	6	0

2.5.3 Seasonality in silver eel fishing

The data set include experimental data (UK), trap counts (Burrishoole, Ireland) and fisheries catches (Figure 3).

The most significant variation occurs at the beginning of the season. The season starts in April (NL IJsselmeer average (female) catches) in May (DK Fjord, SE Vänern, SE Hjalmaren, SE Mälaren), in June (SE Vättern), or in July (SE ICES stat area 27). These early migrations are related to the spring flow in the northern areas like DK Fjord and the SE ICES stat area 21. Catches later in the summer till autumn occur in the southern area, in August (UK Leven, IR Ireland) in September and October (in France).

The mode in monthly catch ranges between 25% and 60% of the annual catch, in August in the northern areas, in September and / or in October in the south.

Table 2.5.3. Seasonality in silver eel fishing. Catch per month, in percentage of annual total.

Country	Area	Lat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
SE	ICES stat area 30	62	0	0	0	0	1	26	27	34	12	1	0	0
SE	stat area 29N	59	0	0	0	0	0	0	28	55	17	0	0	0
SE	Hjälmaren	59	0	0	0	2	20	15	16	28	16	3	0	0
SE	Mälaren	59	0	0	0	0	12	12	21	27	22	6	1	0
SE	Vänern	59	0	0	0	2	10	12	20	24	21	10	2	0
SE	ICES stat area 27	58	0	0	0	0	0	1	13	37	35	13	1	0
SE	Vättern	58	0	0	0	0	0	13	23	28	24	11	0	0
SE	ICES stat area 20	57	0	0	0	0	3	8	12	71	0	6	0	0
SE	ICES stat area 21	56	0	0	0	0	26	15	25	2	5	6	21	0
DK	Coastal ICES stat a	55	0	0	0	0	0	0	0	2	26	46	21	5
DK	Fjord	55	0	1	0	0	8	3	5	4	26	24	10	17
SE	ICES stat area 24	55	0	0	0	0	0	0	0	8	43	23	21	5
SE	ICES stat area 23	55	0	0	0	0	0	0	0	0	6	31	41	22
SE	ICES stat area 25	55	0	0	0	0	0	0	3	15	45	28	8	0
IR	Burrishoole, early	54	0	0	0	0	0	0	0	14	20	59	7	0
IR	Burrishoole, average	54	0	0	0	0	0	0	0	7	22	53	16	2
IR	Burrishoole, late	54	0	0	0	0	0	0	0	2	7	63	26	2
NIR(UK)	L Neagh	54	5	0	0	0	1	2	2	10	25	25	25	5
UK	R. Leven, early	54	0	0	0	0	0	0	0	14	46	35	6	0
UK	R. Leven, average	54	0	0	0	0	0	0	0	7	7	59	11	16
UK	R. Leven, late	54	0	0	0	0	0	0	0	6	13	27	51	2
IR	Ireland	53	0	0	0	0	0	0	0	10	30	40	20	0
NL	L.Ijsselmeer, early	52	0	0	0	0	0	0	2	29	41	27	1	0
NL	L.Ijsselmeer, averag	52	0	0	0	0	0	0	2	14	49	31	3	0
NL	L.Ijsselmeer, late	52	0	0	0	0	1	1	1	3	37	53	3	1
NL	L.Ijsselmeer, female	52	0	0	0	12	3	7	0	29	28	16	4	0
FR	Loire aval fluvial fish	47	0	0	0	0	0	0	0	0	0	45	27	28
FR	Loire moyenne	47	0	0	0	0	0	0	0	0	0	60	19	21

2.5.4 Seasonality in combined yellow and silver eel fishing

This category comprises those data for which no distinction between the yellow and silver eel was available(Figure 4). They show the spring season for yellow eel as well as the autumn season for silver eel, as discussed above.

The most important autumn catches in France are seen in Loire, Seine and Saone and in the Rhone in from October to December.

Table 2.5.4: Yellow eel and silver eel

Country	Area	Lat.	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
DE	Elbe	53	0	0	0	2	16	16	12	18	16	13	6	1
UK	R. Test, early	51	0	0	0	0	4	14	13	30	4	14	21	1
UK	R. Test, average	51	0	0	0	0	7	10	14	18	10	14	22	5
UK	R. Test, late	51	0	0	0	0	8	9	6	16	15	29	8	10
FR	Seine & Somme	50	2	2	7	9	14	10	8	13	9	21	3	1
FR	Loire aval fluvial fishermen	47	1	1	2	5	8	8	6	5	3	32	24	6
FR	Loire moyenne	47	1	1	5	5	10	7	6	4	3	47	8	3
FR	Charentes fluvial fishermen	46	6	7	11	16	20	16	8	3	6	5	3	1
FR	Saone aval	45	3	4	6	12	10	22	12	9	3	6	4	8
FR	Adour fluvial fishermen	43	0	2	7	23	24	18	8	7	2	4	6	0
FR	Rhone aval	43	0	0	2	7	18	26	18	10	6	13	0	0
FR	Rhone delta fluvial fishermen	43	3	1	1	4	7	10	14	15	14	9	12	9

3 Objectives, targets and management measures

3.1 Introduction

There are fundamental differences in biology and our knowledge base between the eel and almost all other (marine) fish species to which international management systems are applied. The advice on the status of the eel stock, and the management actions required, so far has largely paralleled the advice given for the other species. However, the case of the eel is aberrant, in the sense that the eel stock is extremely scattered over a multitude of inland waters with divergent characteristics, and that anthropogenic impacts, such as barriers in migration ways, pollution, habitat loss, etc. presumably have an impact on the eel stock of a comparable magnitude as exploitation. In addition, recent evidence suggests that the relationship between spawning stock and recruitment might show depensation. In this Section, the objectives of sustainable management are reviewed with respect to the eel, and the complications arising from the other impacts, and from potential depensation, are integrated in this conceptual framework.

3.2 Main objectives

There is no centrally formulated long term management objective for the European eel population, and no proactive fisheries management system operating on a stock wide basis. A logical scientific objective is the maintenance of a population which is capable of sustaining itself within the range of anthropogenic and natural pressures it faces. Both spawning stock biomass and recruitment have declined over recent decades. Scientific advice has been that the population is outside safe biological limits, that fishery and anthropogenic impact should be reduced to the lowest possible level and that a recovery plan be developed. (ICES, 2001; 2002).

Conventional fishery management for species breeding in marine waters is based on pooling annual estimates of recruitment (R) and catch at age for all stock subunits into a combined virtual population analysis, resulting in an annual estimate of Spawning Stock Biomass (SSB) and continuous refinement of a known stock-recruitment relationship. Fishing effort levels and catches are then adjusted annually in an attempt to return or maintain the stock to within sustainable levels. Such an analysis is currently not possible for eel. Data on which management advice can be based are limited to annual indices from a number of sites for recruitment, measured as glass eel catch, immigration data (see Figures 2.1.1 and 2.1.2), and Catch per Unit Effort (CPUE) in yellow eel fisheries.

The decline in the recruitment data series is the basis for the current advice. Only recently has a tentative SSB – R relationship been postulated for European eel, based on the known recruitment data series and the assumption that SSB is proportional to continental landings (see Figure 3.2.1). The shape of this postulated relationship suggests that eel spawning and recruitment dynamics may follow an asymptotic stock-recruitment relationship, in which reproductive success is strongly impaired below a certain threshold spawning stock size, which might be the case since 1980 (Dekker 2004).

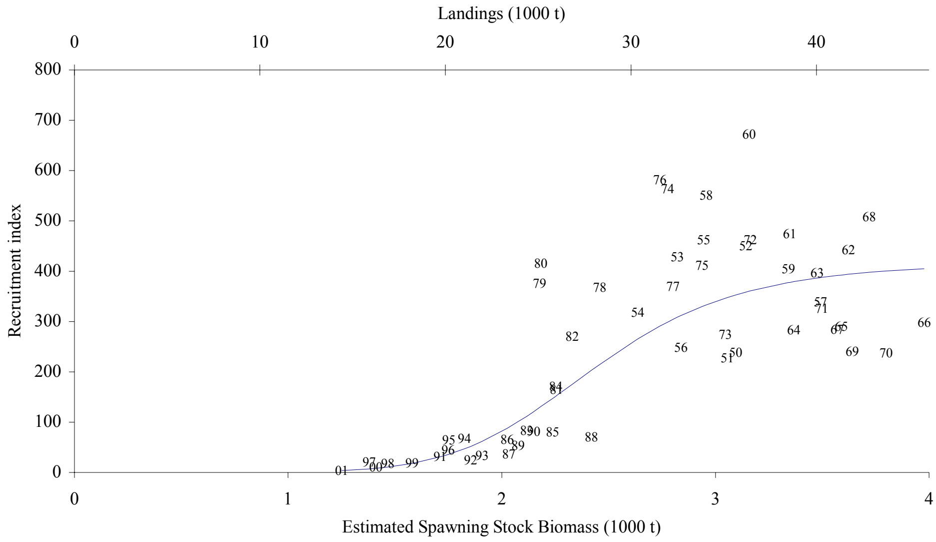

Figure 3.2.1. Estimated stock-recruitment relationship for the European eel. Numbers indicate the year of recruitment. The spawning stock is assumed proportional to the landings from the continental stock (after Dekker 2004).

The currently identifiable milestones leading from the current decline through a recovery plan to ultimate sustainable management are:

Immediate:	Halt recruitment decline
Next	Reverse trend to upward (rebuilding)
Then	Bring the stock to a sustainably exploitable state.

A management framework has been proposed (ICES/EIFAC WGEel 2001 onwards), based on reducing fishing and other anthropogenic mortality, with the following reference points:

A *provisional limit reference point* of 30% SPR

And a second, *more precautionary reference point* of 50% SPR considering the many uncertainties in eel biology and management.

3.3 Pristine state

It is important to note that these SPR reference points do not mean an actual ratio of spawner to recruit, but rather a notional point on an SSB to R relationship. These %SPR reference points are conventionally applied with harvest rate models, in which the unexploited state can be estimated, irrespective of absolute levels of recruitment. In the case of eel, current knowledge is insufficient to allow this approach, predominantly since anthropogenic impacts other than fisheries have an impact on the stock. Therefore, the reference points proposed for eel relate to a percentage of spawner production in a notional “pristine” or “virgin” state. No explicit definition has so far been given of what this pristine state might be for eels. At one extreme it can be defined as a stock level arising from a continental population growing in a habitat free from all anthropogenic impacts and supplied with optimal recruitment levels. This notional pristine state can only be set on a regional, preferably catchment, basis and may in the most data rich cases refer to known historical data. On the other hand, for data poor catchments this level may only be derivable theoretically or by modelling. This theoretical approach requires that decisions are made as to what point in history is selected as the reference point. A SPR level referenced back to a pre-industrial era will be extremely difficult to attain, given the large loss of freshwater habitats. However, a pragmatic, historical level need not be a sustainable level. There is considerable overlap between this discussion on eel management and the process of defining reference conditions required in the Water Framework Directive. Further convergence of these two needs is likely to present a useful way forward.

3.4 Dual approach for exploitation and remaining factors

We suggest that in the context of fisheries management an appropriate provisional starting point for a definition of a pristine state is the spawner production from currently available habitat with no fishery and at the pre-1980s average recruitment level. Within the additional context of habitat management and/or restoration the definition of pristine should coincide with Water Framework Directive WFD requirements referring to, *inter alia,* a situation without upstream or downstream migration restriction. The use of WFD requirements as a means to aid eel population management has the inherent assumption that EU member states interpret the objective of "good ecological status" as incorporating a requirement for full connectivity of eel habitat. The two contexts of habitat and fisheries management requiring a definition of pristine state should be seen in combination, with synergistic effects, but compliance should be determined according to the impacts managed as well as by monitoring for local and regional stock level improvement. A stepwise 5 point approach to habitat management and improvement to aid stock recovery was proposed by ICES (2002) (i.e. full use of existing habitat; restore habitat where easily done; full use of existing recruitment; restore historical habitat; restore pristine conditions).

This dual approach (fisheries vs. habitats) solves the problem with evaluation of compliance against targets set for separate elements of a management plan. This constitutes a pragmatic approach to the complex problem of managing both fisheries and habitats, that is: mortalities and absolute biomasses. In the long run, these two, separate approaches will have to be integrated into a single, comprehensive approach. However, it is felt that separate handling of the two issues facilitates rapid derivation of target values, and more rapid implementation.

For arbitrarily defined working targets such as these, the evaluation process must enable not only an assessment of whether or not the target is met, but also of whether or not the target itself is appropriate. Given the specificity of eel biology and ecology, targets required may differ from default levels taken directly from experience of managing other species. The target levels now set at 30 or 50% SPR may have to be revised if the expected recovery is achieved before they are met, or not achieved.

3.5 Depensation and re-stocking

WGEEL first proposed %SPR reference points in 2001, following the decline in recruitment first noted in the 1980s. Previous advice from the Working Group has been based on the view that depensation (see below) may not be an issue and that recovery can be expected, even from very low levels of recruitment and SSB.

While the shape of the postulated SSB – R relationship suggests that eel spawning and recruitment dynamics may follow a similar type of relationship to other fish species, (see above) the recruitment data shows a recent decline which is potentially much faster than being simply proportional to the SSB decline. This indicates a possible depensation or "Allee effect" (Allee 1931**)** at low population levels, namely where negative feedback effects move stocks to a very low level or towards extinction. Should SSB fall to levels where spawning becomes unsuccessful due to low densities on spawning grounds, depensation could occur.

The possibility, now put forward, that depensation might have been occurring for up to 20 years, was not considered by the Working Group before. Continued historically low levels of recruitment since 2000 further reinforce the need to consider this possibility. There is now a requirement to consider that depensation may be a reality and that we have reached a minimum viable level of SSB. This conclusion is in line with the basis of previous advice, namely that in the presence on uncertainty, the precautionary principle applies (ICES, 1997).

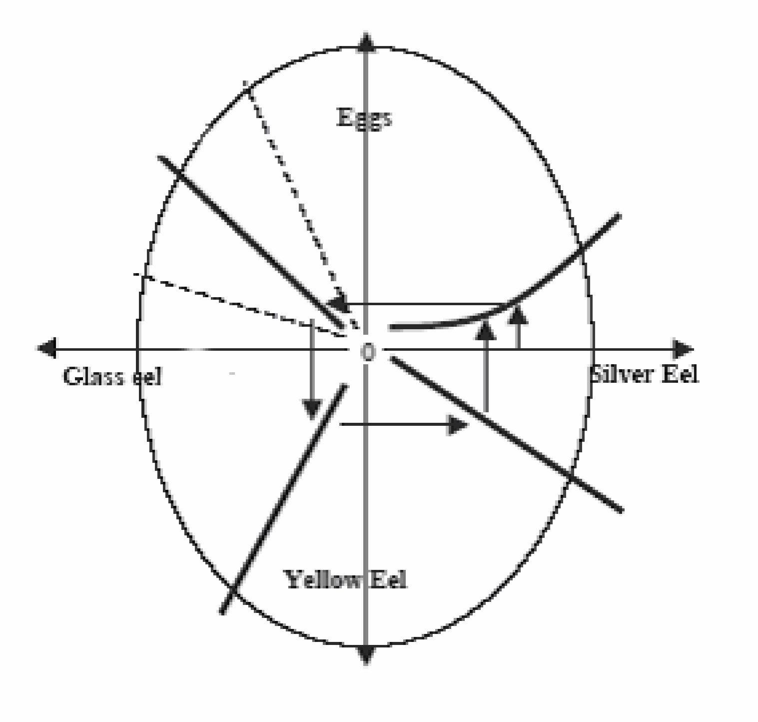

Figure 3.5.1 Production trajectory among the life stages of eel. Production trajectory of stages proceeds in a counter-clockwise manner from silver eels →eggs→glass eel → yellow eels → silver eels. The oval highlights portion of this Paulik diagram corresponding to low silver eel production. This panel shows scenario of low spawning escapement, followed by a depensatory response. (From ICES, 2001adapted).

The issue of possible depensation triggers a new and heightened level of precautionary advice. The critical management objective in a depensation scenario is to return SSB to the level above which recruitment increase results from increased SSB. It is no longer sufficient to manage on the basis of fishing mortality restriction alone. In this situation the logical action is to stop all anthropogenic causes of mortality and in addition to consider re-stocking.

Preliminary modelling results discussed in Annex 3 indicate that a full closure of fishing may be insufficient to achieve an immediate increase in silver eel escapement large enough to escape depensation in the reproductive phase. A further decline in the potential maximum escapement achievable from the continental stock is also inevitable in the medium term as the known recruitment drop in the recent decade feeds through to derived silver eels. The probability of achieving large habitat improvements in the short term is low. In this situation, stocking with a view to maximising spawner output from existing glass eel stock can be proposed as a potential precautionary measure. There are a number of essential preconditions, first of all that demonstrable surplus exists in some local glass-eel stocks, that this is available for use, and that anthropogenic mortality in the recipient areas is minimised.

3.6 Risks involved in re-stocking

The risks involved in re-stocking have been discussed at length by ICES (2000). The major issues concerned are the following:

Movement and stocking of fish involves a risk of decreased genetic variability. Traditionally the European eel has been regarded as a single, panmictic stock (ICES, 2004, WGAGFM). The results of microsatelite analysis (Wirth and Bernatchez 2001)) have challenged this, indicating a gradual change in genetics across the geographic range. Later research on material from the full range of the species (Dannewitz, Maes, Johansson, Wickstrom, Volckaert and Jarvi, submitted) has made it likely that this result may be due to a temporal trend in genetic setup rather than a geographic difference. In that case the stock is indeed panmictic and relocation involves no risk of genetic effects.

Even in a genetically homogenous population, movement of eels may disrupt the migration behaviour. If there is a phase during the glass-eel stage when cues are imprinted then the spawning migration of relocated eels may be impossible or compromised (Westin 1990). In that case the effect of stocking will be absent or less than expected.

The spreading of diseases is always a risk when fish are transported and introduced in new areas. There are known ways of minimising this by the use of quarantines etc.

A further consideration is the observation that the sex ratio of eels varies according to stock density in a catchment. The factors involved in sex determination and the optimum sex ratio of the SSB are unknown, but deliberate manipulation of sex ratio may be an advantage rather than a risk.

In view of these risks, ICES (2000) recommended to prefer seed-stock from within or from nearby river systems, when applying re-stocking as a stock enhancement measure. The potentially beneficial effect of stock enhancement on the production of spawner escapement was noted, but given the (un-quantified) risks involved, a precautionary and risk-averse strategy (enhancement of spawner escapement by reduction of exploitation and other anthropogenic impacts) was preferred.

3.7 Choosing between risks

The current state of our knowledge is now characterised by a balance of unknown risks.

On the one hand is the hypothesis, that the recruitment decline observed since 1980 might be the consequence of depensatory processes in the reproductive phase. Most recent data support this, rather than the alternative hypothesis of environmental variation (in ocean climate) causing increased juvenile mortality, but due to the absence of sufficiently adequate proof, no final judgement can be made. If depensation occurs, a rapid (near)-extinction of the stock is foreseen. Provisional calculations (Annex 3) indicate that a full cessation of exploitation is inadequate to restore silver eel escapement immediately to levels at which depensation is unlikely to occur. Re-distribution of incoming recruitment from areas of highest abundance (core of the distribution area and lower river stretches, where overabundant population leads to density dependent mortality) into lower abundance areas, will potentially increase the overall production of spawners above the hypothesised depensation threshold.

On the other hand, the risks involved in re-stocking, notably: potential genetic pollution; possible transfer of diseases and parasites; re-stocking possibly changing sex ratios; and absence of positive effects due to unfit behaviour of re-stocked eels. The evidence for genetic effects is equivocal. The spread of diseases and parasites can be prevented by quarantine procedures, in theory. It is doubtful, whether re-stocking without positive effects on the spawning stock due to behavioural misfits, has any effect on the natural stock. At the bottom line, although some of the potential negative effects can be remedied, the overall risk involved in re-stocking is unknown, and quantification of the risk within a limited time frame is rather unlikely.

Using re-stocking of glass eel as one of a suite of stock rebuilding measures takes certain risks, but not doing so faces the risk that might continue to collapse towards (near)-extinction. The precautionary approach, in which preference is given to the most risk-averse management strategy, does not tip the scale in either direction, since both ends involve un-quantified risks. As a consequence, the desirability of restocking programmes as an additional stock protection measure must be re-considered, given the current extremely low recruitment of glass eels over much of their range, and the possibly limited time frame (ca. 5 years) available for enhancement of future silver eel escapement to levels at which depensation is unlikely to occur. In this consideration, the inability to quantify the risks involved must be borne in mind.

3.8 Scientific and management actions needed for implementation of a stock recovery plan

The management actions available for correcting stock decline in European eel and moving towards sustainable exploitation have been discussed in previous Working Group reports and other documents (ICES, 2001; Commission paper COM(2003) 573 final). The proposed actions include

1. Measures to limit exploitation by fisheries
   - 1.1. Prohibition of fishing
   - 1.2. Total allowable catches or quotas
   - 1.3. Gear controls
   - 1.4. Landing size limits
   - 1.5. Closed seasons and/or areas
   - 1.6. Licensing of fishermen and dealers
2. Measures regarding eel Habitat re-creation
   - 2.1. Ensuring habitat accessibility
   - 2.2. Reduction of habitat loss
   - 2.3. Ensure habitat and water quality
   - 2.4. Ensure downstream migration
3. Controls on non-fishery mortality
   - 3.1. Turbine mortality
   - 3.2. Predation
   - 3.3. Disease and contamination
4. Restocking measures
   - 4.1. Using glass eels from sources where there is still a demonstrable surplus
   - 4.2. Using eels from aquaculture production (aquaculture being totally dependent on wild seed)

3.9 Time frames for rebuilding measures to take effect

The current stock, fishing yield and spawner production are derived from glass eel that recruited to the continental stock in the mid-1990s. Glass eel abundance in the mid-1990s was around 10% of former levels. Subsequent recruitment has been much lower, with values since 2000 ranging between 1 and 5%. A further decline in stock, yield and spawner production is therefore expected in the coming years; based on an average life span, a reduction in spawner escapement is expected around 2009, which might translate into a further decline in recruitment two years later. Swift precautionary action to protect the production of spawners is required, becoming effective before the recruitment decline in 2000 translates into a corresponding decline of spawner production, in a period of ca. five years.

There is considerable variation in time from glass eel recruit to silver eel emigration, depending largely on temperature, habitat suitability and productivity. At the extremes of the range of the European eel, lifespan from immigrant glass eel to emigrant silver eel ranges from around five to 10 years in the Mediterranean region to in excess of 25 or 30 years at the least productive extremes. This means that measures designed to generate local stock level improvements, for instance by restricting fisheries, restoring access to currently inaccessible habitats, or restocking, will have much more rapid effect in southern Europe than in the areas of longer eel lifespan. Similar measures applied in different areas may have essentially different purposes and outcomes. For example stocking in southern areas could be designed for rapid regeneration of a regional spawning emigration, whereas in long lifespan areas this would be a 20 to 30 year "Insurance policy" aimed at future spawner production. Stock evaluation models must be capable of incorporating the full range of life history strategies in different regions.

Whatever stock enhancement measures are taken, these measures should take place throughout the range of the eel, to insure against the lack of knowledge of possible rates of recovery should oceanic processes prove to be the dominant factor in recruitment decline. In this case, long term "Insurance" measures might be more important than short term, but in the case of continental mortalities being a dominant component, short term measures become more important. Currently, knowledge of the relative importance of the proposed drivers of recruitment decline is so poor that a recovery programme has to cover for both these extreme possibilities.

The history of recruitment decline is such that silver eels now leaving some areas, particularly in the south of the range, are already derived from low recruitment levels following Europe wide declines in recruitment in the 1980s. This is progressively becoming relevant to eels leaving middle and northern parts of the range. Management options based on optimal use of existing silver eel escapement are becoming more limited with time due to age profile and recruitment history. The American fisheries society declaration (Dekker *et al*. 2003) following the Quebec eel symposium in 2003 state that "Opportunities to protect these species (American and European eel) will fade along with the stocks".

3.10 The potential role of oceanic impacts on the eel stock

While the relative contribution of the various possible influences causing stock decline remain unknown, specific focus is necessarily placed on those processes and influences which are potentially manageable. Some authors (e.g. Knights 2003) propose that the over-riding cause of decline is oceanic or climatological, as there is no evident change in known factors – such as habitat, fishing pressure or health status of the stock – that can explain the totality of a drop of recruitment by a factor 5–10 in the last decade (see Dekker 2004 for a comprehensive discussion). This, however, is not a reason for inaction, but rather a driver focusing the need for corrective action on those potential causes of decline which are potentially controllable or correctable by human management action.

3.11 Exploitation control and habitat improvement measures

Just as in the marine spawner to recruit phase, there is severe lack of knowledge of the relative scale of importance of impacts on the freshwater phase. This drives a need for a spread of measures in addition to addressing fishery controls. Some non-fishery factors act in essence like fishery impacts, for instance power turbine mortalities. Others are essentially "habitat restriction" based, such as habitat degradation or access restriction at obstacles. It is important that rapidly acting measures are taken where these are possible, for instance providing access through passes to useful habitat where this is currently blocked, and trapping and transport of elvers upstream and silver eels downstream where the scale and cost of modification to obstacles prevents short term physical modifications.

Market conditions will influence and may limit ability to take measures and vice versa, particularly in the glass eel restocking sector. The effects of measures interact and care must be taken to avoid measures which have detrimental consequences for other potential options.

Existing capability and funding of research and monitoring activity is such that many monitoring authorities are already fully stretched and limited by human resource or other financial restriction. This must be taken into account in proposing measures which will have significant additional cost. There is a natural tendency for management measures to be selected on a least cost basis irrespective of their likely effectiveness.

3.12 Special factors affecting stocked and managed fisheries currently achieving significant spawner escapement

Fisheries supported by supplementary stocking may deviate significantly from their notional "pristine state" and may, through stocking and/or upstream transport of glass eel, achieve higher outputs of spawners in their current managed state than if they were left unmanaged. Fishery activity can support management activity including glass eel transport and import stocking. There is a risk that measures limiting the viability of fisheries to the point where the transport and stocking activity cannot be maintained, could result in a net loss of spawners locally rather than a net gain**.**

Low density freshwater populations tend to produce more females. This may be a natural compensation mechanism by which the eel population is capable of surviving periods of naturally low recruitment. In local management actions, this effect can be used to maximise female spawner escapement, for instance by spreading stocking over as wide a range of productive habitat as possible rather that in one concentrated location. The potential success of such action is based on the usual assumption that female spawning stock is the limiting factor in producing offspring. Alternatively, however, behavioural aspects might require an adequate number of males to be present, in order to perform successful courtship or spawning behaviour.

Nevertheless, the extent of anthropogenic effects on the current stock is such that the stabilisation of the female spawning stock biomass at low stock density can not be used as a reason for failure to take action.

4 Modelling local stock dynamics

4.1 Introduction

In last year's report (ICES, 2004), the WG presented the concept of a Habitat Suitability Index model (HIS), a Reference Condition Model (RCM) with which to assess compliance with biological targets in relation to pristine state, and included a brief discussion on Harvest Rate Models (HRM). None of these was fully worked out, and it was not clear how linkage might be made between them. The group suggested that there is a need to show how we might identify which processes are limiting, how these might be translated into selection and quantitative of advice on management measures, and to clarify the type of monitoring data required to assess status. This can be achieved using HRM focusing on fisheries, though only in relation to exploitation, but neither HIS nor RCM address these issues. Whatever model is used, decision rules are needed to point to the severity of failure, or whether the stock achieves compliance in relation to a target or reference point, and whether and where management is needed (see Section 3).

This Section attempts to detail the features of an "ideal" model, and to provide a template against which those models that are being developed can be tested to see how far we are from achieving this. Descriptions of the methodology and structure of existing models presented at this meeting, their information needs and output are provided in annexes to this report. A more complete overview of relevant modelling approaches is needed to fully aid the future construction of a model.

4.2 Model requirements

The most urgent requirement is for an operating model capable of using monitoring data to assess the degree of compliance with reference points/targets, to indicate the pressures on a population leading to failure, and to quantify the strength of measures needed in relation to exploitation and habitat (e.g. reduction in mortality, increased passage, improved habitat quality). The model also needs to be able to evaluate the effects of implemented measures on stock recovery, through time and in relation to reference points. It should be able to predict changes in size structure and in survival or mortality at size and age (preferably with a spatial component in relation to colonisation front or RCM, for example) and, eventually, spawner escapement. Note that, if the reference point is expressed in terms of spawner escapement, it may be necessary to introduce an index of "quality" of spawners, to account for impacts on reproductive success due to parasites, contaminants etc, thus giving "effective SSB"

The ideal model should be related to mortality at all life stages, identified by size and/or age (at least from glass eel to silver eel escapement), and will be able to use data collected at the various life stages, and several types of data: size structures, presence absence, or densities at different levels of the basin. In evaluating the effects of management measures, the model must be capable of predicting the effects of a change in exploitation level and pattern (mortality at size, age or life stage) or amelioration in habitat, linked through the life stages by the peculiar biological characteristics of eels. (Note that this is more complicated than a similar analysis applied to marine Teleosts, for example, where the only biological parameters considered are usually growth and size at maturity). In relating assessments to targets, a %SPR derived through mortality analysis can be converted into an SSB target by multiplying by levels of recruitment.

The model needs to be capable of being applied uniformally across the European stock area, or at a national or catchment level, operated in a standard way but able to accommodate very different biological conditions as well as different types and quantity of data. It must also be flexible, both to accept sub-model inputs (on habitat quality, for example) and capable of being used in data-poor situations, using proxies for different aspects of stock status (such as mean length of yellow eels), as well as using existing time series to validate both model parameters and output in relation to observed historic stock changes. We also need to ensure that the model can continue to be used in the absence of fishery data (if fisheries are closed), using fishery-independent data collected according to agreed protocols.

Management will need feedback much earlier than the average life span (approx. 11.5 year). It would therefore be useful to relate the output from the model to "checkpoints", giving not only an assessment of stock status in relation to the reference point, but indicating whether changes from the glass eel to silver eel stages fit with what was predicted from either changes in recruitment, fishery management measures or habitat improvement.

It may be also useful in the future if the model has the ability to utilise the results of socio-economic analyses, so that it is possible to carry out a cost-benefit evaluation of different management measures (and therefore their likely acceptability).

4.3 Information needs

By carrying out a sensitivity analysis, it should be possible to indicate which data and parameters are most important for model output and, consequently, what are the most informative data to be collected, and also to indicate the confidence that we have in the output. This should also help to address the question of where is the best place to sample, indicating whether we need population information from representative sites in a whole catchment, if it is possible to provide advice by sampling just the most informative part of the population/life stage, and indicating the need for further research.

Note that it may be necessary to identify and measure two phases of recruitment: of glass eels in relation to spawning success; and of pigmented elvers or small yellow eels in relation to recruitment to the yellow eel population and exploited part of the stock. There may be a linear relationship between these at present low levels of recruitment (an assumption that needs testing?), but probably not at higher levels, due to density dependent processes in the phase in-between. Thus, recruitment of small yellow eels might be the most important measure in many catchments, with or without glass eel fisheries, whilst trends in glass eel recruitment can be measured at the existing (20) index sites, possibly extended into presently uncovered areas such as the Mediterranean and Eastern Baltic.

If information on biological parameters is not available for individual catchments, we can use biological rules (an eel is an eel) to make assumptions on , for example, growth, size at silvering, using temperature or other environmental information to adjust parameters known from catchments with other conditions. On the question of habitat quality, the Group notes that indices are already available from work on salmon conservation limits, linking physical features to juvenile production in Northern Europe(though they will need to be extended into lakes and more lowland habitats, even estuaries, and more southerly regions, e.g. Mediterranean), and for eco-regions and the EU FAME project. The degree of connectivity is also important, and indices of “passability” of elvers and yellow eels upstream and silver eels downstream between reaches are required.

One problem identified in this context is the problem of weighting production or population structure measured in different parts of a catchment, in relation to the productive area of each part (considering the adopted definition of pristine state), and especially in estuaries/marine waters compared to fresh waters. In many systems, the main part of the production of spawners could come from outside freshwater and be very difficult to measure. A similar problem exists for deep areas in the freshwater, especially lakes, and methods such as trawling could be used to measure size structures (or age structures) and estimate densities. In lakes, however, the measurements of productive area enable us to calculate absolute numbers, whereas estuaries are more “open ended” and it may not be possible to provide estimates in many cases.

4.4 Future plans

Most importantly, we need to know how far we are from having a model we can use, because we cannot afford to wait much longer. It is recommended that a workshop is held within the next 6 months, at which the results of intersessional work testing the available models, including modelling concepts not represented within the present Working Group, where at least one good data set will be examined and decisions made as to which features of the various models could be used in an operating model.

5 Monitoring of eel stock and fisheries

5.1 Introduction

Monitoring stocks of European eel in a comprehensive manner to evaluate progress of a stock recovery plan will be a complex process that will require careful planning and a high degree of international cooperation. The unique biological characteristics of this species (trans-Atlantic migrations, panmixia, euryhaline physiology, facultative catadromy, variable growth / maturation, extensive continental and coastal range, etc) and variation in the life-history stages (glass eel, yellow eel, silver eel) exploited in different countries are factors that need to be kept in mind. However, the primary objectives should be to enable stock assessments to be made, as required, at catchment, national and overall European levels. Annual stock assessments, and periodic (5-year e.g.) stock management reviews, will be essential for evaluating the progress of the international stock recovery plan. Likewise, such stock assessments will be necessary for individual governments to determine that compliance with recovery plan catchment or national targets is adequate, as well as to enable the overall progress of the plan to be evaluated. Short-term, medium-term and long-term evaluations will require the focus of the monitoring programmes to be progressively adapted, taking account of life-history traits and future fishery activities. Pilot projects, to refine data acquisition protocols, to test models and in selected catchments are anticipated. A workshop specifically addressing monitoring problems is also recognised as being important to develop practical cost-effective programmes that will be applicable at different stock management levels and throughout the range of the species.

It is important that data on stock trends and mortality factors are representative of the total spawning population(s?).Therefore, special adaptations of monitoring programmes may be required in respect of the non-EU areas. Likewise, special integration of monitoring activities will be appropriate in respect of major marine basins (Baltic, Mediterranean) and larger international river systems. International cooperation in monitoring eel catches, as indicated by export/ import records and other eel trade statistics, should also be promoted in future.

Implementation of the WFD will provide opportunities for acquisition of data on eel stocks and environmental conditions in inland and transitional eel habitats. The potential synergies between the WFD and eel monitoring programmes, from catchment to international levels, needs to be more widely recognised so that where practicable fish stock surveys are undertaken using protocols appropriate for eel stock assessments. Likewise, data management for eel monitoring purposes should be compatible with systems adopted at national and European levels for the WFD. Highlighting special requirements, such as the need to fully document fish stockings and anthropogenic obstacles to fish migration, as part of WFD national programmes could significantly increase the quality of eel population data that can potentially become available, at little extra cost, throughout much of EU.

The objectives for the monitoring are:

- evaluate progress towards the objectives of a stock recovery plan
- assess the compliance at sub-sampled (cf. WFD) catchments, national levels, EU levels and EU-Plus (Non-EU countries contributing to the eel stock) levels

When appropriate, at least the output of the monitoring on the different levels should be standardised among the nations.

The main geographic compartments to consider with regard to the different life stages are the Atlantic, the Mediterranean Coasts and the Baltic Sea. Large international river systems also need special attention.

The need of intercalibration exercises should also be considered.

5.2 Fisheries monitoring

The following items should be considered:

- catches (location/catchment, age- and size-structures)
- Effort
- CPUE

In regard to fisheries monitoring there is a need for catch data to cover the whole distribution area of the species. These data include commercial landings, angling and non-commercial catches, as well as discards.

There is a hierarchy of information needs relating to capture fisheries. At the International and National level the minimum data required is total catch for each life stage (glass eel, yellow eel and silver eel). At the catchment level and local levels more detailed data are necessary for management specifically data on catch, effort (CPUE) as well as size structure (and possibly age structure and sex ratio for the yellow and silver eel component), by gear type and location.

Ideally catch and effort data should be obtained using a logbook scheme where the fishermen records the weight of eel caught and the location on a daily basis. For passive gea, the number of instruments (hooks, traps, fyke net ends etc) and the number of nights deployed need to be recorded. For active gear such as trawls it is necessary to have some estimate of distance fished or time spent fishing. These data can then be summarised to provide monthly and/or annual reports as necessary. Improvements in the accuracy of the data can be obtained by the inclusion of observers on board the vessels or accompanying some of the fishermen, this also provides an opportunity to obtain supporting biological information. Information on landings can also be obtained from dealers and from custom and excise and does enable the accuracy of the returns to be assessed.

Catch returns should be compulsory for all types of licensed eel fisheries, and ideally be sent into the administrating body at monthly intervals through the season, as this helps to ensure compliance and reporting deadlines. However, in certain countries, considerable quantities of eel are caught quite legally by net fishermen who are not included in the licensing system. These fishermen either need to be included in the catch return system or their catch estimated using other methods such as postal or telephone surveys.

These data should be stored on a database to enable summary catch statistics to be produced and further analysis to be carried out at national and international levels. Biological data on the catch will also be needed and sampling will need to be stratified in relation to the size of the fishery, gear type and location.

5.3 Stock monitoring

The following should be considered:

- Recruitment
    - Natural *vs.* restocking
- Yellow eel
    - As recruits
    - Abundance, age, size, growth, mortality
- Silver eel escapement
    - Contaminants, pathogens

5.3.1 Recruitment

The recruitment of young eels to Europe is divided into two components, one being the oceanic part with glass eels at the coasts representing the spawning success and the other is the recruitment of larger eels to the yellow eel stock and to the exploited part of the stock, i.e. into catchments. The relationships between these two components are not known in any detail but density dependent processes are probably involved.

Recruitment needs to continue to be monitored according to the scheme outlined in the Final Report from the EU Concerted Action on Glass Eel Monitoring (Dekker 2002). In short, about 20 indices are derived from various sources of experimental and standardised sampling (like Den Oever, Netherlands), catches of ascending glass eels in eel passes (e.g. River Viskan, Sweden) or from fisheries data (e.g. Loire, France). Data representing true glass eels and later stages of the same age class are preferred. However, in some countries the only available data concerns older and mixed year classes. Such series could also be used as indices but should be dealt with separately (see 2.1 above). The network of existing sites from where recruitment series derives has considerable gaps in coverage which need to be filled by new, additional sites.

Data series from eel passes should preferably cover the whole season as the upstream migration varies between years due to water temperatures, flow etc. For similar reasons, fishery dependent data has to cover a considerable large part of the whole season

As restocking is a common practise and might become an important tool in a recovery plan, it is of outmost importance to monitor and keep good records on stocked numbers and weight. Additional data on where they are stocked (at least at a catchment level, but preferable referring to water body), their origin and life stage are also required.

5.3.2 Yellow eel

Yellow eel stocks are to be monitored as recruits to distant parts within the eel's distribution area and to freshwater (e.g. as in the Baltic Basin).

Monitoring yellow eel stocks in the more traditional way includes sampling from the stock to achieve estimates of their abundance (CPUE), size- and age distributions. There are several methods to adopt. Depending on the size structure of the stock and kind of habitat, methods such as electro-fishing, fyke netting, long lining, trawling etc. could be used. All methods are more or less selective, so the results have to be corrected for that. It is important that the samples are taken from non-graded catches. Large rivers might pose sampling problem, being too large for electro-fishing and to swift for e.g. fyke-netting and trawling.

Coastal areas, e.g. as in the Baltic Sea are complex systems with very long shore lines and gradients in salinities, water depths, productivity etc., making representative sampling difficult to perform. One approach to be further investigated is sampling with e.g. fyke nets along a number of transects from the inner parts of an archipelago to outer areas down to a certain water depth.

5.3.3 Silver eel escapement

The silver eels leaving Europe for the presumptive spawning area in the Sargasso Sea might be the most difficult part of eel's life to monitor. Silver eels are often descending rivers when sampling is difficult to perform due to high velocities, low temperatures and large amounts as debris are clogging the fishing gears.

Due to this and other reasons, estimates of total numbers of silver eel escapees are often hard or impossible to achieve and we have instead to relay on measurements of CPUE and other indices. In some cases, mark-recapture studies could help when correlating an index to the true values of silver eel escapement. In cases when such data all are not available, the yellow eel stock may be used as a proxy.

The biological sampling should include size, sex and age determination. Samples for that could be obtained from any more substantial fishery in a catchment according to some stratified sampling scheme. In catchments and areas without a fishery for silver eels samples might be taken from monitoring stations set up using some appropriate technique as fixed traps (pound nets) in standing waters or fishing weirs and eel boxes (Wolf-traps) in rivers (but see above on difficulties).

The extent and importance of silver eel escapement from some areas as the eastern parts of the Mediterranean Sea (e.g. Greece, Turkey and Egypt) is virtually unknown. Therefore it is important to have a good coverage all over the distribution area of the European eel.

An approach to representatively monitor the three major life stages in the European eel requires a full coverage of the main distribution area of the species. Details concerning sampling strategies with respect to spatial and temporal coverage and intensities are not yet formulated and requires a thorough analysis taking into account what the appropriate models require.

5.3.4 Contaminants and pathogens

Eels are as long-living, slow-growing and semelparous fish susceptible to a variety of persistent organic pollutants such as PCB, DDT, dioxins etc. They are also hosts of a large variety of parasites and other pathogens. They might all influence and decrease both the survival (quantity) and the quality of silver eels that supports the spawning stock, i.e. they are probably involved in the dimensioning of the effective population size.

Although we do not yet know the importance and relationships between these factors and the effective population size, we have to monitor and to investigate the importance of some of these factors and the quality of silver eels.

5.4 Habitat monitoring

Monitoring the habitat of the eel should preferably be done by making use as much as possible of the habitat monitoring in the WFD (2003).

The WFD covers all waters including inland waters (a.o. surface water) and transitional and coastal waters up to one sea mile (and for the chemical status also territorial waters which may extend to 12 sea miles) from the territorial baseline of a Member State independent of the size and the characteristics.

This totality of waters is, for the purpose of the implementation of the Directive, attributed to geographical or administrative units, in particular the river basin, the river basin district, and the “water body”. All water bodies are classified to Rivers, Lakes, Transitional Waters and Coastal Waters and these four elements all are included in river basins.

National authorities are responsible for reporting to the EU.

Rivers with catchment areas greater than 10 km^2 and lakes greater than 0.5 km^2 in surface area are water bodies that fall under the requirements of the Directive and might need to be included within the water status assessment and monitoring.

The Directive requires that sufficient surface water bodies are monitored in surveillance programme to provide an assessment of the overall surface water status within each catchment and sub-catchment within the river basin district. Operational monitoring is to establish the status of those water bodies identified as being at risk of failing their environmental objectives, and to assess any changes in their status from the programmes of measures. Operational monitoring programmes must use parameters indicative of the quality element or elements most sensitive to the pressure or pressures to which the body or group of bodies is subject.

Surveillance monitoring has to be undertaken for at least a period of one year during the period of a River Basin Management Plan (RBMP). The deadline for the first RBMP is 22 December 2009. The monitoring programmes must start by 22 December 2006. The first results will be needed for the first draft RBMP to be published at the end of 2008, and then for the finalised RBMPs at the end of 2009. These plans must include status maps.

Although the quality element (QE) “Fish” is only mentioned in Rivers, Lakes and Transitional Waters, the habitat in general sense will also be monitored in coastal waters. As coastal waters are important habitats for eel, the WFD habitat monitoring results can be used in the habitat models for the eel.

The WFD applies for all EU-countries. The habitat will be sampled according to the WFD in more or less the whole geographical distribution area of the eel and in both coastal and in inland waters and in rivers as well as in lakes. Note, however, that non-EU countries in the Southern and Eastern Mediterranean and Norway are not involved in the WFD.

Data collected with regard to the habitat will not only be the quality parameters, but will also be surface areas of habitat and hydromorphological pressures such as weirs (and hydropower stations?). Therefore, if available, the data can relatively easily be aggregated to different management levels: the Baltic, the Mediterranean, the Atlantic Coast, large international rivers, catchments, national and European-plus levels.

5.5 Use of WFD habitat data for the eel

The extent to which the WFD data are sufficient for the use for management purposes of the eel depends on the input variables of the habitat models for the eel. As has been discussed elsewhere, these input variables are not known yet. One may conclude at this stage that the WFD habitat data are likely to provide sufficient data, but this has to be checked.

There is still some uncertainty about the exact habitat parameters sampled by the member states and how they will do their samplings, because they may decide about that by themselves to some extend. This is another reason why it is not possible at this moment to compare the habitat data generated by the WFD with the habitat data needed as input for the habitat models. Additional inquiries are needed to get a clear picture of the actual practise of habitat sampling foreseen in the EU member states (has any MS made plans, yet?).

The use of the WFD data for eel management is not stipulated in the WFD. It is important that these WFD data will become available for drawing up the models and ultimately for the management of the eel on a catchment and higher scale by using these models by the appropriate authorities.

It is therefore recommended that the results of the monitoring programmes on habitat indicated in the WFD are made available for use by scientists and managers involved with recovery plans for the eel. Eel specific extensions of the WFD should be considered in order to increase efficiency.

5.6 Fisheries Data Collection Programme

The following items should be considered:

- Precision and accuracy
- Sampling strategies (including also restocking)

  - Subsampling (stratified), catchment and national levels, exploited or not Compliance is required on the national basis, not always on a catchment basis.
  - To evaluate to which extent data from WFD enables compliance to be assessed
- Pilot projects
- Database management
- Communication (feedback to the stakeholders and authorities)
- Financial resources and costs
- Non EU data sources (if available and how to include them)

The fundamental objective is to be able to report on progress of the stock recovery plan, in essence being able to estimate compliance with the target of silver eel escapement of 50% of that under pristine conditions, for the stock as a whole and the trend over time. The main issue being that the stock is widely dispersed over numerous countries and water bodies. It is very unlikely that all water bodies would be assessed for compliance and as such compliance will need to be determined from a subsample of water bodies. Subsampling might be carried out on the following basis:

Fished / unfished waters

Size of river

Habitat: lentic / lotic / transitional / coastal waters

Distance from upstream from the tidal limit

For glass eel there are at the moment circa 20 locations where recruitment is monitored annually. These monitoring programmes need to be maintained as they will provide the first indications of the effectiveness of the management actions taken towards rebuilding the stock.

In a few instances, it will be possible to estimate spawning escapement directly or through mark recapture programmes, but in the vast majority of cases this will not be possible. Silver eel escapement will therefore have to be derived from the yellow eel stock. Though the methods for catching yellow eel are well established, only electric fishing can provide robust estimates of abundance. However, electric fishing is limited to shallow wadeable areas of stream and thus many areas of the catchment (lakes, deep (>1 m) riverine stretches and transitional waters) will be underrepresented. It is therefore suggested a pilot(s) study be undertaken to investigate how best quantify the standing stock of eel in a catchment

The WFDoffers a potential source of data and it is imperative that the data available be assessed with that required for eel in order to ensure efficiency savings. Additional monitoring programs will then be required to assess the shortfall in data requirements, for example an eel-specific programme is likely to be needed to obtain the necessary biological data. It is important to ensure that databases are compatible allowing efficient integration of different data sets, for example environmental data with abundance data.

One of the main concerns is that the data obtained as part of the WFD will not be of sufficient accuracy or biologically detailed, as the surveys will target all species and thus eel will be underrepresented. Figure 5.6.1 shows that the density of eel assessed, at the same site, was substantially lower when all species were targeted as opposed to when only eel was the target species. In fact what appears to be the case is that there is an upper limit of eel recorded at a site irrespective of the actual density of eel.

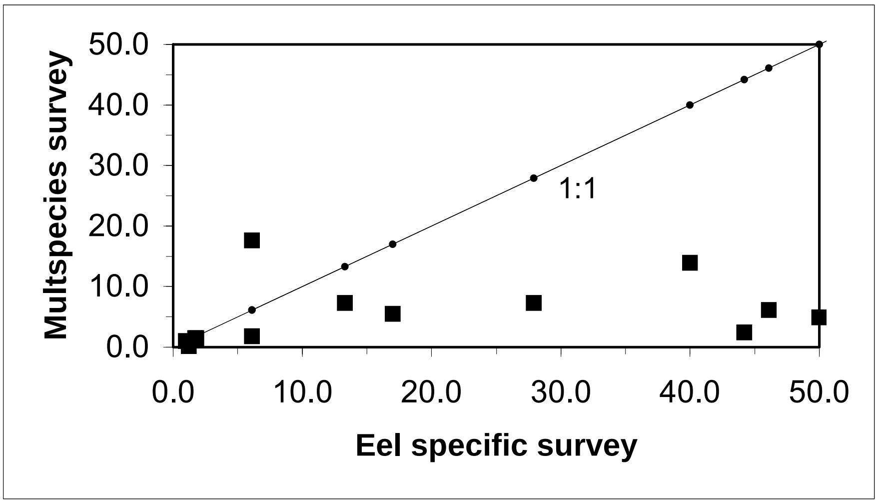

Figure 5.6.1. Comparison of eel density (100m)^2 in multispecies surveys and in eel specific surveys (Knights *et al*, 2001).

5.7 Feedback of results to the management

The following items should be considered:

- Which management (catchment, local, regional, national, EU….)?
- What to feed back? ((analysis), status of fish, fisheries and habitat, advice)
- Periodicity (annual, with a five year review?)
- How are we progressing towards our stock recovery objectives?

6 Conclusions and Recommendations

6.1 Conclusions from this report

Review of the available information on the status of the stock and fisheries of the European eel supports the view that the population as a whole has declined in most of the distribution area, that the stock is outside safe biological limits and that current fisheries are not sustainable. Recruitment is at a historical minimum and most recent observations indicate the decline continues in many areas. There is some evidence that depensation in the reproductive phase might be involved, triggering a new and heightened level of precautionary advice. Under this situation, the advice is to restore SSB above levels at which depensation is expected not to occur.

Evidence has been given in earlier reports that anthropogenic factors (e.g. exploitation, habitat loss, contamination and transfer of parasites and diseases) as well as natural processes (e.g. climate change, predation) have contributed to the decline. Measures aimed at recovery of the stock are well known and may include control of exploitation, restocking of recruits and restoration of habitats (including access to and from).

The continental population extends throughout Europe and northern Africa and fisheries are scattered over many large and small water bodies, both marine and fresh water. Management at the local level has not adequately addressed the global decline of the stock, and no co-ordinated stock-wide management framework has been set up. The continuation of the decline demonstrated by most recent data makes the development and implementation of an international stock recovery plan a necessity.

6.2 Strengthening the knowledge base

The information in this report constitutes a further step in an ongoing process of documenting eel stock status and fisheries and developing a methodology for giving scientific advice on management, specifically for eel. To this end, a line of thought has been generated in previous reports (ICES, 2000; 2002), and an inventory of ultimately required knowledge assembled (Moriarty and Dekker 1997; ICES, 2000; 2001). Given the depleted state of the stock, urgent management actions are required, as emphasized in the recent Communication from the Commission (COM 2003, 573 final). Past meetings of the working group have focused on compilation and completion of the data base for assessment of the status of the stock and subsequent management advice; the current meeting explored the monitoring and assessment framework required for sustainable management of the stock and fisheries.

A recurring theme in previous reports has been the inadequacy of the available data base for analytical assessment of the stock and impacts on it. As indicated in Section 5, improvement of the data base will undoubtedly be required, by judicious extension of field programmes (e.g. Fisheries Data Collection Programme FDCP) as well as by incorporation of data resulting from ongoing programmes (e.g. Water Framework Directive WFD). Monitoring of recruitment, stocks, fisheries and escapement should be at least sustained at current levels. It is unlikely that substantially more and better data, although mandatory for sustainable management of the eel, will become available in short term. Current obligations for monitoring (Fisheries Data Collection Programme and the monitoring under the Water Framework Directive) are not yet adequate for assessment and sustainable management of the eel stock, both in contents and in envisaged time frame. The Water Framework Directive sets a time horizon of several years, while the Fisheries Data Collection Programme already includes an obligation, but not a standing practice of recording landings and monitoring stock and fisheries. Further completion of the conceptual framework, development of assessment and modelling tools and establishment of an international data clearinghouse, overall stock assessment and post-evaluation system must therefore proceed on the basis of the already available, albeit incomplete information.

The global objectives of stock protection and rebuilding must be translated into actual management targets at the national and regional level, considering the three exploited life stages, as well as habitat restoration. It is highly unlikely that a full analytical assessment of the status of a local stock and the anthropogenic impacts in relation to these targets can be implemented in all the waters in Europe where eels are found. Pragmatic approaches and the inclusion of models are required, an initiative that is currently under construction in several research institutes in Europe. Coordination, standardisation and comprehensiveness will be required, to achieve a flexible, cost-effective, adequate, and mutually accepted approach throughout the distribution area. These developments would benefit from, and be accelerated by, provisional application in test case projects. The existing information available for a small selection of catchments is adequate to allow for a pilot implementation. Organisation of a workshop is recommended, in which modelling approaches across Europe are compared, a comprehensive and common approach is selected, and applied to real data available for a judicious choice of water bodies.

6.3 Recommendations

The EIFAC/ICES Working Group on Eels at its 2004 session in Galway (Ireland) reiterates its recommendation first made in 1999 that:

- An international recovery plan for the European eel stock be developed for the whole stock on an urgent basis and that exploitation and other anthropogenic impacts on production/escapement of silver eels be reduced to as close to zero as possible, until such a plan is agreed upon and implemented;

And now recommends that:

- Further development of methodologies to assess stock status, set conservation and management targets, assess compliance with these targets and post-evaluate the effect of appropriate management actions is organised in a work programme, in which existing research efforts are integrated and applied to test cases of water bodies, for which data are readily available.
- The monitoring activities required by the Fisheries Data Collection Programme are implemented for the eel stock and fisheries immediately, and that the adequacy of the monitoring programmes, is reconsidered specifically for eel.
- Under the implementation of the Water Framework Directive, eel specific extensions should be considered/evaluated.
- The desirability of restocking programmes as an additional stock protection measure is given urgent consideration, given the current extremely low recruitment of glass eels over much of their range, and the possibly limited time frame (ca. 5 years) available for enhancement of future silver eel escapement to levels at which depensation is unlikely to occur. In this consideration, the inability to quantify the risks involved must be borne in mind.

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Annex 2: Revision of eel landings statistics

In 2003, the Working Group recognised in its report (ICES 2004), that the statistics on eel landings as collected by ICES and FAO, contained major inconsistencies. It was then decided not to present updated and corrected data series, but to initiate a major revision process. To this end, the data series have been compiled, and circulated amongst the participants in the intersessional period, and following the 2004 meeting, a group met at FAO (Rome, Italy), on 6–7 December, 2004. This subgroup included the chairman of the eel working group (W. Dekker), and the secretary *ad interim* of EIFAC (G. Marmulla), and had some input from FAO Fisheries Statistics (L. Garibaldi and A. Lowther) and from the Italian participant to the WG (E. Ciccotti).

During this meeting it was found, that the complexity and sheer number of problems involved in updating and correcting the landings statistics was such, that derivation of a final set of data series was still far outside reach. It was therefore decided, to describe and list the data inconsistencies (see Tables A.02.1 and A.02.2, below).

Provisional inspection of Table A.02.2 and the details in the data series indicates that the inconsistencies found in the data relate to:

- *Incomplete spatial coverage of administrative regions (e.g. Netherlands, UK, Spain) and/or inadequate reports following a redefinition of political boundaries (e.g. Germany now reporting only Eastern German catches; historical problems occur for Soviet Union, Germany, Yugoslavia and Czechoslovakia),*
- *Incomplete coverage of various types of fishing companies; major focus on large, well organised fishing companies, while the majority of eel catches is made by small-scale, additional-income fishing companies. Additionally, recreational fisheries (angling) and non-commercial, frequent fishers apparently have a major impact on the stock, but these catches have nowhere been included in the landings statistics. Overall, unreported catches are in the same order of magnitude as reported.*
- *Inadequate identification of the species involved. This concerns the culture of European eel in Eastern Asia, for which the data are lumped with cultured (native) Japanese, and introduced American and other eels. Part of the Asian production is marketed in Europe.*
- *Confusion about the proper definition of Capture fisheries versus Aquaculture. FAO has defined these categories*[1]*, but strict application labels nearly all eel production as Aquaculture. Standing practice currently lists under Capture Fisheries: harvesting of wild stock in outdoor waters; idem, stock enhanced by re-stocking; idem, re-stocking in eel-free, outdoor waters – and lists under Aquaculture: harvesting of eel from waters, heavily modified to increase the eel production; idem, stock enhanced by re-stocking; indoor facilities (often re-circulating water) using wild seed stock. Confusion arises from the discrepancy between the formal definition and the uniformly applied standing practice.*
- *Inconsistencies in handling underreporting. Some countries include an estimate of the unreported catches, while others exclude all unreported catches completely. Additionally, implementation of the EU Fisheries Data Collection for eel will presumably have a major*

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1 Aquaculture: The farming of aquatic organisms including fish, molluscs, crustaceans and aquatic plants with some sort of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture.

By exclusion, Capture Fisheries then indicates the capture of natural resources, without intervention in the production process, and without an explicit ownership.

effect on the level of (under)-reporting, jeopardising the interpretation of trends in the coming years.

- *Multiple sources of information within countries (e.g. trade data versus logbooks; gutted versus fresh weight), with divergent results, and inconsistent selection of the data source over the years.*

Updating and correcting data series for individual countries is referred back to the Working Group, with the specific recommendation to further this process by requesting individual countries to address the problems listed, in their national reports to the Working Group for the coming year. Following this revision, the Working Group should then consider whether to recommend revisions to the national data series, as reported to FAO and ICES.

While this revision process is in progress, FAO and ICES should (re)-consider, whether their data base structure allows for adequate storage of the data concerned. As indicated in earlier WG reports (1988), statistics on eel production must be life stage specific, to present a meaningful piece of information. Apparently, this situation is rather specific for eels only. The EU Fisheries Data Collection Programme has applied a pragmatic solution, by listing each life stage as if it was a separate species. It is recommended that FAO and ICES consider the same pragmatic solution, and adapt their data bases and reporting forms accordingly.

The following countries are within the distribution area of the eel, but do not report eel catches: Iceland, Scotland, Luxemburg, Malta, Croatia, Bosnia and Herzegovina, Cyprus, Syria, Lebanon, Israel, Libya, Austria, Moldova, Romania, and Bulgaria. Although catches per country might be small, their combined effect might be comparable to that of many other countries.

Countries reporting eel production to FAO, but not participating in the Working Group, are listed in Table A.02.1, while Table A.02.2 provides details for countries participating in the Working Group.

Table A.02.1. Assessment of the characteristics of eel landings data series, as reported to FAO and ICES; countries not participating in the Working Group.

			Total production reported to FAO (2002)		High temporal variation (>300 %)	
	Country	Statistical area	Capture fisheries	Aquaculture.	Capture fisheries	Aquaculture.
Apparent flaws in reported data	Finland	Inland			alas	
		Atlantic				
	Estonia	Inland	22			
		Atlantic	27		alas	
	Lithuania	Inland	2		alas	
		Atlantic	11			
	Poland	Inland	235			
		Atlantic	127		alas	
	Portugal	Inland		4		alas
		Atlantic	36			alas
	Serbia and	Inland				
		Mediterr./Black Sea	2	2		alas
	Albania	Inland	23		alas	
		Mediterr./Black Sea	2			
	Greece	Inland	5	332		alas
		Mediterr./Black Sea	20	101	alas	
	Tunisia	Inland		9		alas
		Mediterr./Black Sea	202		alas	
	Morocco	Inland	200	23	alas	
		Atlantic				
		Mediterr./Black Sea		24	alas	
	Hungary	Inland	18	36	alas	
Eel catches reported	Norway	Inland				
		Atlantic	310			
	Russian Fe	Inland	3			
		Atlantic	52			
		Mediterr./Black Sea				
	Latvia	Inland	9			
		Atlantic	2			
	Italy	Inland	157	1622		
		Mediterr./Black Sea	245	77		
	Slovenia	Inland	2			
	Macedonia	Inland		35		
	Turkey	Inland	147			
		Mediterr./Black Sea				
	Egypt	Inland	1802			
		Mediterr./Black Sea				
	Algeria	Inland		33		
		Mediterr./Black Sea				
	Switzerlanc	Inland	2			
	Czech Rep	Inland	28			
	Slovakia	Inland	7			
	Belarus	Inland	10			
	Ukraine	Inland	5			
	Eastern Asia		-	(10000)		

Table A.02.2. Assessment of the characteristics of eel landings data series, as reported to FAO and ICES; comparison of official data to Working Group estimates.

			Total production reported to FAO (2002)		High temporal variation (>300 %)			Production by type of fishing companies (tonnes, 2002)					Working Group estimates (2002)		Reported vs. Estimated (%)		Life stages, data separately available for		
	Country	Statistical area	Capture fisheries	Aquaculture.	Capture fisheries	Aquaculture.	Spatial coverage of administrative regions complete?	Eel is main income	Eel is additional income	Non-commercial, frequent fishers	Anglers	Illegal fishing	Capture fisheries	Aquaculture.	Capture fisheries	Aquaculture.	All life stages combined	Glass eel vs. others	Glass eel, yellow eel and silver eel separately.
								Bold=reported to FAO/ICES - *Italics*=guestimates +=negligible quantity - ?=unknown, not negligible											
Working Group participants	Sweden	Inland	102	167		alas	ok	**102**					102	190	100	88		+	
		Atlantic	531				ok	**531**		*1000*			1531		35			+	
	Denmark	Inland	18	2674		alas	ok	**18**+*13*	?	*8*	+	+	39	1880	46	142			
		Atlantic	551				ok	**551**	?	*138*	+	+	689		80				
	Ireland	Inland	104				ok	**81**+*14*		0	?	?	95		109		+	+	0/62/33
		Atlantic					ok												
	Northern Ir	Inland	561	0			ok	**528**	**33**	+	+	+	561	0	100	-		33	528
		Atlantic					ok												
	England ar	Inland	122	0			ok	?	?	?	+	?	122	0	100	100		5	
		Atlantic																	
	UK	Inland	561																
		Atlantic	10																
	Germany	Inland	500	150			alas												
		Atlantic	135		alas		alas												
	Netherland	Inland	353	3868	alas		alas	**353**+*150*	*375*	*0*	*1000*	+	1878	3800	19	102	+	+	
		Atlantic	20				alas	**0**	**20**+*115*	+	*100*	+	235		9		+	+	
	Belgium	Inland	30	100		alas	ok												
		Atlantic					ok												
	France	Inland	130	42		alas	ok	**130**+*20*	*220*	*2000*	*?*	?	2370	42	5	100		+	
		Atlantic	157		alas		alas	**157**+*443*	*330*	*?*		?	930		17		+		
		Mediterr./Black Sea	105		alas		alas	**105**+*95*	*300*			?	500		21		+		
	Spain	Inland		540	alas	alas	alas												
		Atlantic	21	14	alas	alas	alas												
		Mediterr./Black Sea	72				alas												
	Italy	Inland	157	1622									157	1622					
		Mediterr./Black Sea	245	77									245	77	100	100			
	Sum, count or average		4485	9254	6	6	9	1981	1393	2000+?	1100+?	?	9454	7611	47	122			

Annex 3: Overview of modelling approaches currently under development

In Section 4 of the main report, the need for and the characteristics of a modelling tool for eel management is described. There, main focus is on requirements and future developments. In this Annex, ongoing national research to develop models for specific situations is described. These national efforts are seen as the starting points for future development of a comprehensive, unified model. The presentation in this Annex is limited to those that were presented during the meeting of the Working Group; that is: this overview is certainly not exhaustive.

A.3.1 Proximate model to calculate compliance at the glass eel stage

Results of a discussion within the French GRISAM group.

A.3.1.1 Objective

The objective of the model is to calculate a proxy for the compliance with reference points at the glass eel stage.

A.3.1.2 Translation of reference point into reference point per stage

The % SPR methods allow the translation of objective per basins to objective per stage: F' = Anthropogenic mortality rate, F'=F+H, with F mortality rate related to fisheries and H habitat related mortalities.

%SPR=(Spawner per recruit $)_{F'}$/(Spawner per recruit) $_{F'=0}$

If one indicates by:

R=Glass eel stock entering the basin,

Y= Yellow eel stock subjected to exploitation and habitat related mortalities,

S=Silver eel migrant stock subjected to exploitation and habitat related mortalities (turbines, PCB, parasites…),

G=Spawner stock,

And by α, β, γ the percentage of survival concerning glass, yellow and silver migrant eel phases, we have Y= αR, S= βY, G= γS and G/R= αβγ

For mortality level F', we have

%SPR= $(G/R)_{F'}/(G/R)_{F'=0}$

The percentages of survival vary according to the degree of exploitation: one can compare Y = $\alpha_{F'}$ R corresponding to a level of mortality F', and Y=α_0R corresponding to a pristine mortality level. With the same method, we can define β_F and β_0, and $\gamma_{F'}$ and γ_0. Thus $\alpha_{F'}\beta_{F'}\gamma_{F'}/\alpha_0\beta_0\gamma_0$=%SPR.

This writing makes it possible to transpose the values of total survival into values of survival by stage, and address separately the question related to the different stages, in the case of basins where mortality (reduction of survival) takes place for several stages. For example, for a balanced partitioning of the resource to achieve the 50% target, mortality values for the three stages should not exceed 80% of the level F' =0. For example, the yellow eel per glass eel rate after anthropogenic mortality must be larger than 80% of the rate without mortality ($\alpha_{F'}$/

α_0>80%), or in other words the reduction of yellow eel number subsequent to the anthropogenic mortality of glass eel should not exceed 20%.

It is also possible (and necessary) to break up survival by taking account of survival related to the habitat (or reduction of survival due to degradation of habitat), for example S= β_F β_H Y, with β_F=surviving fishing, β_H= habitat related survival.

A.3.1.3 Description of the model

The model applies during glass eel migration in the estuaries, and does not account for mortalities occurring at the settling stage *i.e.* when the glass eel recruit to the yellow eel phase. It uses the indicator of filtered volume by the fishery or industrial filtration as a proxy for exploitation rate, but also includes habitat and environmental conditions in a comprehensive model to calculate the current level of survival compared to the pristine level (only considering natural mortality).

A.3.1.4 Inputs

The model uses logbook information to calculate the seasonal fishing effort of the whole fishery. The filtration capacity of the fishing units is calculated from the relative speed of gears and from the fishing gears' cumulated fishing surface area. It translates into filtration flow in m^3/s of effective effort. The ratio between daily filtration by the fishery and the volume of the estuary is called rate of filtration and is a proxy for the exploitation rate. A parameter of accessibility of glass eels to the fishery can be used to correct the relation between exploitation rate and filtration rate.

When sequential fisheries occur within the same estuary, several separate zones are used, and cross correlation of catches from various fisheries informs on the delay of migration between the zones, and thus on the duration of exploitation by given fisheries. In the places where the rate of filtration is very high (> 1), the relation from rate of filtration to rate of exploitation is biased but it is negligible owing to the fact that the possibilities of escapement are reduced, i.e., survival close to zero.

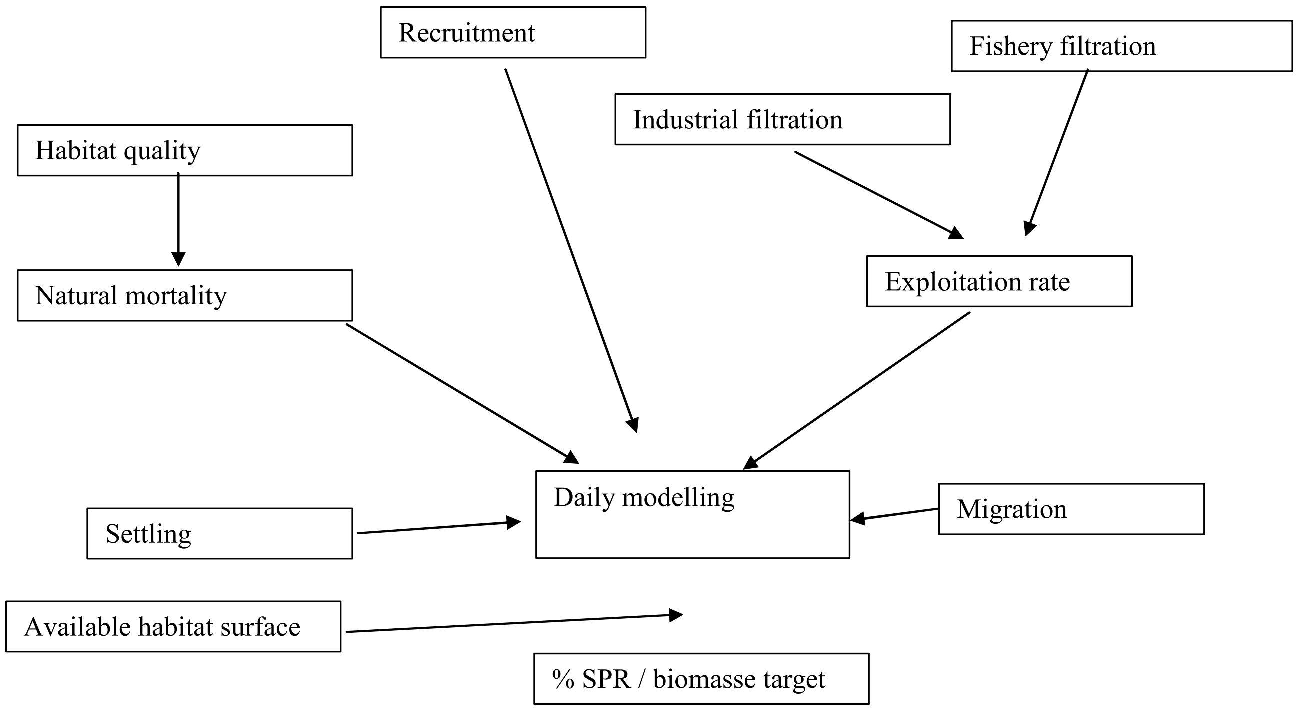
Daily recruitment to the estuary is modelled for one average year and at a given site.

Settling will be modelled according to pigment stage evolution, depending on temperature and salinity.

The evolution of available habitat surface is calculated according to the ratio of accessible areas at the glass eel stage in the current state and before man-made changes. It is expressed in term of % of reduction of surface.

The classification of habitats evaluated by the WFD is used to adjust natural reference mortalities corresponding to the glass eel migrating stage.

Water intakes due to industrial filtrations, power stations, pumping and dredging are included in a similar way to fishery filtration, except that mortality rates of glass eels passing through the filtration device less than 100% can be applied.



A.3.1.5 Output

The outputs of the model are total catches per day, glass eel escapement through settling and escapement to the upstream part, and compliance with targets.

A.3.1.6 Compliance with targets

The model calculates the %SPR for the glass eel stage, and an escapement level. Minimum escapement targets should be proposed for each basin to ensure sufficient production of spawners. They could be calculated relatively to water surface, or to the surface of catchment area. The relationship between the level of recruitment and the population in place is not known. The option suggested is thus to work on provisional targets and a procedure of adaptive management. The escapement is somehow connected with a target in biomass, *i.e.* it informs the manager on the risk that the glass eel fishing pressure and habitat deterioration leads to an unfulfilled level of the yellow eel population.

A.3.1.7 Assumptions/ Uncertainties

The local consequence of the escapement target is not obvious for the glass eel stage because of density dependent mortalities related to the probable local saturation of the carrying capacities of some catchments in the Atlantic area. Decreasing densities in both estuaries and freshwater suggest that density-dependent effects could be ignored in a preliminary approach. However, if density-dependent effects can be ignored at the actual stock level, then the reduction of the surface of habitat available is no longer a dominating factor in the mortality process. However, as this reduction is probably one of the historical factors of the stock decrease, the accounting for a situation of reference must integrate the habitat factor. Any improvement of habitat will play a favourable role on natural mortalities.

The weak points for this model are the estimation of recruitment, and the analysis of the feasibility of a predictive modelling for recruitment remains to be studied. Though this input has a large influence on the possibility to reach a biomass target it has no consequence on % SPR.

A.3.1.8 Future developments / Model testing

The inclusion of catchability, for the moment parameterised on the Adour estuary, would enhance the model performances. Research projects Indicang conducted on the Loire, Adour, and Isle (Gironde) will provide absolute levels of recruitment, and help to validate the model.

To test the model, several data sets might be available: Oria (Basque county), Adour, Gironde, Sèvre Niortaise, Loire, Vilaine, Aulne (France).

In the actual state, the model only relates fishing effort to a calculated escapement level and a % SPR target. Post evaluation should be developed including a prediction of change in pigment stage structure. Modelling the relationship between glass eel escapement and yellow eel population parameters would provide another way to post evaluate compliance.

A.3.2 The UK operating model

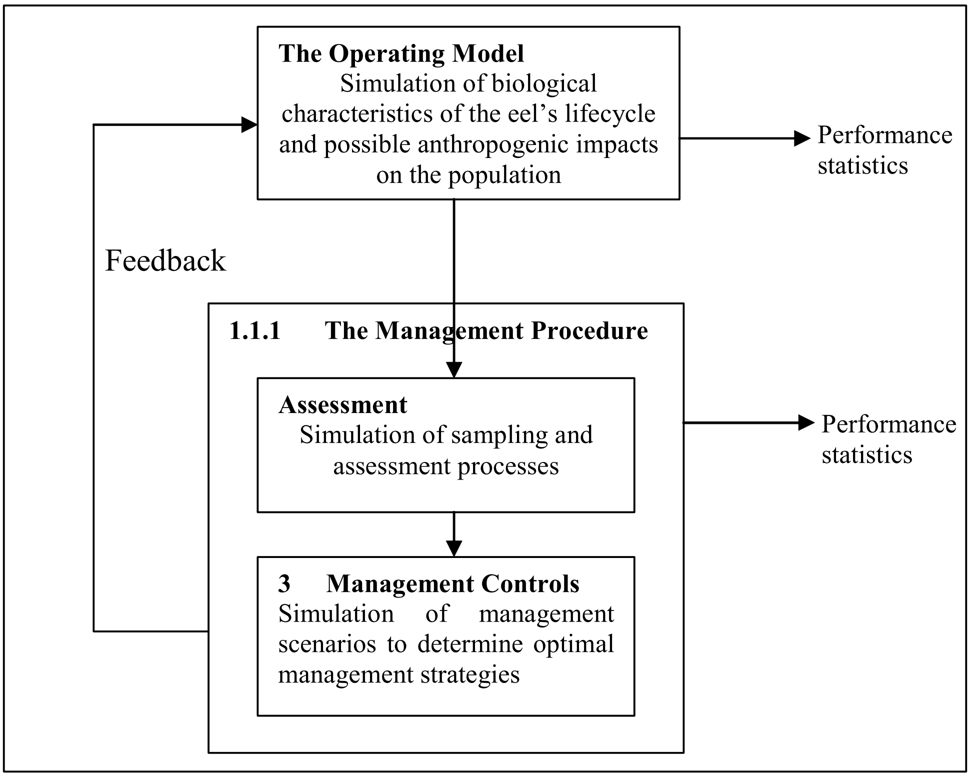
A.3.2.1 Introduction

The EU Commission has proposed three types of targets for its eel Recovery Plan, namely Settlement (glass eel), Stock (yellow eels) and Spawner Escapement (silver eel production/escapement). Of these, spawner escapement must be the ultimate target, and the ICES/EIFAC WGEEL has proposed a silver eel escapement limit of 30%SPR and a target of 50% of the ‘pristine state’, explicitly emphasising that maximum spawner escapement is the key priority of the Recovery Plan. It is apparent that the use of a reference based approach to eel stock assessment targets will require the use of models to compare actual stock status with the expected for a system (catchment, river, late, estuary) of that type and geographical location, and to evaluate the potential effects of management measures. This Defra (UK) funded project has been developed to take a proactive approach to these European developments.

The Defra project’s GIS platform and model provide the basis for a robust and practical reference-based approach to setting of biological reference points (BRP’s), compliance monitoring and management decision making. The core objective of the Defra project is the development of BRPs for the management of the European eel, considering how these can be applied to recruitment, yellow eel stocks and spawner escapement, and their interrelationship. However, in light of developments at the European level, the Defra project has now placed greater emphasis on the direct assessment of silver eel production and escapement.

A.3.2.2 Model Framework Structure

The model is being developed to evaluate fishery systems in response to a variety of management scenarios. The highest level of abstraction, incorporating the fundamentals of the modelling, is given in the Figure below.



A.3.2.3 Model status

Currently, the operating model uses the following inputs:

Initial sex ratio (if not available, an assumption of 1:1 is made)

Initial total population estimate

Initial length-frequency distribution

Mean number of recruits (or index)

Estimate of biomass carrying capacity of catchment

The initial population structure is calculated using the initial values for sex ratio, total population estimate and length-frequency distribution. The following processes are implemented:

Growth

Recruitment

Sexual differentiation and determinism

Maturation (silvering)

Mortality (both natural and fishing)

A.3.2.4 Model inputs

The model uses a number of required input files:

Initial Length frequency distribution

Reach Descriptions, *for example*:

Reach	Length (m)	Width (m)	
1	1000	10	/* starts at tidal limit */
2	2000	5	
3	3000	5	
4	2200	5	

and optional input files:

Recruitment Levels –

- *default: constant recruitment at mean level (i.e. 1.0)*

pre-defined options:

- *observed declines in European recruitment*
- *increases in recruitment (reverse European declines)*

Fishing levels

- *Glass eel, through time*
- *Yellow eel, by length class and through time*
- *Silver eel, through time*

or constant fishing levels

or no fishing

Environmental / Habitat Quality Index, for example:

	Reach:				
Time	1	2	3	4	5
1	0.95	0.95	0.82	0.80	0.75
2	0.93	0.95	0.81	0.76	0.75
3	0.20	0.46	0.39	0.55	0.68
4	0.36	0.54	0.43	0.59	0.66
5	0.78	0.86	0.62	0.67	0.73
6	0.82	0.84	0.75	0.69	0.69
7	0.90	0.90	0.90	0.77	0.70
8	0.95	0.95	0.82	0.80	0.75
9	0.91	0.92	0.83	0.82	0.76
10	**0.90**	**0.87**	**0.79**	**0.75**	**0.69**

Barriers to Migration, for example:

Reach containing barrier	Proportion of eels passing barrier
1	0.65
3	**0.80**

Restocking, for example:

Reach:	Length (mm):	Sex:	
3	350	M	100
3	400	F	100
3	450	F	50
5	**300**	**M**	**200**

A.3.2.5 Model outputs

The model's outputs are:

Total abundance (length frequencies for female, male, undifferentiated eels)
Total biomass (female, male, undifferentiated biomass)
Silver eel abundance (LFs for female, male abundance)
Silver eel biomass (female, male biomass)
Total fecundity of female emigrants
Sex ratio
Growth rates
Predicted catch (using Baranov catch equation)

The operating model is still being developed to include a spatial component to account for distances from the tidal limit. Further extensions are required for the impacts of different types of fisheries and fishing methods, and to incorporate multivariate analyses to determine significant environmental impacts on the population in order to develop a habitat index that will be used to quantify the impacts of a variety of conditions, rather than considering 'environmental conditions' as a single theoretical value

A.3.2.6 Usage: stock assessment and evaluation of management measures

Once a biological reference point has been selected (for example, 50% spawner escapement relative to 'pristine conditions'), framed in terms of silver eel biomass or expressed as a proxy such as yellow eel biomass, density or size distribution, the model can be used to determine the impact of potential management options on a given population. The impact of altering levels of fishing at different stages of the life-cycle and of altering factors affecting suitability of the habitat (accounting for spatial considerations) can be measured using the model to reassess the status of the stock relative to the given reference point.

A.3.2.7 Case study

As an illustration of the parameterisation and preliminary simulations possible with this model, an example is given for the River Piddle in Dorset, using historical data and data acquired from a chalk stream with an established commercial silver eel fishery. The Piddle connects to the sea via a large tidal lagoon which supports a commercial fyke net fishery. Moderate recruitment is expected due to its location relative to glass eel migratory pathways, and good historic data are available for temporal trend analysis.

Electro-fishing survey sampling in 2003 showed a lack of small eels in the system, few 'middle' sized eels and larger females than previously. Analysis of these and historic data showed that population densities appear to have declined from 1977 to 1999, whilst the proportion of females increased from 0.319 to 0.925 (Knights *et al*, 2001).

During the 2003 electro-fishing survey all eels that were silver or apparently silvering were marked on the pectoral fin(s) with elastomer, and catches from the silver eel trap in the autumn were used to estimate of silver eel escapement at 3540 eels, of which approximately 95% are female.

A.3.2.7.1 Modelling sex ratios

One of the strongest drivers in the estimation of spawner escapement in relation to yellow eel abundance is the influence of local density of small yellow eels on sexual determinism: areas of high density tend to become male dominated, while areas of low density tend to become female dominated (Krueger and Oliveira, 1999). This has implications for overall output of female eels from a catchment, and the time taken to emigration.

The model considers sexual determinism to be regulated by the ratio of the current biomass levels of undifferentiated eels to the maximum biomass levels that can be sustained by the region. In those regions in which the population is at carrying capacity, all sexually differentiating eels become male. Assuming that at the half-saturation level, an equal proportion become male as become female, Figure 2 shows that any sex ratio is attainable by varying the level of recruitment. Moreover, an improvement in environmental conditions favours a higher ratio of females at a given level of recruitment. (Note that this simulation is for a population with no spatial considerations. This is clearly simplistic and the implementation of the spatial component is being developed).

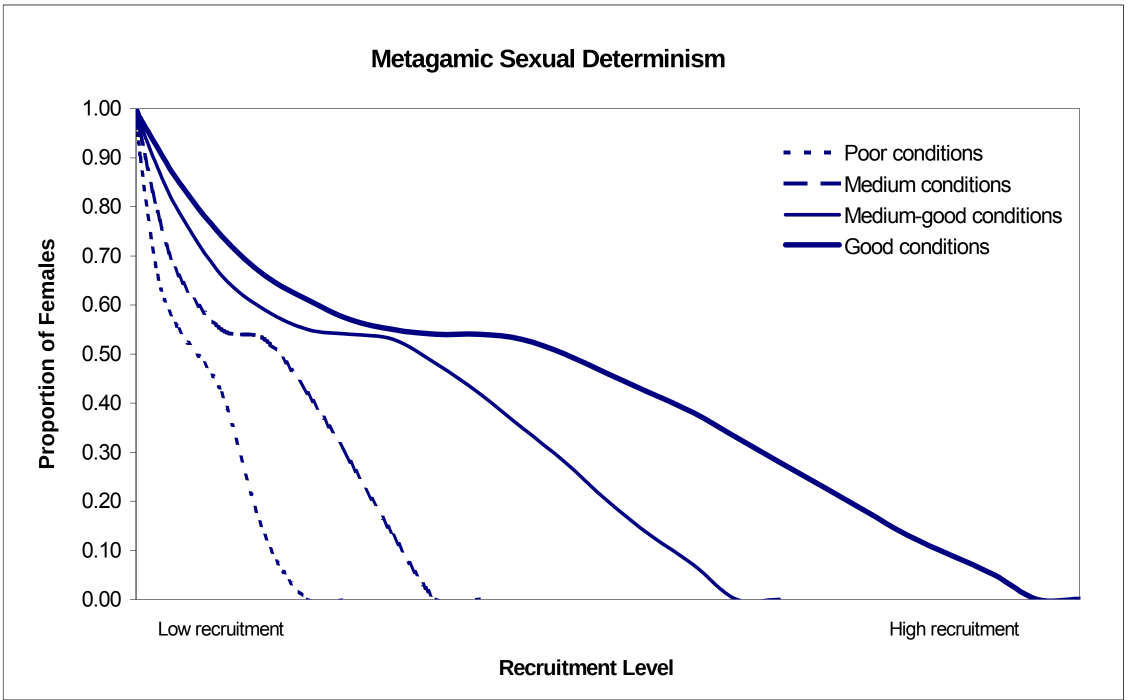
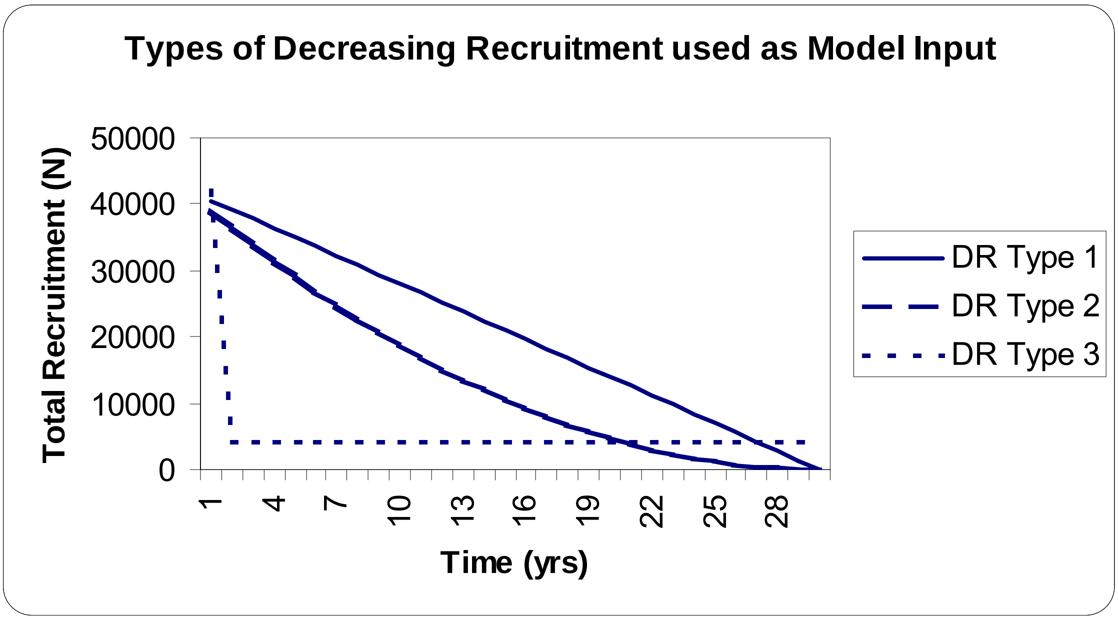


Figure 2: Sex ratios attained for varying levels of recruitment and for a range of environmental conditions.

The model was parameterised with data for the River Piddle. Model results show that if fishing mortality is considered to be negligible, such a change in sex ratios is possible if there is either a decrease in the numbers of recruits to the river system or an improvement in environmental conditions. However, such an improvement in environmental conditions have to have been of a considerable magnitude, i.e. ≈37 times the original state, which is unrealistic as the River Piddle is already a highly productive water system (Knights *et al*, 2001). Hence, the most likely inference is that there has been a substantial decrease in recruitment levels, though both processes could have acted synchronously.

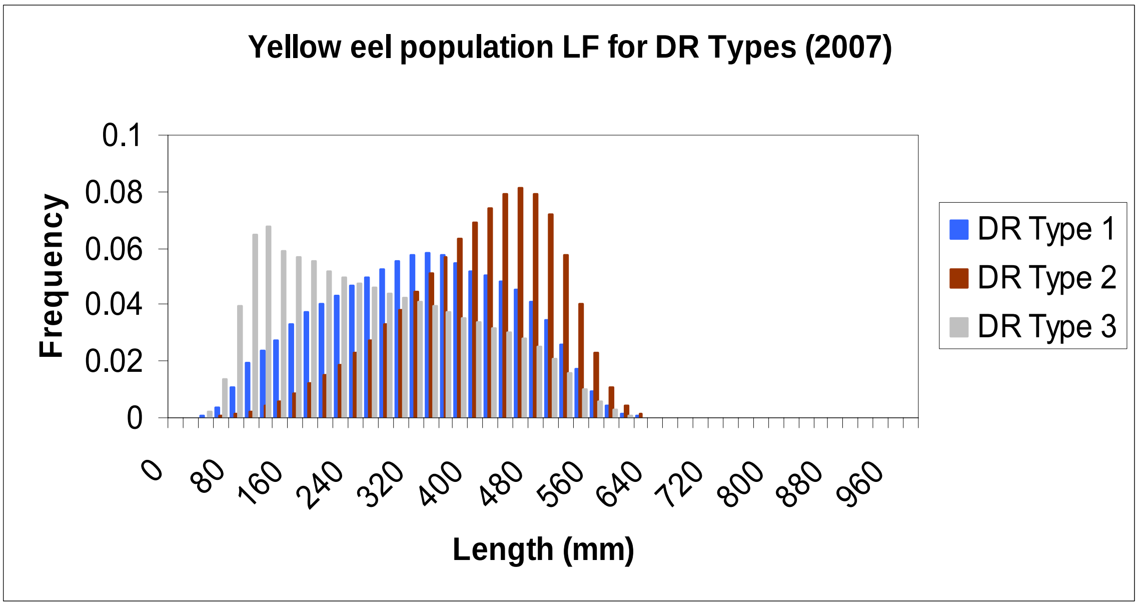
A.3.2.7.2 Decline in recruitment level

Keeping environmental conditions constant, levels of recruitment were simulated to achieve a shift in sex ratio from 31.9% females in 1977 to 92.5% females in 1999. Such a shift is possible if levels are reduced to ≈ 3% of the original recruitment level. This reduction could be simulated under three broad scenarios, depicted below.

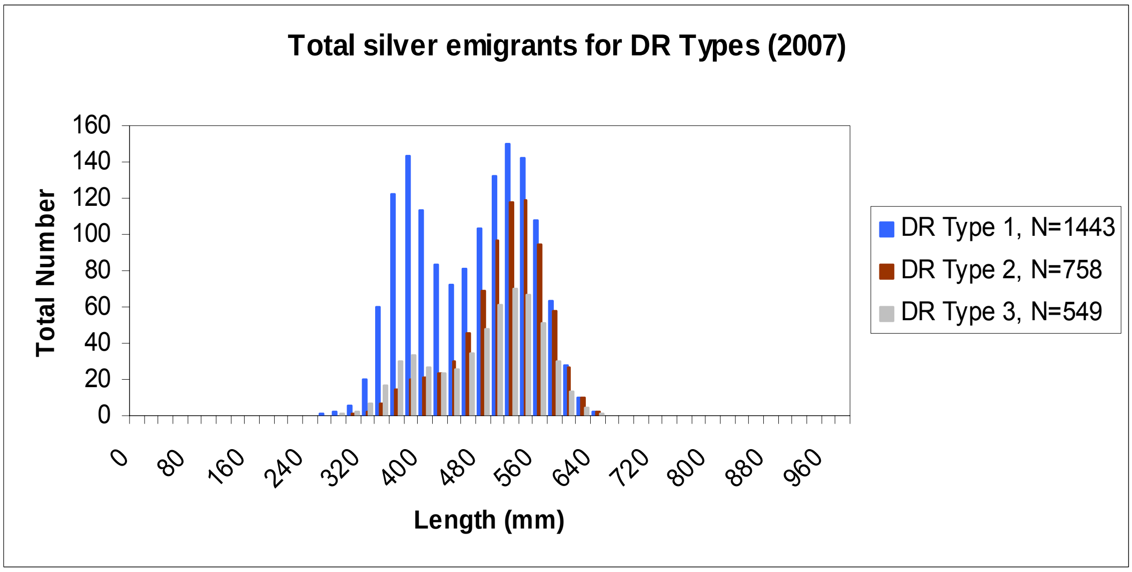


OUTPUTS	REAL DATA	Scenario 1 Output	Scenario 2 Output	Scenario 3 Output
Density (N 100m -2)	26.8 ± 12.0	34.5	36.5	37.4
Mean biomass (g 100m -2)	2570 ± 1200	2312	2516	2485
Sex ratio (proportion female)	0.32	0.324	0.36	0.311
Number Emigrants	?	4259	4363	4652

Following these scenarios through to predicted size distributions of yellow eels gives



which reflects the current situation in the Piddle in 2003, and into predictions of silver eel escapees in 2007.



Although simulations such as those described above are possible, they are still fairly rudimentary. The objective is to have an operating model that represents the 'real' stock and the actual fishery dynamics. Data simulated from this can then be used within the management procedure to assess the status of the stock in relation to biological reference points and, secondly, to apply management measures (on exploitation and habitat) to the system and to use performance statistics to illustrate the consequent behaviour of the system.

The model is still undergoing development and requires further implementation or extensions for the following:

- *a spatial component to account for distances from the tidal limit*
- *the impacts of different types of fisheries and fishing methods*

- *multivariate analyses to determine significant environmental impacts on the population in order to develop a habitat index; this index will be used to quantify the impacts of a variety of conditions rather than considering 'environmental conditions' as a single theoretical value*
- *an assessment technique is required to establish the relation of stock status to selected biological reference points*
- *technique to determine optimal management options*

A.3.2.8River Severn

We also have good eel population data for the Severn catchment, with which to test models. This is a large river system, relatively easily sampled in 'representative' tributaries, with high potential/actual recruitment – the nature and location of Bristol Channel implies the highest recruitment in the UK – and supporting a major glass eel fishery but with minimal exploitation of yellow/silver eels (like some French catchments?).

This represents the most extensive historic quantitative dataset on glass eel catches and trend and on yellow eel stocks for any UK river and is potentially useful for temporal validation of model.

During recent surveys at fourteen sites a large number of very small eels were caught, reflecting the recent recruitment of glass and newly pigmented eels to the lower tributaries, and with an unchanged population structure overall. These data suggest that, despite declining recruitment and the fishing pressure from the Severn glass eel fishery, recruitment is still sufficient to meet local carrying capacity in the Lower Severn tributaries. One further year data collection from the Lower Severn tributaries (since the recruits in 2001 will be big enough to be caught efficiently) plus an analysis of Upper Severn eel distribution is planned in order to examine temporal and spatial trends and to provide a data rich test catchment for the Model.

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A.3.3 Spawner escapement from yellow and silver eel fishery

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A.3.3.1 Parameter definitions

We assume that yellow eels of exploitable ages grow in a linear fashion with an individual growth rate measured in mm per year (g) (Svedäng 1999). The minimum allowable length for catch of yellow eels is defined as L_R, measured in mm. Only female eels are considered and they are assumed to grow in a linear fashion until they reach, a geographically specific, mean silver eel length L_λ , when they, for simplicity, are assumed to all turn into silver eels and leave the coast to eventually leave for the Sea of Sargasso. This means that the mean time required to grow from the size L_R to the average size of silver eels L_λ can be expressed as $T_{R\lambda} = (L_\lambda - L_R)/g$, expressed in years. In Swedish waters there is only a very low proportion of male eels, so in all the following only female eels are taken into account.

The parameter M is the instantaneous natural mortality rate year^{-1}, and F is the instantaneous mortality rate due to yellow eel fishing. When individual growth is assumed to be linear, the mortalities can also be measured in terms of mortality rate per unit of length increment and are then denoted m and f, respectively, with units mm^{-1}. The different mortality measurements presented in different units can easily be converted between each others using the relationships $M = m \cdot g$, and $F = f \cdot g$. The instantaneous rate of mortality due to the silver eel fishery is denoted Φ. In the present analysis this is entered with the aid of an estimate of the proportion of the silver eels caught in the silver eel fishery over one year, denoted q, and the instantaneous rate is then calculated as $\Phi = -\ln(1-q)$ with unit year^{-1} (based on the recognition that $q = 1 - e^{-\Phi}$). The fishery induced mortality rates are assumed to be proportional to the fishing efforts exerted in each type of fishery. The number of recruits entering the exploitable stock each year is denoted R.

A.3.3.2 Proportional spawner escapement

Following the general approach of classical fisheries modelling (e.g. Beverton and Holt 1957, Ricker 1975) survival (S) from L_R until spawner escapement at a mean length of L_λ can be defined as

$$S = e^{-M\frac{(L_\lambda - L_R)}{g} - F\frac{(L_\lambda - L_m)}{g} - \Phi} = e^{-m(L_\lambda - L_R) - f(L_\lambda - L_m) - \Phi}, \qquad (1)$$

where L_m is a possible new minimum length limit ($L_R \le L_m$). The latter allows having an estimate of the number of recruits entering the population at one length (L_R), while the actual length limit is at another, larger, length (L_m). Note, however, that equation (1) is describing an equilibrium situation, i.e. where transient effects of changing the length limits are no longer relevant. The time perspective of possible changes in mortality rates and length limit is presented further below. Equation (1) is often referred to as “spawners per recruit (SPR)”.

Setting the fishery mortalities to zero allow us to estimate the present possible maximum SPR without fishing,

$$S_{\max} = e^{-M\frac{(L_\lambda - L_R)}{g}} = e^{-m(L_\lambda - L_R)}. \qquad (2)$$

This provide us with the possibility to calculate the present survival until spawner escapement as a proportion of the present possible unfished survival, p, where

$$p = \frac{S}{S_{\max}} = e^{-F\frac{(L_\lambda - L_m)}{g} - \Phi} = e^{-f(L_\lambda - L_m) - \Phi}. \qquad (3)$$

When dealing with sustainable fisheries according to the precautionary approach, percentages of pristine levels of spawner per recruit are often used as goals. When the relation between spawner biomass and recruitment is unknown, 30% of pristine SPR as a limit and 50% of pristine SPR as a target have been suggested, and these are adopted as the limit and target for the sustainability of the European eel. However, if the spawning stock is very low compared to the pristine level, only targeting a relative measure such as spawners per recruit (also referred to as mortality limits) most likely does not suffice to recover the population (ICES, 2002).

A.3.3.3 Proportional spawner escapement weighted by the relation between present and pristine stock levels

We define a factor relating the present population level to the pristine population level as θ, in order to relate the present unfished spawner escapement to the unfished spawner escapement of a pristine population. We first identify that the present spawner escapement in numbers is

$$\psi = RS, \qquad (4)$$

and that the present maximum number of spawners escaping without fishing can be expressed as

$$\psi_{\max} = RS_{\max}. \qquad (5)$$

Using the factor θ to calculate pristine levels of recruitment into the yellow eel fishery ($\theta \cdot R$), we realize that pristine maximum number of spawner escapees can be estimated as

$$\psi_{\max,\theta} = \theta RS_{\max}. \qquad (6)$$

Then we define the proportion of unfished pristine spawner escapement (p_θ) as

$$p_\theta = \frac{\psi}{\psi_{\max,\theta}} = \frac{RS}{\theta RS_{\max}} = \frac{S}{\theta S_{\max}} = \frac{e^{-F\frac{(L_\lambda - L_m)}{g} - \Phi}}{\theta} = \frac{e^{-f(L_\lambda - L_m) - \Phi}}{\theta}. \tag{7}$$

Regarding equation (7) we find that in order to estimate the proportion of unfished pristine spawner escapement we do not need to know exact populations levels, only the relation between some measures of present population level to pristine population level. This relation might, e.g., be estimated as the relation between present and pristine recruitment indexes, without knowledge of absolute recruitment levels, assuming that the recruitment indexes to some extent reflect the size of the spawning stock, or in cases where there is no density dependent processes in connection to the recruitment, reflect the basis for the future eel stock. Note also that knowledge about the natural mortality rate (*M* or *m*) is not needed, if fishing mortality rates can be estimated without such knowledge.

Equation (7) might also be defined as expressing the proportion of unfished pristine survival, or proportion of pristine SPR, when weighing in the present stock level in relation to the pristine stock level. Equation (7) can be used to evaluate the present survival until spawner escapement as a proportion of present (θ=1) or pristine population levels, using an estimate for θ. So, introducing θ takes us from regarding the escapement goal only in terms of mortality rates to a combination of mortality rates and spawning stock biomass. When spawning stock biomass is low (high θ) mortality rates due to fishing need to be lowered more than if spawning stock numbers is high (low θ). If estimates of θ can be updated regularly (e.g. each year) this will allow recommendations on safe fishing mortality rates to be updated in response to either a further decline in the population or a recovering population.

We can also replace the left hand side of equation (7) with a desired goal (e.g. 0.50 to receive 50% of pristine spawning stock numbers), and solve for F, L_m or Φ to assess how fishing pressures need to be changed in order to fulfil that goal. A general setting of this could be expressed by defining p_{pa} as the precautionary goal for the spawner escapement, thus arriving at

$$F_{pa} = \frac{g\left(\ln\left(\frac{1}{p_{pa}\theta}\right) - \Phi\right)}{L_\lambda - L_m}, \tag{8}$$

or

$$f_{pa} = \frac{\ln\left(\frac{1}{p_{pa}\theta}\right) - \Phi}{L_\lambda - L_m}, \tag{9}$$

as formulations describing the levels of the yellow eel fishing mortality necessary to achieve the precautionary goal of p_{pa}. If the solution ends at negative values for F_{pa} or f_{pa}, this indicates that closing the yellow eel fishery is not sufficient to achieve the desired goal, decreasing Φ and increasing L_m might also be needed. In situations when setting $\Phi = 0$ and L_m close to L_λ still result in negative values for F_{pa} or f_{pa}, not even a complete closure of the fishery can be anticipated to suffice to recover the population. Other measures like habitat improvement and restocking should then be considered (se below on combinations of management efforts, including restocking).

Examples:

In order to demonstrate some of the possible uses of the above equations we exemplifying with parameter values from the yellow eel fishery at the Swedish west coast according to Svedäng (1999) (g = 45 mm/year, L_R = 370 mm, L_λ = 650 mm, F = 0.31 year^{-1}) and a very rough estimate that 23% of the eels escaping the yellow eel fishery get caught in the silver eel fishery (q = 0.23 and thus Φ = -ln(1-q) = 0.261). The latter stems from an estimate that 90 000 silver eels are caught each year at the west coast, assuming that half of these stem from the coastal population (and half from freshwaters) and that 194 900 escape the yellow eel fishery at the coast. With the aid of equation (3) we find that p = 0.11, i.e. that the present level of spawners per recruit is 11% of the present maximum possible spawners per recruit. In order to understand the role of the different fisheries, targeting different life stages, we can set Φ = 0 in equation (3) to then find that p = 0.145. It is thus clear that already the yellow fishery at the Swedish west coast reduces the spawners per recruit with 85.5%.

Using the information that the recruitment level of elvers of the last 20 years is only about 10% of the recruitment in the middle of the 20th century we therefore define θ = 10. With the aid of equation (7) we then find that p_θ = 0.011, i.e. that the present spawner escapement is only 1.1% of the more pristine escapement in the middle of the 20th century.

From equation (8), using the parameter values for the Swedish west coast, θ = 10 and p_{pa} = 0.5, we find that F_{pa} = -0.30, i.e. we can not achieve 50% of pristine spawner escapement by only restricting the yellow eel fishery. Not even stopping the silver eel fishery (i.e. Φ = 0) is sufficient, producing F_{pa} = -0.26.

If our only goal is to achieve 50% of present maximum spawners per recruit (i.e. θ = 1) silver eel fishery can be unchanged if yellow eel fishery mortality is lowered to F = 0.069, i.e. lowered by 78%.

A.3.3.4 Response in spawner escapement to combinations of management efforts

I will now present an approach that allows us to compare effects of different management efforts, including re-stocking, on spawner escapement. We start by defining the following equality

$$\Psi_{pa,\theta} = \psi + \psi_{+}, \tag{10}$$

where the left side represents the escapement goal that should be achieved. Again, defining p_{pa} as the precautionary target for the spawner escapement (in the examples below p_{pa} = 0.5), the left side of equation (10) would be calculated as

$$\Psi_{pa,\theta} = \theta\psi_{\max} p_{pa}. \tag{11}$$

The right side of equation (10) represents first spawners stemming from natural recruitment, and then spawners stemming from re-stocked elvers. For the latter we for simplicity assume the same natural mortality rate, from elver size to the size at recruitment to the yellow eel fishery, as for larger eels. This gives us the following expression for the right hand side of equation (10)

$$\psi + \psi_{+} = Re^{-m(L_{\lambda}-L_{R})-yf(L_{\lambda}-L_{m})-x\Phi} + r_{u}e^{-m(L_{\lambda}-L_{u})-yf(L_{\lambda}-L_{m})-x\Phi}, \tag{12}$$

where y and x represents the proportion of yellow and silver eel fishery allowed, respectively. We can now insert equations (11) and (12) into equation (10) and solve, e.g., for y giving

$$y = \frac{\ln\left(R + r_{u}e^{-m(L_{R}-L_{u})}\right) - \ln\left(\theta\psi_{\max}p_{pa}\right) - m(L_{\lambda} - L_{R}) - x\Phi}{f(L_{\lambda} - L_{m})}. \tag{13}$$

Equation (13) can be used to illustrate the efforts needed to achieve the desired spawner escapement. In Figure 1 it can be seen that along with a complete ban of all fishery around 89 million elvers have to be supplied in order to achieve 50% of pristine spawner escapement from the Swedish west coast. It has to be remembered that the above approach represents only equilibrium situations, i.e. when no parameters change over time. Therefore it is not possible to use the above formulations to illustrate a more long-term approach to fulfilling the management goals, e.g. allowing increased spawner escapement to increase the subsequent recruitment, therefore allowing for, e.g., less demanding re-stocking programmes

There might also be possibility to include effects of habitat improvements in an indirect way by allowing management to affect the natural mortality rate. A better approach would probably be to extend the modelling with a spatial dimension, allowing modelling improved access to habitats directly.

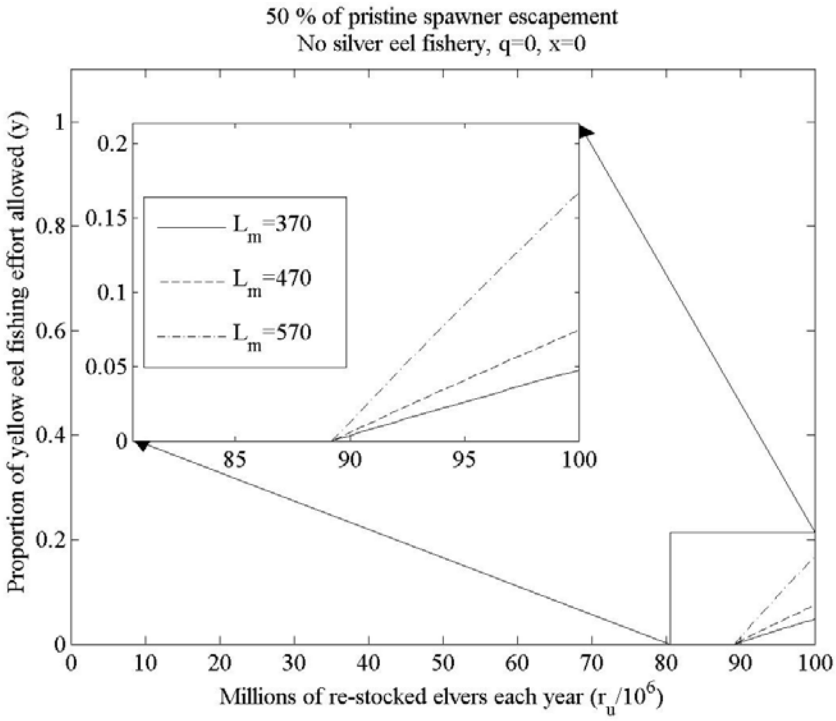

Figure 1. How to achieve 50% of pristine spawner escapement from the Swedish west coast by combinations of proportions of yellow eel fishery effort allowed (y) and number of re-stocked elvers (r_u), for three different length limits for the yellow eel fishery (L_m). No silver eel fishery is assumed (i.e. $x = 0$). Parameter values relevant for the Swedish west coast, as presented above with the addition of $m = M/g = 0.23/45 = 0.0051$, were used. The parameter R was estimated using equation (22) and an estimated yearly yellow eel catch of 359 tonnes.

A.3.3.5 Spawner escapement over time since management effort

All results above refer to equilibrium conditions, i.e. when no variables or parameters change over time, or sufficient time has past since such changes has taken place, so that no further effects can be expected. Below I present equations that allow us to illustrate the time perspective of different management efforts. To be able to handle a time perspective the individual growth rate has to be known, beside the parameter values that have been needed above. In the following we let square brackets around a time interval, $[T_{ab}]$, denote the integer part of that time interval, T_{ab}, and curly brackets, $\{T_{ab}\}$, denote the fractional part. Changing the minimum length limit for the yellow eel fishery (L_m), the fishing efforts, and thus the fishing mortalities, for both the yellow (F) and the silver (Φ) eel fisheries and re-stocking elvers (r_u) at time t would give the following spawner escapement at time $t + j$, for $j = 0, 1, 2, \ldots$,

$$\psi_{t+j} = \begin{cases} R_{t-[T_{R\lambda}]+j} e^{-T_{R\lambda}M - \tau F_1 - (j+1)F_2 - \Phi_2} & \text{if } T_{m\lambda} - j \geq 1 \\ R_{t-[T_{R\lambda}]+j} e^{-T_{R\lambda}M - \tau F_1 - \omega F_2 - \Phi_2} & \text{if } 1 < T_{m\lambda} < 1 + j \text{ and } j < [T_{u\lambda}] \\ \left(R_{t-[T_{R\lambda}]+j} + R_{u,t-[T_{R\lambda}]+j}\right) e^{-T_{R\lambda}M - \tau F_1 - \omega F_2 - \Phi_2} & \text{if } 1 < T_{m\lambda} < 1 + j \text{ and } j \geq [T_{u\lambda}] \\ R_{t-[T_{R\lambda}]+j} e^{-T_{R\lambda}M - \xi F_1 - \{T_{m\lambda}\}F_2 - \Phi_2} & \text{if } T_{m\lambda} < 1 \text{ and } j < [T_{u\lambda}] \\ \left(R_{t-[T_{R\lambda}]+j} + R_{u,t-[T_{R\lambda}]+j}\right) e^{-T_{R\lambda}M - \xi F_1 - \{T_{m\lambda}\}F_2 - \Phi_2} & \text{if } T_{m\lambda} < 1 \text{ and } j \geq [T_{u\lambda}] \end{cases} \tag{14}$$

where:

$$\begin{aligned} \tau &= \max(T_{R\lambda} - 1 - j, 0), \\ \omega &= \min(j + 1, T_{m\lambda}), \\ R_u &= r_u e^{-T_{uR}M}, \\ \xi &= \max(T_{Rm} - j - (1 - \{T_{m\lambda}\}, 0). \end{aligned} \tag{15}$$

The indexing of the fishing mortalities indicates their values before (F_1 and Φ_1) and after the change (F_2 and Φ_2). Note that we already from equation (14) can tell that changes of the silver eel fishing effort immediately have effect of the spawner escapement, since Φ_1 does not enter into the equation at all.

Note that since R is time indexed in Equation (14), this approach allows including changes over time in the number of natural recruits to the yellow eel fishery. Such changes could reflect further decrease in recruitment or future increase in recruitment due to increased spawner escapement. The latter does, however, require knowledge of the spawner-recruit relation, or measured changes in recruitment. This is not further exploited in this text.

As above we express the spawner escapement as a proportion of maximum unfished present (θ = 1) or pristine spawner escapement (θ > 1) according to

$$p_{\theta,t+j} = \frac{\psi_{t+j}}{\theta \psi_{\max}}. \tag{16}$$

It is worth to note that if re-stocking is not considered (r_u = 0) and there is no time trend in the number of recruits (R), the absolute number of recruits will cancel from equation (16) just as shown above.

First we use equation (14) inserted in equation (16) to illustrate the effects on spawner escapement when only changing the length limit in the yellow eel fishery (L_m). Figure 2 illustrates that the larger the increase of the minimum length limit is, the faster do the spawner escapement start to increase and the increase is also larger. Note however, that irrespective of the magnitude of the limit increase the full effect on the spawning escapement is not reached until $j = [T_{R\lambda}] = [(L_\lambda\text{-}L_R)/g]=6$, i.e. it takes an amount of time equal to the (integer part of the) time it takes to grow from recruitment to the fishery (before the limit change) until the mean length of spawners. Note that the Figure illustrates a situation of unchanged fishing effort both in the yellow and the silver eel fishery. It is also important to remember that if we are looking for expected effects on the glass eel recruitment we have to add something like 1–3 additional years until effects can be expected to be seen.

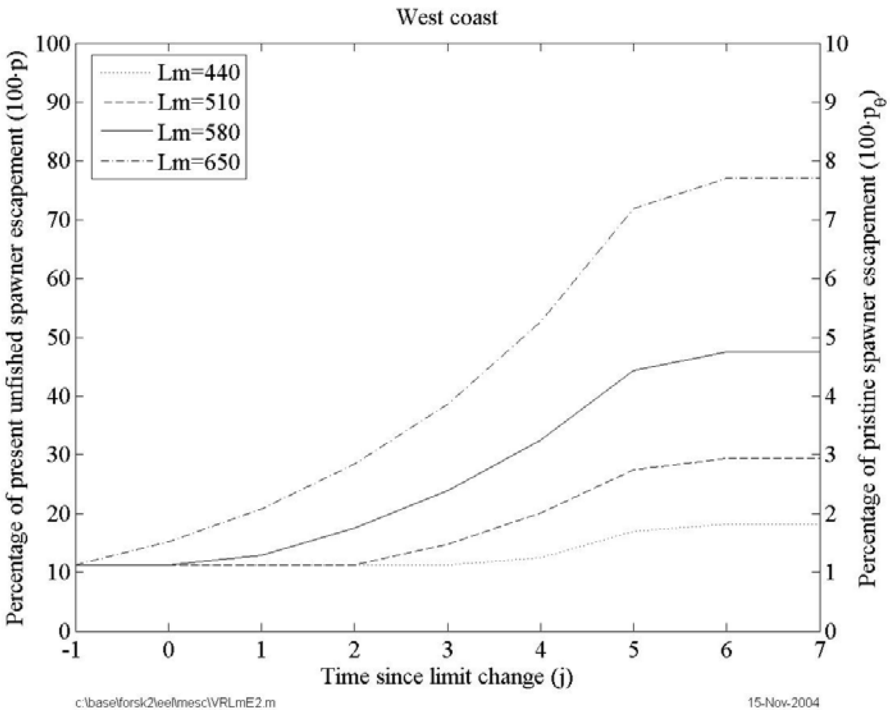

Figure 2. Percentage of present maximum spawner escapement (θ = 1), left y-axis, and percentage of pristine spawner escapement (θ = 10) on the right y-axis, over time since the minimum length limit (L_m) was increased (j). The effects of changes to four different length limits are presented, representing changes in steps of 25% of the increase that is possible, i.e. $L_m = L_R + 0.25\cdot(L_\lambda - L_R)$ = 440 mm, etc, up to $L_m = L_\lambda$ = 650 mm, i.e. no yellow eel fishing. The same parameter values as in Figure 1 were used, including $F_2 = F_1 = 0.31$ year^{-1} and $\Phi_2 = 0.261$ year^{-1}, i.e. unchanged yellow and silver eel fishing efforts.

Next we illustrate the effect of decreasing only the instantaneous yellow eel fishing mortality on spawner escapement. Figure 3 show that a decrease of the yellow eel fishing effort (assumed proportional to F) has an immediate effect on spawner escapement. Full effect is, however, again not reached until 6 years after the effort change, i.e. until $j = [T_{R\lambda}]$, i.e. after the time it takes the eels to grow from the minimum size allowed in the yellow eel fishery until the mean size of silver eels (spawners to be). Note that the Figure illustrates a situation of unchanged minimum length limit for the yellow eel fishery and unchanged fishing effort in the silver eel fishery.

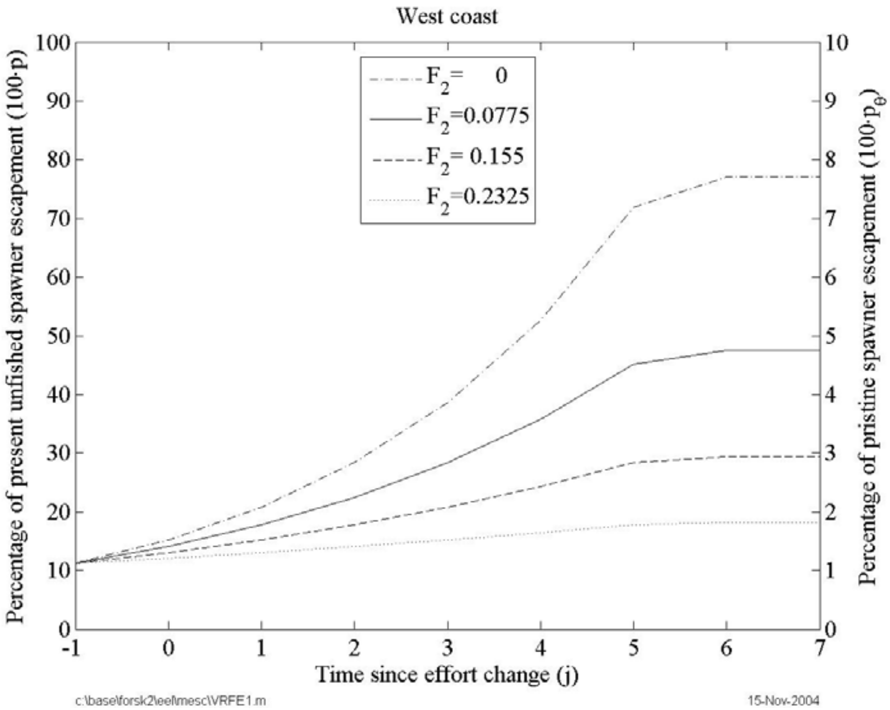

Figure 3. Percentage of present ($100 \cdot p_\theta$ when $\theta = 1$), left y-axis, and pristine unfished spawner escapement ($\theta = 10$), on the right y-axis, over time since the yellow eel fishing effort was decreased (j). Four different levels of yellow fishing mortality rates are presented, representing decrease in steps of 25%, until $F_2 = 0$, i.e. no yellow eel fishery. The same parameter values as in Figure 1 were used, with $F_1 = 0.31$ and including $L_m = L_R = 370$ mm and $\Phi_2 = 0.261$ year^{-1}, i.e. unchanged yellow eel length limit and silver eel fishing effort.

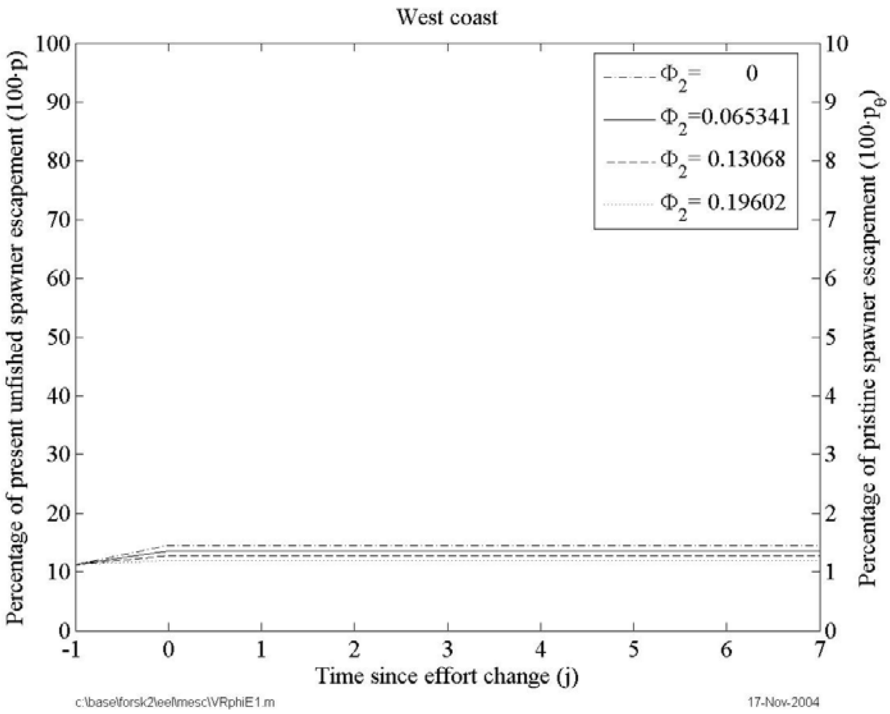

Figure 4. Percentage of present ($100 \cdot p_\theta$ when $\theta = 1$), left y-axis, and pristine unfished spawner escapement ($\theta = 10$), on the right y-axis, over time since the silver eel fishing effort was decreased (j). Four different levels of silver eel fishing mortality rates are presented, representing decrease in steps of 25%, until $\Phi_2 = 0$, i.e. no silver eel fishery. The same parameter values as in Figure 1 were used, with $\Phi_1 = 0.261$ and including $L_m = L_R = 370$ mm and $F_2 = F_1 = 0.31$ year^{-1}, i.e. unchanged yellow eel length limit and fishing effort.

The effect of decreasing only the silver eel fishing effort is illustrated in Figure 4. As pointed out earlier we find that decreasing the silver eel fishing effort get full effect on the spawner escapement immediately, when $j = 0$, i.e. already the year the change is implemented. The effects is however not very large in Figure 4 because the yellow eel fishery still reduces the escapement by about 85%, before the silver eel fishery further reduce the spawner escapement.

The last example of effects of one sole management measure regards re-stocking of glass eels. In Figure 5 we see that it takes a very long time from the release of the re-stocked elvers until they can contribute to the spawning. When no restrictions on fishing are applied the effect on the spawner escapement is also very modest.

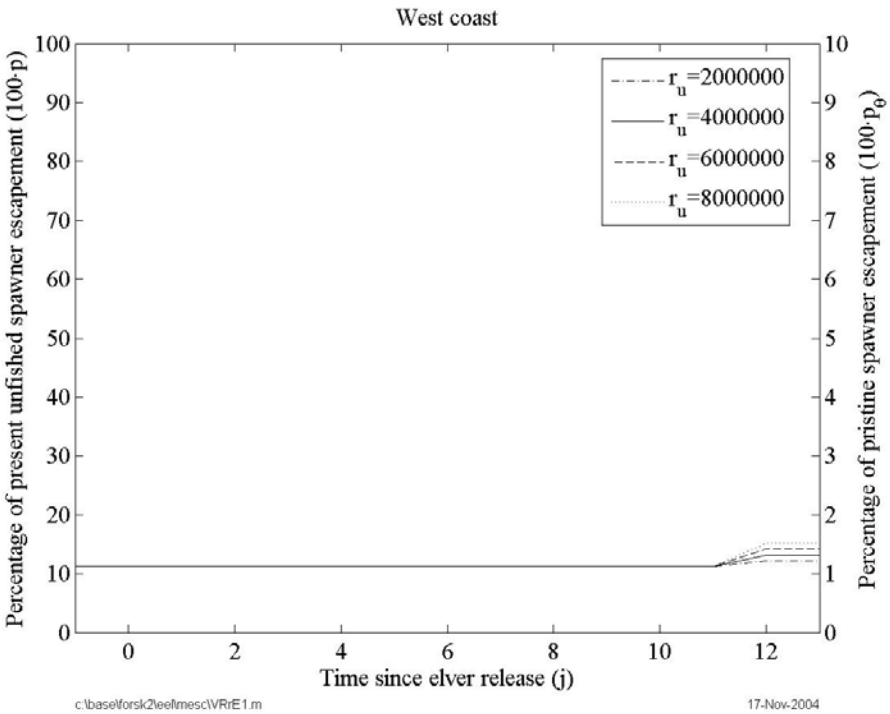

Figure 5. Percentage of present ($100 \cdot p_\theta$ when $\theta = 1$), left y-axis, and pristine unfished spawner escapement ($\theta = 10$), on the right y-axis, over time since hypothetical elvers were released (j). Four different levels of re-stocking (r_u) are presented. The same parameter values as in Figure 1 were used, including $\Phi_2 = 0.261$, $L_m = L_R = 370$ mm and $F_2 = F_1 = 0.31$ year^{-1}, i.e. unchanged yellow eel length limit, as well as yellow and silver eel fishing efforts.

Considering the possible effects of a combination of management actions we start with 50% reductions in the efforts of both the yellow and the silver eel fisheries and a 50% increase of the possible length limit in the yellow eel fishery combined with four different levels of re-stocking of elvers. Figure 6 depicts the direct effects on spawner escapement, and we see that spawner escapement during the first six years increases to just above 50% of present maximum escapement and stays there until the re-stock takes effect six additional years after that. Note that re-stocking of elvers in Swedish waters have in the recent past averaged to about 1.8 million elvers, with an all time high of 2.5 millions in 1997.

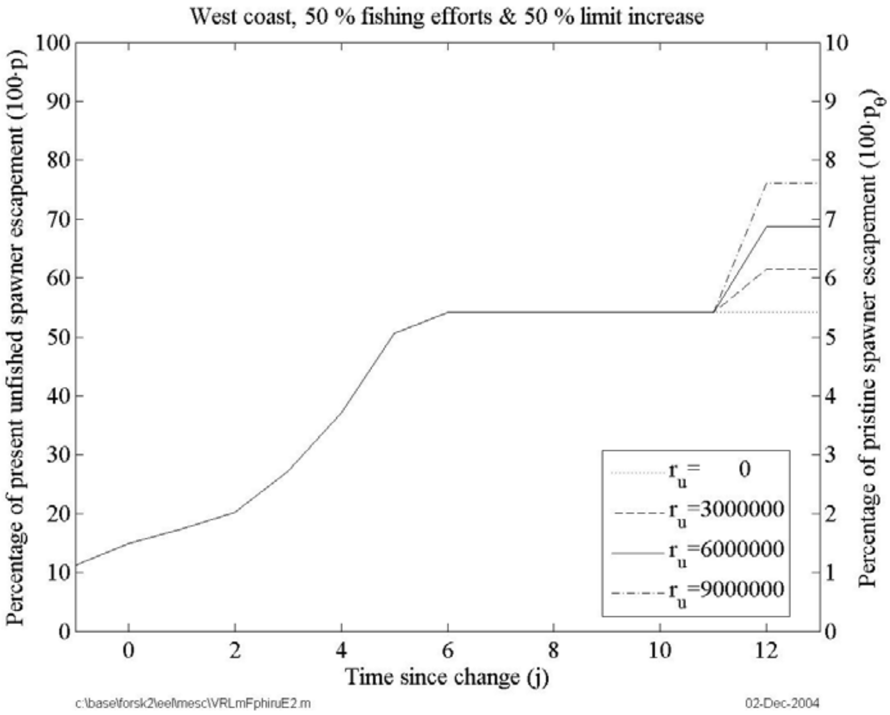

Figure 6. Percentage of present ($100 \cdot p_\theta$ when $\theta = 1$), left y-axis, and pristine unfished spawner escapement ($\theta = 10$), on the right y-axis, over time since 50% reductions in both yellow and silver eel fishing efforts, 50% (of possible) increase of length limit in yellow eel fishery and different levels of re-stocking of elvers (r_u). The same parameter values as in Figure 1 were used.

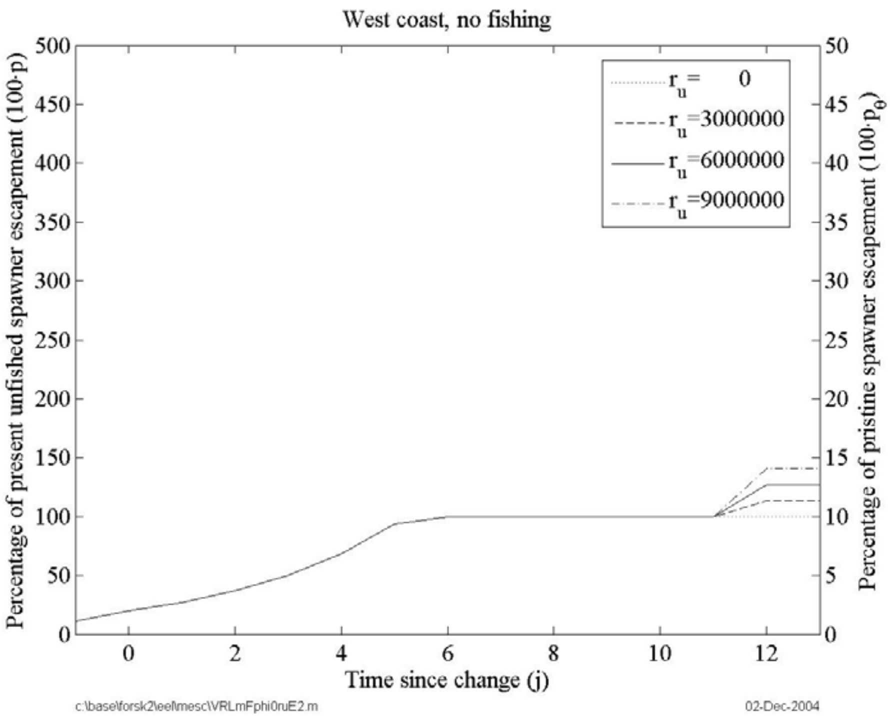

Figure 7. Percentage of present ($100 \cdot p_\theta$ when $\theta = 1$), left y-axis, and pristine unfished spawner escapement ($\theta = 10$), on the right y-axis, over time since total ban of all eel fishing, combined with different levels of re-stocking of elvers (r_u). The same parameter values as in Figure 1 were used.

Finally we illustrate the possible direct effects of total bans of all fisheries combined with re-stocking of elvers in Figure 7. Note that in order to put the achieved spawner escapement in the perspective of the target level of spawner escapement (50% of pristine spawner escapement), the y-axes in this Figure have been extended so that the right y-axis reaches that level. The sad conclusion is that irrespective of how vigorous management actions we apply, in terms of fishery restrictions and re-stocking, we can only expect to achieve very modest direct increases of the spawner escapement, in terms of the pristine level. Re-stocking has a potential to contribute, but only in a long-term perspective. It is also important to bear in mind that if we are ultimately looking for expected effects on glass eel recruitment we have to add something like 1 – 3 additional years until affects can be seen. Unfortunately we have no idea of how an increase in the Swedish spawner escapement translates into recruitment.

Hopefully, implementing far reaching fishery restrictions, habitat improvements and perhaps re-stocking throughout Europe would brighten the picture somewhat. Then taking into account the anticipated increase in the natural recruitment due to increased spawner escapement a higher increase in the spawner escapement would eventually be expected. Exactly how much higher depends on the, so far unknown, spawner-recruitment relationship of the European eel.

A.3.3.6 Note on absolute number of spawner escapees

It should be noted that it might be important to not only deal with proportional spawner escapement when deciding on the allocation of management resources. I have performed calculations on the situation on both the Swedish west coast and the Swedish coasts of the Baltic Sea, and found that the former has much larger potential in maximum possible number of spawners with present recruitment and no fishing (1 341 100 spawners from the west coast compared to 395 700 spawners from the Swedish coasts of the Baltic Sea). This is mostly because of the shorter time span between recruitment and spawner escapement on the west coast. This can be illustrated with calculations on the number of spawners stemming from a certain number of re-stocked elvers. Re-stocking 80 million elvers and totally stopping all fishery on the west coast would result in the elvers giving rise to about 4 841 000 spawners around 12 years later, while total ban of fishery and the same amount of elvers stocked around the Swedish coasts of the Baltic Sea would only result in about 1 587 000 spawners arising from the stocked elvers, around 16 years later.

A.3.3.7 Assumptions

Beside the assumptions explicitly mentioned above it is important to note that the approaches described here relies on the implicit assumptions that natural mortality rate does not change with size of the eels and that fishery-induced mortality rates do not change with sizes above the minimum length limit in the yellow eel fishery. Yellow eels are also assumed to be fully selected to the yellow eel fishery as soon as they reach the minimum length limit. Mortality rates are, moreover, assumed to not vary between years. Implicitly it is also assumed that all calculations are done for areas small enough so that spatial variation in the parameters is small.

A.3.3.8 Producing parameter estimates for the model

A.3.3.8.1 Estimating θ, the factor relating present population levels with pristine levels

The parameter θ can probably be estimated in several different ways. A very rough approximation might involve comparing recruitment levels at the present with those at some time when the recruitment is supposed to be more pristine.

A.3.3.8.2 Estimating F and M or f and m, and Φ

Estimating mortality rates can also be done in many different ways, e.g. traditional analyses of catch-at-length or catch-at age on eels from adjacent unfished and fished localities. Silver eel fishing mortality often require other approaches like mark-recapture studies.

A.3.3.8.3 Estimating population levels at some life stages

Estimates of absolute population levels at some life stage is only needed if spawner escapement is calculated in numbers, instead of in proportion to pristine levels. In the above this is only really necessary when the possible effects of re-stocking is considered. Equations (20) and (21), below, show examples of how it can be possible to transform estimates of numbers at one life stage to numbers at another life stage, e.g. estimating the number eels entering the exploitable stock of yellow eels each year (R), from knowledge on the number of yellow eels caught ($C_{N,y}$), the mortality and growth rates (M, F and g, or just f and m), the length at recruitment to the yellow eel fishery (L_R) and the average length at silvering (L_λ). Mark-recapture studies can also give good estimates of population levels.

A.3.3.9 Sensitivity analysis

It is important to be able to analyse how sensitive the modelling approach is to uncertainty in parameter estimates and violations of assumptions. One of the easiest ways to illustrate parameter sensitivity is to produce model outputs for a range of values of each parameter. If uncertainty is large for many parameters, scenarios of different combinations of parameter values can be constructed, e.g. perturb all parameters 5% in the directions that would increase (or decrease) the model output and register the change in the output. In this manner one can get an idea of the effects of uncertain parameter estimates. Violations of assumptions are much harder to test in a rigorous way, other than tweaking the model in different ways, which can be very laborious.

Figure 8 illustrates how a sensitivity analysis of the result in Figure 6 could look, when each of the most uncertain parameters M, F, L_λ, g and Φ are changed by 5% in the directions which increase or decrease the proportional spawner escapement, respectively. In the "Increase" scenario M, F, L_λ and Φ were decreased and g was increased by 5%, and in the "Decrease" scenario the parameters were changed the other way around. The "Basic" scenario has the same parameter values as in Figure 6. If we believe that the precision of the parameter estimates is about 90%, the "Increase" and the "Decrease" lines in Figure 8 encloses an area of the most likely outcomes. This approach should, however, not be confused with estimating statistically defined confidence intervals.

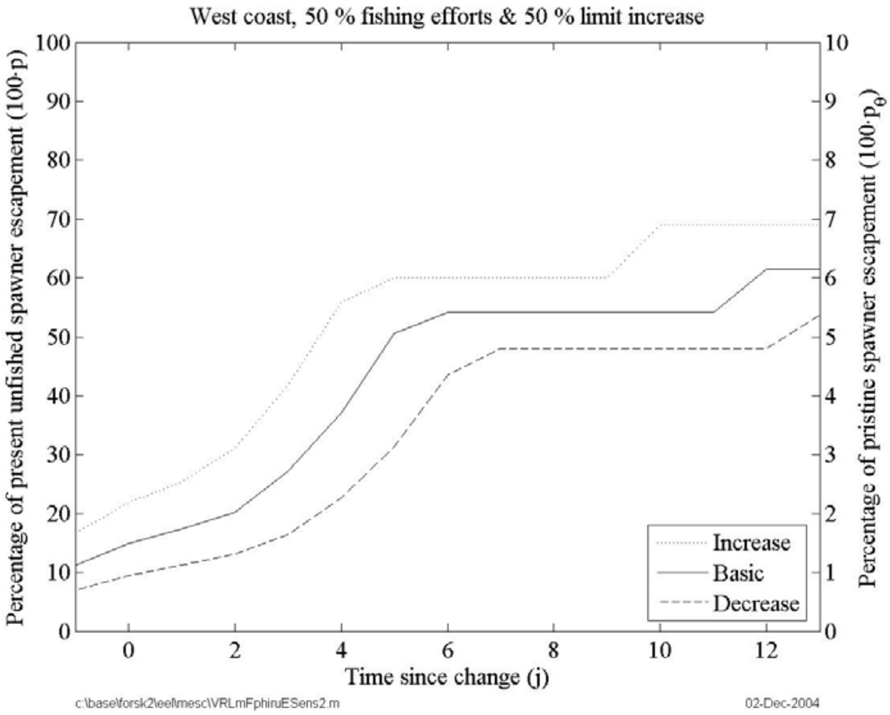

Figure 8. Sensitivity analysis for the same situation as in Figure 6 but only with one re-stocking level, $r_υ$ = 3 million elvers, showing two scenarios where each of the parameters *M*, *F*, $L_λ$, *g* and *Φ* are changed by 5%, as well as the "Basic" scenario with constitute the same parameter values as in Figure 6. In the "Increase" scenario *M*, *F*, $L_λ$ and *Φ* were decreased and *g* was increased by 5%, and in the "Decrease" scenario the parameters were changed the other way around.

A.3.3.10 Calculating recruitment levels from yellow eel yield in numbers

These calculations are based on Baranov (1918), as presented in Ricker (1975), just modifying the upper limit of integration from infinity to a specific size to apply to the semelparity of the eel. Again, assuming that the numbers of recruits entering the exploitable stock each year (*R*) do not vary between years, we start by defining the number of recruits (of length L_R) entering the exploitable population per unit length increment as,

$$\frac{R}{g} = N_0^{'} e^{-L_R \frac{(F+M)}{g}} = N_0^{'} e^{-L_R (f+m)} \qquad (17)$$

where $N_0^{'}$ is a constant that describes the hypothetical number of fish that would have existed at the time when $L = 0$, if the mortality rate per unit length increment, $(F + M) / g$ or $(f + m)$, were constant back to that (hypothetical) time. The parameter $N_0^{'}$ is thus only hypothetical, and is cancelled out in the next few steps. The average number of exploitable eels over a year, in a steady-state situation, can then be found by integrating this expression over all the exploitable sizes,

$$\bar{N} = \int_{L_R}^{L_\lambda} N_0 e^{-L\frac{(F+M)}{g}} \mathrm{d}L = \frac{gN_0^{'} e^{-\frac{L_R}{g}(F+M)} e^{-\frac{L_\lambda}{g}(F+M)} \left(e^{\frac{L_\lambda}{g}(F+M)} - e^{\frac{L_R}{g}(F+M)} \right)}{F+M}. \tag{18}$$

This expression can be simplified, by identifying that the first terms in the denominator can be replaced with *R* according to equation (17), then simplifying to give,

$$\bar{N} = R \frac{\left(1 - e^{-\frac{(L_\lambda - L_R)}{g}(F+M)} \right)}{F+M}. \tag{19}$$

Yellow eel yield in numbers can now be calculated multiplying the instantaneous fishing mortality rate (*F*) with the average number of exploitable eels over a year (Ricker 1975), giving

$$C_{N,y} = F\bar{N} = FR \frac{\left(1 - e^{-\frac{(L_\lambda - L_R)}{g}(F+M)} \right)}{F+M} = fR \frac{\left(1 - e^{-(L_\lambda - L_R)(f+m)} \right)}{f+m}. \tag{20}$$

This equation is useful if you have information on the number of recruits entering the exploitable stock each year (*R*). If this is not the case, but you have information on the total yellow eel catch in numbers ($C_{N,y}$) you can solve equation (20) for *R*, and get an expression useful for calculating *R*,

$$R = C_{N,y} \frac{(F+M)}{F\left(1 - e^{-\frac{(L_\lambda - L_R)}{g}(F+M)} \right)} = C_{N,y} \frac{(f+m)}{f\left(1 - e^{-(L_\lambda - L_R)(f+m)} \right)}. \tag{21}$$

A version of these calculations has been developed handling biomasses of exploitable stock and biomass yield. These calculations require information on the relation between weight (*W*) and length for the relevant sizes (e.g. $W = \alpha L^\beta$). A complication arises since the form of the equations describing biomass of exploitable stock and biomass yield depend on the value of the parameter β. Ricker (1975) present result for $\beta = 3.0$, and I have been deriving expressions for situations when $\beta = 3.2$, since Svedäng (1999) estimated that $\alpha = 3.64 \cdot 10^{-7}$ and $\beta = 3.21$ for yellow eels at the Swedish west coast. The derivation of these results will, however, not be presented here, only the equivalent of equation (21) based on yellow eel catch in biomass ($C_{B,y}$), since this was used in the calculation of R for the Figures above. Thus,

$$R = C_{B,y}\frac{(F+M)}{F\alpha\left(L_R^{\frac{16}{5}}V_{L_R} - L_\lambda^{\frac{16}{5}}V_{L_\lambda}e^{-\frac{L_\lambda - L_R}{g}(F+M)} + U_{L_R,L_\lambda}\right)}, \tag{22}$$

where

$$V_{L_i} = 1 + \frac{16g}{5L_i(F+M)} + \frac{176g^2}{\left(5L_i(F+M)\right)^2} + \frac{1056g^3}{\left(5L_i(F+M)\right)^3}, \tag{23}$$

and

$$U_{L_i,L_j} = \frac{1056g^3 e^{\frac{L_i}{g}(F+M)}\int_{L_i}^{L_j}\frac{e^{-\frac{L}{g}(F+M)}}{L^{\frac{4}{5}}}\mathrm{d}L}{625(F+M)^3}. \tag{24}$$

The inability to fully solve the integral analytically, as seen in Equation (24), forces us to perform numerical integration to solve equation (22). However, fairly good approximations to R can be produced with equation (21) if we approximate numbers caught from biomass caught, using an estimate of the mean weight of eels caught ($\overline{w}$), i.e. $C_{N,y} = C_{B,y}/\overline{w}$. It should, though, be noticed that this approximation generally underestimates the number of eel caught.

A.3.3.11 Possible extensions

A large number of extensions of the presented approach are possible, of which I will only mention a few. One of the most apparent extensions would be to include size dependent silver metamorphosis of males and females. This also points to the urge to separate the sexes in situations where sex ratios are more even than in Swedish waters.

When there is no explicit minimum length limit it might become important to allow for size dependent selectivity in the fishery.

At the present it is possible to include variable recruitment into the equations describing the time perspective of the spawner escapement over time since management efforts have been applied. So far, no such analysis has been performed, however.

Making the mortality rates size dependent, and allowing them to vary between years would increase the generality of the approach, but severely reduce the possibility of analytical solutions. Such an approach would take the modelling towards the approach of virtual population analyses (VPA) and increase the demand for data extensively.

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Ricker, W.E. 1975. Computation and interpretation of biological statistics of fish populations. Bulletin of Fisheries Research Board of Canada 191.

Svedäng, H. 1999. Vital population statistics of the exploited eel stock on the Swedish west coast. Fisheries Research 40: 251–265.

Annex 4: Eel stock and fisheries reported by country in 2004

Report on eel stock and fishery in Sweden, 2004

Country: Sweden

Authors: Håkan Wickström

Author address: including email. National Board of Fisheries, Institute of Freshwater Research, SE-178 93 DROTTNINGHOLM, Sweden

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Reporting date and last reported year: November 2004, most data through 2003.

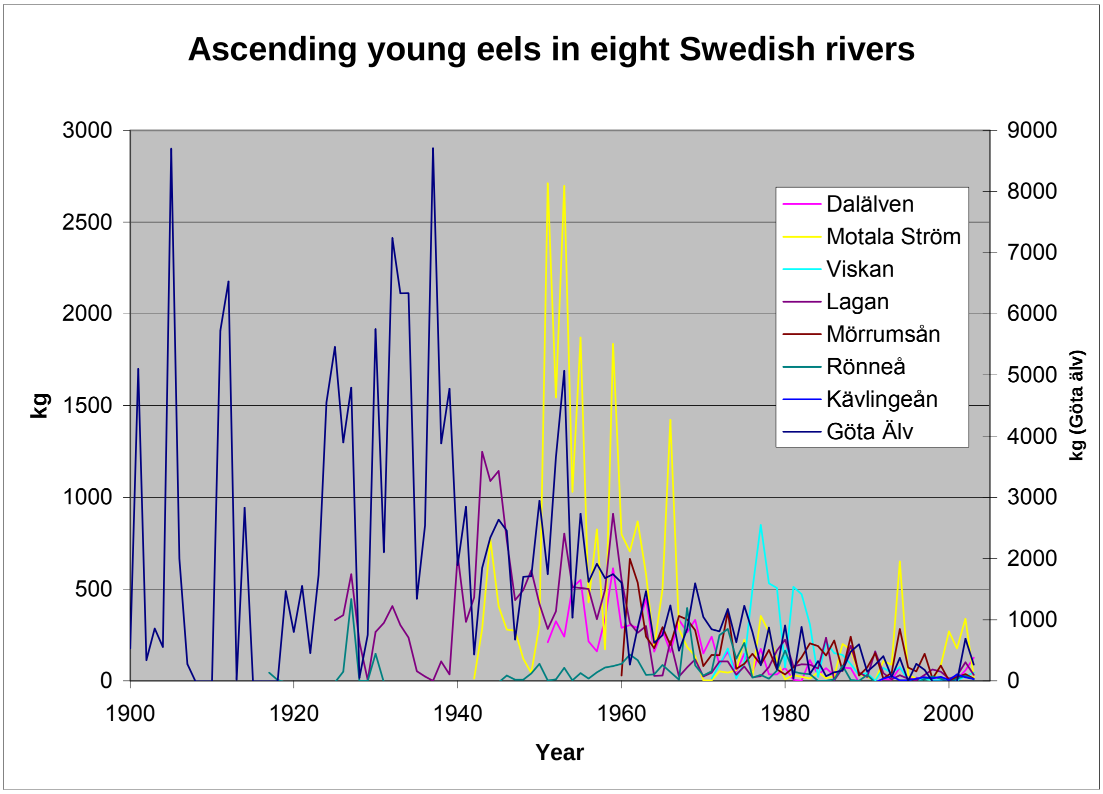
SE.1 Data

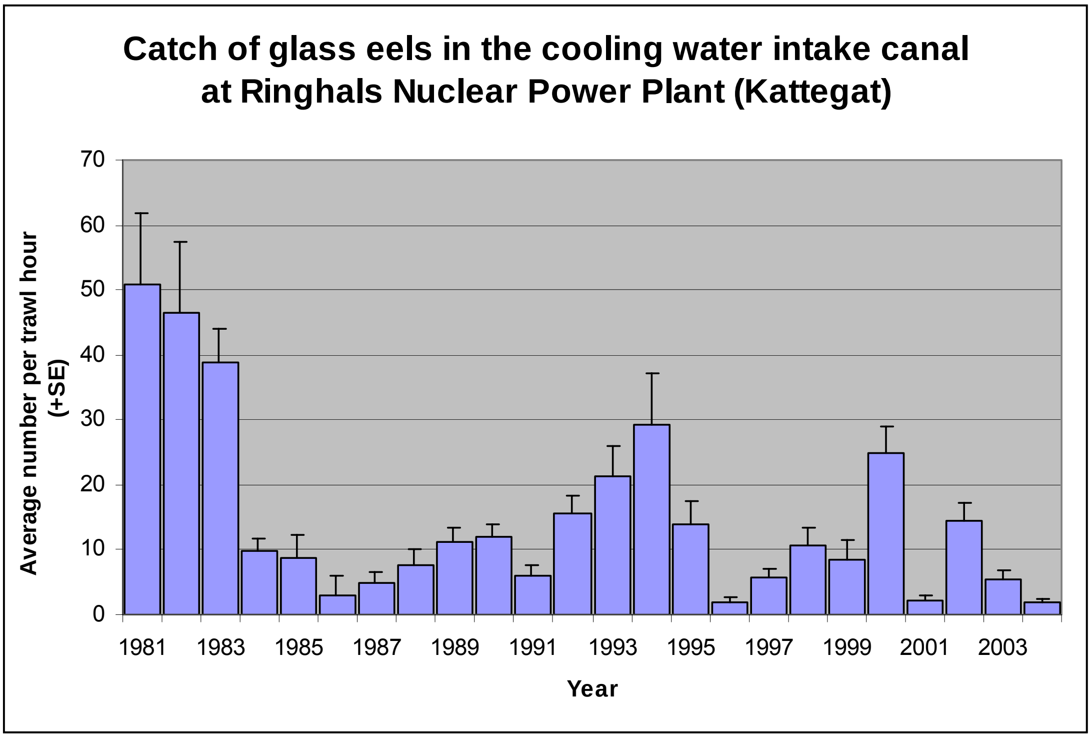
SE.1.1 Trend in recruitment

The amount (in kg and sometimes in numbers) of young eels (0+ and older) ascending several rivers along the Swedish coast from Kattegat to the Gulf of Bothnia (northern part of the Baltic Sea) are monitored according to judgements in the Water Courts. The following rivers are reported on here; Rivers Göta Älv, Viskan, Lagan, Rönne å, Kävlingeån, Mörrumsån, Motala Ström and Dalälven. Viskan is the only Swedish river where "glass eels" (elvers) are totally dominating. In the remaining rivers there is a mix of age classes, from 0+, 1+, 2+ and 3+ up to about 10+ in age. Eels of this size are not exploited at all in Sweden as the smallest minimum legal size is 35 cm. Additional recruitment series on glass eels come from an experimental trawl fishery (with an IKMWT) in the intake channel for cooling water at the Ringhals Nuclear Power Plant (in Kattegat) and from the ICES-IBTS (formerly YFS) using an MIK-trawl in Skagerrak-Kattegat. The latter series is not available here.

This year's (2004) recruitment is in most rivers as low as were common during the last ten years. In contrast the catch of ascending young eels from River Kävlingeån was unexpectedly the very best in that series.

The data behind the following figure is given in the Annex of the report on Sweden.


Ascending young eels in eight Swedish rivers
kg
kg (Göta älv)
Year
Dalälven
Motala Ström
Viskan
Lagan
Mörrumsån
Rönneå
Kävlingeån
Göta Älv
0
500
1000
1500
2000
2500
3000
9000
8000
7000
6000
5000
4000
3000
2000
1000
1900
1920
1940
1960
1980
2000


Catch of glass eels in the cooling water intake canal at Ringhals Nuclear Power Plant (Kattegat)
Average number per trawl hour (+SE)
Year
0
10
20
30
40
50
60
70
1981
1983
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003

SE.1.2 Trend in fishery

Yellow eels are the main targets for the commercial fishery along the Swedish West Coast (88% yellow eels). In the Baltic Sea and most freshwater fisheries migrating (mostly silver) eels are the targets although a small proportion (9% in the Baltic Sea) consists of yellow eels.

EU-logbook is kept by all licensed fishing vessels with a length of ten meter and above and also on trawlers under ten meter. For the other licensed fishers a monthly "Coastal Fishery Journal" are the information sources in marine/brackish waters. In inland waters a similar system (monthly or in smaller lakes yearly journals) is used. From 2005 it will be mandatory also for non-licensed fishermen to use logbook or journal if they sell fish to authorised first buyers. In addition a parallel source of information is sales notes drawn up by auctions and other first buyers of marine fish. This data includes landings also from non-licensed fishermen. Logbooks as well as sales notes are delivered directly to the Board of Fisheries and the information is recorded in an integrated database. Effort data are included in the logbook/journal systems.

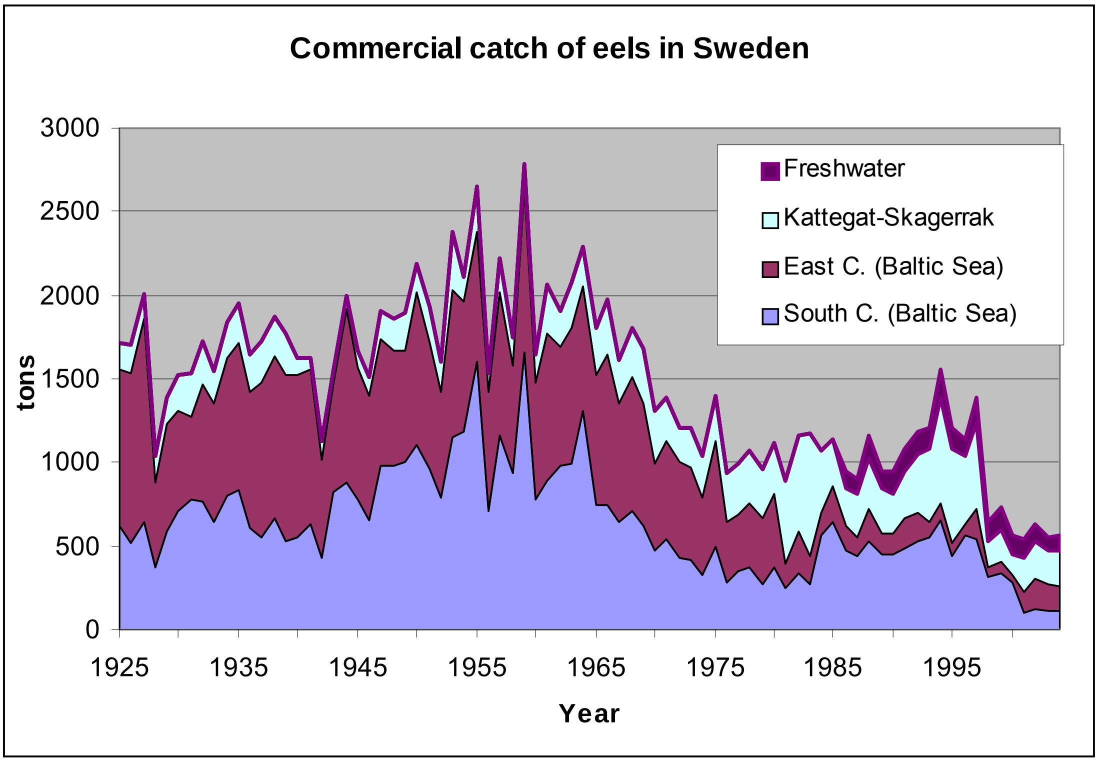
There is no information available on the impact of the fishery on the stock except some mortality estimates done by Svedäng (1999) and during work in progress with the national management plan.

MARINE CATCHES				
Year/Coastal districts	West Coast	South Coast	East Coast	Total
1959	400	1420	977	2797
1964	503	579	893	1975
1968	488	535	794	1817
1985	169	647	213	1116*
2000	123	286	39	448
2001	199	110	134	443
2002	239	126	166	531
2003	209	115	145	469

* Incl. 87 tons landed abroad

FRESHWATER CATCHES						
Year/Lake	Vänern	Vättern	Mälaren	Hjälmaren	Other lakes	Total
2001	25	0	38	23	32	118
2002	22	0	34	18	29	103
2003	23	0	31	16	26	96

For both the marine and freshwater catches there are much longer and complete series available on request.



Until quite recently the commercial catch of eel along the West Coast (Skagerrak-Kattegat) was regarded as remarkable stable, but since about 1997 also the catches from this area have fallen. This might be the final evidence that the recruitment failure now has broken through in all eel fisheries in Sweden. The only exception concerns the eel catches in some lakes that are stocked with elvers and/or with medium-sized yellow eels. In such lakes the commercial catches are quite stable or even increasing.

SE.1.3 Trend in the stock

There is no monitoring programme regarding eel in freshwater in Sweden. However, the Institute of Freshwater Research initiated a survey of silver eels in 2003. Samples from the commercial fishery in eight lakes (freshwater) were collected. In a parallel study large samples were also collected from the Öresund area (both from Sweden and Denmark) where most eels leaving the Baltic Sea have to pass. In addition to the traditional data on stage, length, weight etc. most eels will be aged and a proportion also analysed with respect to the Sr/Ca-ratio in their otoliths. Sr/Ca-ratios will be used to determine the life histories of the silver eels, with emphasis of being stocked or not and the proportion of freshwater-grown eels among the commercial catch close to the open sea. A subsample of eels will also be analysed with regard to their fat content.

The Institute of Coastal Research has recently included eels in the marine environments (both from the West Coast and from the Baltic Sea) in their Extended Data Collection Programme.

SE.1.4 Trend in re-stocking

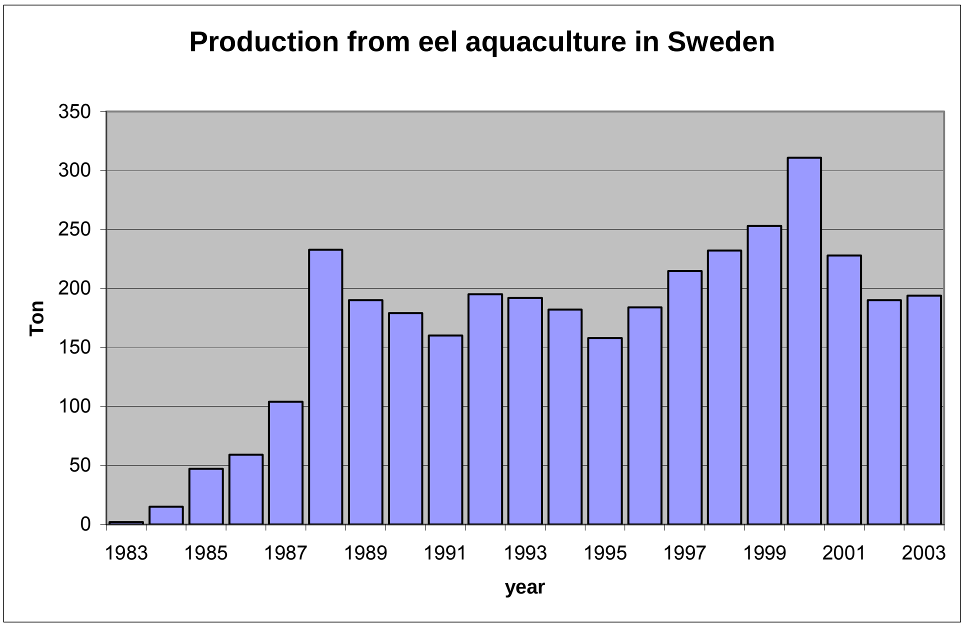
Eels are re-stocked either as imported and quarantined elvers (from River Severn in the UK) or as medium-sized yellow eels (c. 370–400 mm) from the Swedish West Coast. During the last 12 years about 2.3 million individuals were stocked annually corresponding to an annual cost of about 6.2 million SEK (c. 670 000 €). Due to high prices during 2004 only 805 000 imported elvers were stocked at a cost of 3.2 million SEK (c. 346 000 €). In addition to the elvers some 122 000 medium-sized yellow eels were also stocked at a cost of 1.0 million SEK

(c. 108 000 €). The government covered the main part of the costs, but also hydropower companies (regulated by the Water Rights Courts) and the fishermen's organisations paid their shares.

SE.1.5 Trend in aquaculture

There are today only two eel aquaculture plants for eel in Sweden. Both are indoor facilities. One is based on imported glass eels/elvers from the UK (River Severn) and the second one on medium-sized yellow eels from the Swedish West Coast. The former one is the only approved quarantine for imported eels in the country. Besides the production of eels for consumption they also supply pre-grown elvers as seed for aquaculture in other countries and for re-stocking purposes.

YEAR	PRODUCTION (TONS)
1983	2
1984	15
1985	47
1986	59
1987	104
1988	233
1989	190
1990	179
1991	160
1992	195
1993	192
1994	182
1995	158
1996	184
1997	215
1998	232
1999	253
2000	311
2001	228
2002	190
2003	194



SE.2 Management

A national management plan for eel is in preparation. Its major contents besides a general description of the problematic situation for the European eel is a list of different management measures and estimations to what extent they could increase the numbers of escaping silver eels by decreasing fishing mortality and increasing recruitment. There are three major components, viz. improvements of the up- and downstream migration routes, including the issue of mortality in hydropower turbines, an increase of the minimum legal size and finally extensive re-stocking programs.

So far no formal target is defined except a general increase of potential spawners leaving Sweden. Thereby, neither compliance nor efficiency is monitored yet. However, we intend to follow the 30% SPR rule. At this moment the plan has to be compiled from different parts produced by different persons and be made into a suitable format.

The current management measures include minimum legal size restrictions. Along the Skagerrak-Kattegat coast an eel has to be at least 370 mm, in the Sound 350 mm (in agreement with Denmark) and in the Baltic Sea including the five largest lakes the minimum legal size is now 600 mm. These limits apply to yellow eels only. In rivers emptying to the Skagerrak-Kattegat the minimum legal size is 400 mm for all stages. This rule applies up to the first complete obstacle to migration (with reference to salmonids).

The fyke-net fishery for eels in Skagerrak-Kattegat is closed from 1st January until the 1st Monday in April. For licensed and non-licensed fishermen 600 fyke nets (1 200 cod-ends) and 6 (12 cod-ends) are allowed, respectively. The fykes have to be lifted with less than 72 hours interval. Spearing and the use of trammel nets are not allowed. There are also regulations about the use of weirs and fixed traps in rivers, requiring time periods and parts of a river to be left open to allow free migration.

The use of grids is often prescribed to protect silver eels and other fish to enter hydroelectric power plants as are eel passes at many sites where ascending young eels are/were known to occur.

SE.3 Research

There are some eel research projects running with obvious relevance to today's issues. One is "100 years of silver eel tagging in the Baltic Sea – do stocked eels find their way out of the Baltic Sea?" It has now been running for almost three years and involves one research assistant and a budget of about 50 000 € per year. This project will probably run for another year and might then include additional tagging experiments combined with otolith microchemistry and fat analysis of recaptured individuals.

Another project concerns "The origin of silver eels leaving the Baltic Sea". By applying otolith chemistry to silver eels caught close to the exits of the Baltic Sea we will be able to estimate the proportion of eels grown in brackish and freshwater environments, respectively. To some extent we will also be able to estimate the contribution from stocked eels to the potential escapees. This project involves about one research scientist and a research assistant with a total budget of about 300 000 € distributed over two and a half year. This project also includes samples from a number of freshwater lakes and a genetic approach with the aim to estimate the effective population size of the European eel.

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Acknowledgements

Björn Fagerholm, Anders Bogelius, and Håkan Westerberg have, in addition to several persons responsible for the different monitoring stations, given valuable input to this report.

Annex to report on eel in Sweden, 2004.

RECRUITMENT DATA SERIES FROM SOME SWEDISH RIVERS (ALL IN KG, -9.0= DATA NOT AVAILABLE, 2004 NOT YET COMPLETE)								
Year	Göta Älv	Dalälven	Motala Ström	Viskan	Lagan	Mörrumsån	Rönneå	Kävlingeån
1900	530.0							
1901	5100.0							
1902	340.0							
1903	858.0							
1904	552.0							
1905	8700.0							
1906	2000.0							
1907	275.0							
1908	-9.0							
1909	-9.0							
1910	-9.0							
1911	5728.0							
1912	6529.0							
1913	20.0							
1914	2828.0							
1915	-9.0							
1916	-9.0							
1917	-9.0						45.0	
1918	-9.0						4.5	
1919	1465.0						-9.0	
1920	800.0						-9.0	
1921	1555.0						-9.0	
1922	455.0						-9.0	
1923	1732.0						-9.0	
1924	4551.0						-9.0	
1925	5463.0				331.3		-9.0	
1926	3893.0				357.8		49.0	
1927	4796.0				581.1		445.0	
1928	47.0				211.9		0.0	
1929	756.0				4.5		0.0	
1930	5753.0				268.0		147.0	
1931	2103.0				316.0		-9.0	
1932	7238.0				408.0		-9.0	
1933	6333.0				303.5		-9.0	
1934	6338.0				236.0		-9.0	
1935	1336.0				53.5		-9.0	
1936	2537.0				24.5		-9.0	
1937	8711.0				0.5		-9.0	
1938	3879.0				106.5		-9.0	
1939	4775.0				36.0		-9.0	
1940	1894.0				684.0		-9.0	
1941	2846.0				321.0		-9.0	
1942	427.0		14.0		454.0		-9.0	
1943	1848.0		283.0		1248.0		-9.0	
1944	2342.0		773.0		1090.0		-9.0	
1945	2636.0		406.0		1143.0		-9.0	
1946	2452.0		280.0		766.5		29.7	

Recruitment data series from some Swedish rivers (all in kg, -9.0= data not available, 2004 not yet complete)								
Year	Göta Älv	Dalälven	Motala Ström	Viskan	Lagan	Mörrumsån	Rönneå	Kävlingeån
1947	675.0		272.5		440.8		5.8	
1948	1702.0		120.0		494.7		6.0	
1949	1711.0		43.0		603.6		39.4	
1950	2947.0		304.5		419.9		93.5	
1951	1744.0	210.0	2713.0		281.8		1.0	
1952	3662.0	324.0	1543.5		379.1		9.1	
1953	5071.0	241.5	2698.0		802.4		70.0	
1954	1031.0	508.5	1030.0		511.3		2.7	
1955	2732.0	550.0	1871.0		506.9		42.6	
1956	1622.0	215.0	429.0		501.6		14.1	
1957	1915.0	161.5	826.0		336.1		46.8	
1958	1675.0	336.7	172.0		497.2		73.2	
1959	1745.0	612.6	1837.0		910.5		80.0	
1960	1605.0	289.0	799.0		552.4	29.0	93.0	
1961	269.0	303.0	706.0		314.8	665.5	143.7	
1962	873.0	289.0	870.0		261.9	534.8	113.0	
1963	1469.0	445.4	581.0		298.1	241.2	32.5	
1964	622.0	158.0	181.6		27.5	177.8	34.7	
1965	746.0	276.4	500.0		28.0	292.3	87.1	
1966	1232.0	157.5	1423.0		216.5	196.3	48.5	
1967	493.0	331.8	283.0		24.4	353.6	6.6	
1968	849.0	265.5	184.0		74.4	334.8	398.0	
1969	1595.0	333.7	135.0		117.1	276.8	85.7	
1970	1046.0	149.8	2.0		24.7	80.4	29.8	
1971	842.0	242.0	1.0	12.0	45.3	141.1	53.3	
1972	810.0	87.6	51.0	88.0	106.2	139.9	249.0	
1973	1179.0	159.7	46.0	177.0	107.1	375.0	282.3	
1974	631.0	49.5	58.5	13.0	33.6	65.4	120.7	
1975	1230.0	148.7	224.0	99.0	78.4	93.3	206.7	
1976	798.0	44.0	24.0	501.0	20.2	147.2	17.1	
1977	256.0	176.4	353.0	850.0	26.4	89.6	32.1	
1978	873.0	35.1	266.0	532.6	75.8	168.4	10.8	
1979	190.0	34.3	112.0	505.2	165.9	61.4	56.1	
1980	906.0	71.2	7.0	72.5	226.0	36.5	165.7	
1981	40.0	6.8	31.0	513.1	78.0	72.8	49.2	
1982	882.0	0.5	22.0	472.0	90.8	129.0	40.0	
1983	113.0	112.1	12.0	308.4	87.8	204.6	37.6	
1984	325.0	33.9	48.0	20.7	68.0	189.9	0.5	
1985	77.0	69.7	15.2	211.5	234.1	138.1	0.0	
1986	143.0	28.4	26.0	150.9	2.5	220.3	8.6	
1987	168.0	73.5	201.0	140.9	69.8	54.5	84.8	
1988	475.0	69.0	169.5	91.9	191.7	241.0	4.9	
1989	598.0	-9.0	35.2	32.7	44.0	30.0	0.0	
1990	149.0	-9.0	21.0	42.1	21.6	72.5	32.0	
1991	264.0	-9.0	2.0	0.4	161.3	151.0	-9.0	-9.0
1992	404.0	9.6	108.0	70.3	42.2	14.0	-9.0	12.5
1993	64.0	6.6	89.0	43.4	8.7	45.7	-9.0	25.8
1994	377.0	71.9	650.0	76.1	30.7	283.0	-9.0	4.0
1995	0.0	7.6	32.0	5.5	11.6	72.4	-9.0	2.9
1996	277.0	17.5	14.0	10.0	2.8	51.9	-9.0	13.5

Recruitment data series from some Swedish rivers (all in kg, -9.0= data not available, 2004 not yet complete)								
Year	Göta Älv	Dalälven	Motala Ström	Viskan	Lagan	Mörrumsån	Rönneå	Kävlingeån
1997	180.0	7.5	8.1	7.6	31.7	148.0	10.4	19.4
1998	-9.0	14.7	5.5	5.0	62.6	12.9	24.0	15.3
1999	-9.0	15.5	85.0	1.8	49.5	84.2	11.4	22.2
2000	-9.0	12.4	270.1	14.1	13.0	1.0	-9.0	5.0
2001	-9.0	8.2	177.5	1.8	26.8	19.3	13.7	34.5
2002	693.0	58.6	338.8	26.2	102.0	37.4	27.0	19.3
2003	266.0	126.1	19.0	45.1	31.7	11.0	9.1	9.7
2004	*c. 110*	*c. 26.3*	*c. 42*	5.0	*c. 14*	-	2.0	248.3

DK – Eel stock and fishery in Denmark in 2004

Country: Denmark

Authors: Michael I. Pedersen

Author address: Vejlsøvej 39, Dk-8600 Silkeborg: mip@dfu.min.dk

Reporting date and last reported year: September 2004, last report October 2003

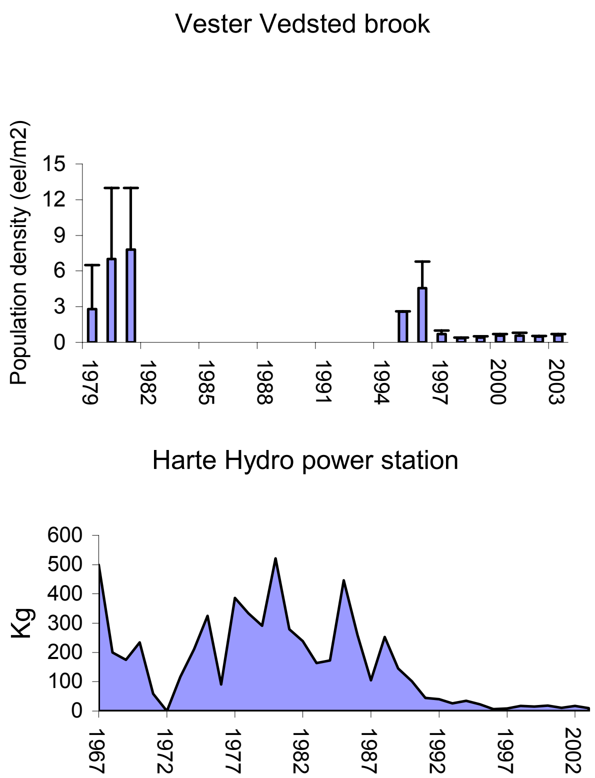
DK.1 Data on stock and fisheries

DK 1.1 Trend in recruitment

Monitoring methodology, life stage, gear type

Recruitment monitoring takes place at two pass traps catching ascending yellow eel. The pass traps are placed at Tange Hydro power station in River GudenÅ and at Harte Hydro power station in River Kolding Å, both rivers empty into Kattegat on the east coast of Denmark. On the west coast, recruitment is monitored by electro fishing, in a small brook that empty into the Waddensea (further details see - Dekker 2002).

Recruitment monitoring results



Figures 1, 2: Recruitment of young eel to freshwater

In Vester Vedsted brook on the west coast, monitoring took place from 1979–1981 and again from 1995 – till today. From very high eel densities in the beginning of the 1980s densities have been very poor since the mid 1990s. The pass trap at Harte Hydropower station shows a similar marked decrease since the beginning of the 1990s. The pass trap at Tange (Table 1) does not give a similar picture, probably because the monitoring place is 40 km upriver from the Kattegat coast!

Table1. Recruitment data

YEAR	TANGE	HARTE	VESTER VEDSTED BROOK	
	(kg)	(kg)	Density	
1967		500	Mean	max (season)
1968		200	eel/m2	eel/m2
1969		175		
1970		235		
1971		59		
1973		117		
1974		212		
1975		325		
1976		91		
1977		386		
1978		334		
1979		291	2,8	6,5
1980	93	522	7,0	13,0
1981	187	279	7,8	13,0
1982	257	239		
1983	146	164		
1984	84	172		
1985	315	446		
1986	676	260		
1987	145	105		
1988	252	253		
1989	354	145		
1990	367	101		
1991	434	44		
1992	53	40		
1993	93	26		
1994	312	35		
1995	83	23	2,6	2,6
1996	56	6	4,6	6,8
1997	390	9	0,7	1
1998	29	18	0,3	0,4
1999	346	15	0,4	0,5
2000	88	18	0,6	0,7
2001	239	11	0,6	0,8
2002	278	17	0,5	0,6
2003	260	9	0,6	0,7

DK 1.2 Trend in fishery

Life stage concerned:

Exploitation concern yellow eel and silver eels. Glass eel fisheries stopped in 1990.

Description of fisheries, information sources, gear types

Along the open Danish coast in Kattegat and Øresund and The Belt Sea, poundnets exploit migrating silver eels during autumn.

In Fjords, Bays and shallow water mainly yellow eel are caught during summer, by use of small pound nets, fyke nets and baited hooks.

The source of information on yield is from eel traders. The traders are obliged to report to the Ministry of Food the amount of eel that are traded and what life stage (yellow or silver eel).

Fishing Effort

The countrywide effort is most probably decreasing, but there is no statistics readily available concerning the number of fishermen or number of gear to give an indication of the effort except on Roskilde Fjord. Recent reports on the status of the poundnet fishery were made in 1994 and 1997. (Koed and Pedersen 1996, Danmarks Fiskeriforening 1998)

Roskilde Fjord

Roskilde Fjord has a catchment area of 1200 km2 and a water surface of 123 km2. A fishing gear survey was made in August 2003. The survey was made by counting the number of gears from a small helicopter while flying over the Fjord. The total number of fyke nets recorded was 485 and the total number of pound nets was counted to 147. Only professional fishermen are allowed to fish with pound nets.

Licence marks on fyke nets differ weather you are professional or recreational fisherman. A survey of licence identity in 2003 showed that 72% of the fyke nets belonged to recreational fishermen and only 28% to the professional fishermen, suggesting that the unrecorded recreational fishery is important.

The effort in recent years is probably the lowest in the last 50 years! In the 1950s about 2000 fyke nets were recorded in Roskilde Fjord, increasing to 7000 during the 1970s and hereafter dropping to 485 in 2003.

The number of pound nets registered in the 1950s were ca. 500, increasing to 800 in the 1970s and hereafter dropping to 146 in 2003.

Data series on fishing yield

The officially statistics reflect decreasing yield since the 1960s; however, selling on the black market is part of the fishermen’s culture. More or less constant prises due to large amount of farmed eel released in the market and low catches may encourage the fishermen to sell part of the catch from the boat to increase income by avoiding taxes.

In some areas the fishery is probably not sustainable. For example on Roskilde Fjord, landings are almost exclusively small eels below 45 cm. Despite female silver eels (> 45 cm) are quite rare. Sex ratios of yellow eel before recruiting the fishery are found to be ca. 50% females, suggesting that the stock is exploited very hard. F-values from a survey in 1990 have been calculated to be between 0.22–0.80 per 1.5 cm length interval for the population above legal size (Pedersen 1997). The official catch in recent years was 10 – 14 tons/year, however Roskilde Fjord constitutes a rather small part (2%) of the total landings ca. 600 tons/year.

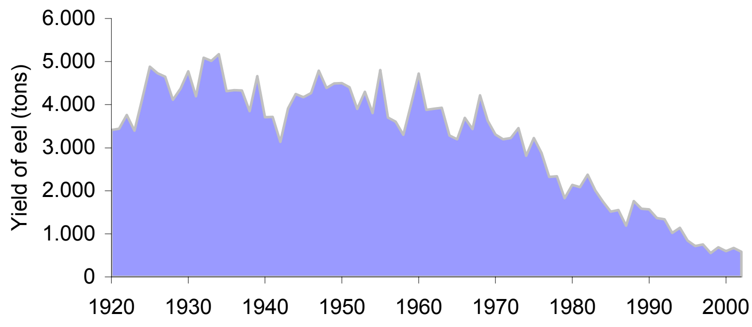


Figure 3. Total official catch (yellow and silver)

Tabel 2. Total official catch of silver and yellow eel for the last ten years.

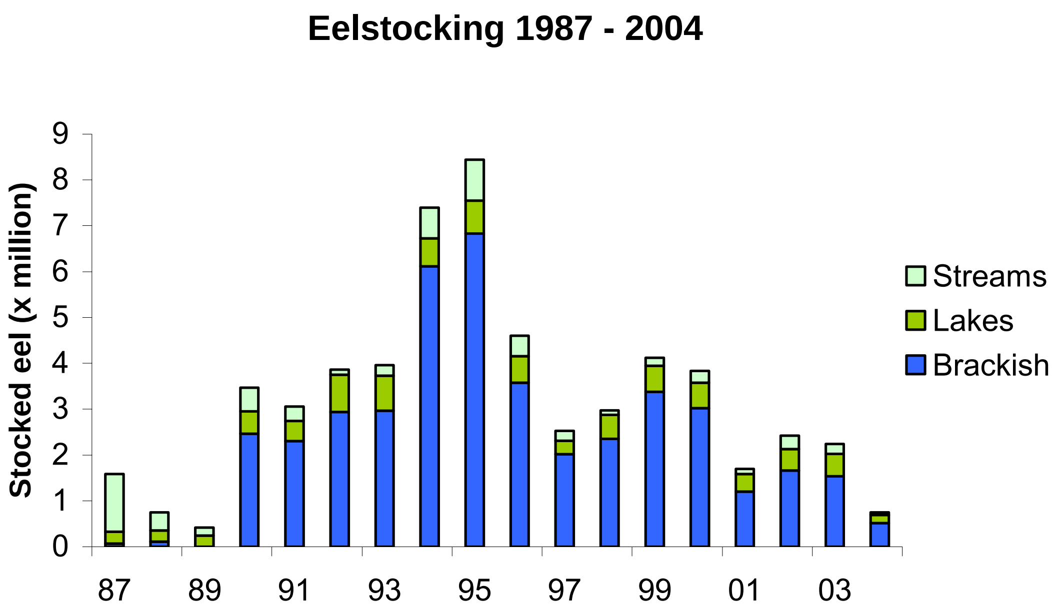
YEAR	SILVER	YELLOW	TOTAL
1993	523	500	1023
1994	509	631	1140
1995	408	432	840
1996	381	337	718
1997	375	383	758
1998	306	251	557
1999	380	307	687
2000	382	218	600
2001	446	225	671
2002	365	217	582
2003	437	188	625

Recent development in fisheries and market

The recruitment of new eel-fishermen is insignificant and the mean age of the active fishermen are high, so the number of professional fishermen is decreasing. The fishermen have difficulties surviving on the income from fishing. In general there is a shift from fulltime eel fishermen toward part time or recreational fishermen.

DK 1.3 Trend in restocking

A countrywide stocking program has been developed since 1987. The program is financed by licence fees from leisure fishermen. The seed stock is imported glass eels from southern Europe raised in culture to 2–5 gram before stocked. Ca. 75% is released in brackish marine areas such as fjords and bays and 25% in freshwater. In recent years the level of stocking has been 2–4 million eels. In 2004 it was not possible to buy the wanted amount of elvers form eel farmers because of poor catches and high prices of glass eel, in southern Europe.



DK 1.4 Trend in aquaculture

Year	Production units	Production [ton]
1984	??	18
1985	30	40
1986	30	200
1987	30	240
1988	32	195
1989	40	430
1990	47	586
1991	43	866
1992	41	748
1993	35	782
1994	30	1034
1995	29	1324
1996	28	1568
1997	30	1913
1998	28	2483
1999	27	2718
2000	25	2674
2001	17	2000
2002	16	1880
2003	13	2050

Aquaculture production of eel in Denmark takes place at 13 production units producing 2050 ton of eel in 2003. All production takes place at indoor, heated aquaculture systems.

DK 2. Management

There is currently no explicit national management plan, no target is defined and no monitoring concerning exploitation takes place; however management measures have been in effect for many years. For example has eel pass been part of the freshwater legislation for more than 100 years, since 1898.

Management measures currently in effect

1) 1. Minimum legal size. Glass eel are protected by the minimum legal size on yellow eel which in fresh water is 45 cm. In salt water 29,5 - 34,5 - 35,5 - 38 cm depending on region.

   Silver eels have no legal size limit.
2) Technical measures. There is a variety of technical measures depending on region. The regulations on fishing gear include gear type, mesh size and number of gears per fisherman. The technical measures on eel fishing gear primarily concern leisure fishermen.
3) Closed areas. In lakes where a stream enters or leave the lake there is a restricted 50 m zone where fishing is prohibited. In salt water fishing is restricted in a distance of 500 m around a river mouth. In streams fishing gear may only cover 2/3 of the stream width.
4) Eel passes. At all freshwater barriers eel passes should be in operation from April through October.

DK 3. Research

Monitoring and research projects listed below are financed by the board of leisure fishermen. Total cost 108.000 EURO.

Project title: Population dynamics of stocked eel in a river system

Objectives:

Part 1) The overall objective is to evaluate the effect of stocking eel in a river system. Part 2).Study the effect of anthropogenic factors on the downstream migration of silver eel, including weirs, reservoirs and trout farms that the eel have to bypass.

Abstract:

Part 1) Previous studies have aimed to assess the biological value of stocking elvers in small to medium size streams. The studies however, showed that the eels either suffer high mortality or disperse to downstream sections of the streams where monitoring by electro fishing is not possible. Thus, only limited information on the fate of the stocked elvers is available. This project seeks to alleviate this shortcoming.

No, or only very little, natural recruitment occurs to the upper part of River Gudenå. Therefore, the area is excellent for eel stocking experiments, and all migrating fish can be monitored in a downstream fish trap. During 1987, 1988 and 1992 the area was stocked with 1.6 mill elvers. The size and age composition of the silver eel run at Vestbirk fish trap suggest that most males from these stockings have by now left the feeding areas for the spawning runs, whereas older (>10 years) females are immigrating in these years. All eel passing the trap are being recorded and measured, and sub samples of these are aged. The population parameters growth rate, numbers, sex and age at silvering are used in models to describe the yield of the stockings.

In year 2000 and 2001 new stockings were performed in upstream tributaries of the river Gudenå. These stockings were cw-tagged and surveyed by electro fishing to measure post stocking growth and dispersal.

Part 2) Silver eels leaving the upper reaches of the River Gudenå have to pass several weirs and lakes when migrating towards the coast. How these obstructions influence the migration is largely unknown, but a delay and possibly a higher mortality may be expected. Migrating silver eels will be equipped with telemetric tags and the downstream migration will be surveyed by automatic listening stations and manual tracking.

Duration: 2000 – 2007

Project leader and participants: Michael Ingemann Pedersen, DIFRES

Project title: Assess the yield to fisheries of eel stocking in a marine fjord

Objectives: The objective is to estimate the biological outcome of stocking eel in a marine area, to estimate the yield to the fishery and the proportions of eels escaping the fishery.

Abstract: About 2 million elvers are annually stocked in Danish marine waters. Currently there are only vague indications that these stockings are worth while, in terms of improving numbers of fish recruiting the fisheries.

In 1998 and 1999 a total of 100.000 coded wire tagged eel were stocked in the inner parts of Roskilde Fjord. Recruitment of the stocked eel to the fishery is expected to reach a maximum in 2003 and 2004 and thereafter gradually decrease. During 2000 – 2006 the eel catches made by professional and recreational fishermen will be analysed for recapture of marked fish in order to establish the ratio of tagged to untagged fish in the eel catches in Roskilde Fjord. Based on knowledge of numbers of fish caught in the yellow eel fishery as well as the silver eel fishery, the yield to the fishery may be calculated. Data collections are made within different strata of the fjord and adjacent fisheries, Issefjord and Arresø. In September and October migrating silver eels will be Carlin tagged and released. Based on reported recaptures from fishermen an estimate of fishing mortality may be established as well as of the number of silver eels leaving the Fjord and migrating toward the Sargasso spawning grounds. The total catches made by recreational fishermen will be sought established through questionnaires to recreational fishermen.

Duration: 1998 – 2007

Project leader and participants: Michael Ingemann Pedersen, DIFRES

Project title: Monitoring *Anguillicola* parasites in Danish eel populations and their negative effects on the eel.

Objectives: To monitor the parasite abundance and variation in eel populations ranging from fresh to brackish water bodies. To assess any harm caused by the parasite to the health of infected eels in general, and to the host's swim bladder in particular.

Abstract: The swim bladder worm *Anguillicola crassus* was introduced to Europe from the far east in the beginning of the 1980s. It was discovered in Danish wild eels in 1986. The parasites are thought to be one of the causes of the decline of the European eel population. Therefore the colonisation of Anguillicola in Denmark has since 1988 been monitored in several fresh and marine water bodies to assess the abundance of parasites, as well as their effects on the swim bladder and the general health of parasitized eels. The geographical distribution and the stability of the parasite abundance are of international interest due to the decline of the eel stock, but also because large effort is done to secure that the 2–3 million annually stocked eel are free of parasites.

Project leader and participants: Michael Ingemann Pedersen, DIFRES

Project title: Monitoring of glass eel recruitment to Danish inland waters.

Objectives: Collect data on the glass eel recruitment from the ocean to Danish inland waters, to be used in national and international advice on fisheries and stocks**.**

Abstract: A decline in recruitment of glass eel to the Danish coast and elsewhere in Europe has been persistent through several decades. The yield in fisheries has also declined and the stock is considered by ICES to be outside safe biological limits. Several hypotheses have been proposed for the decline but no unambiguous cause has been identified.

In Denmark the monitoring is currently taking place at two hydropower stations where ascending eels are monitored in bypass traps. Personnel at the hydropower stations are doing the daily monitoring. The distance from the ocean to the hydropower dams are 5 and 35 km and the ascending eels do not directly reflect the annual size of the glass eel recruitment but consist of several age groups (0–5 years).

Glass eels recruitment directly from the ocean is better quantified by electro fishing in the Vester Vedsted brook where population data further are available between 1979 and 1983. Four sections of the brook are electro fished four times a year allowing for calculation of numbers and fluctuations in the recruitment to the brook. The monitoring data are used in the content of joint ICES/EIFAC working group on eel.

Duration: 1996–2007

Project leader and participants: Michael Ingemann Pedersen, DIFRES

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IE – Report on eel stock and fishery in Ireland, 2004

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IE.1 Data

IE.1.1 Trend in recruitment (as an index of the stock, be it exploited or not)

- *What is monitored? Life stage, information source, exploited or not, gear type*

  Monitoring of elver migrating at Ardnacrusha (Shannon), Cathleens Falls (Erne) and for the Feale, Inagh and Maigue Rivers and monitoring of bootlace eel migrating at Parteen Dam (Shannon).

- *Tabular data and graph, one record per year, for all years for which information is available (that repeats most information of last years report, but we want to be sure all is correct and updated)*

Monitoring is carried out at six fixed stations by the ESB and fishing is also undertaken by the ESB/Shannon Regional Fisheries Board in the Shannon Estuary for glass eels (Table 1). Indications are that recruitment remains low. Catches in 2004 for both Erne and Shannon were the second lowest recorded and while there is no effort data available, the total catch for all stations in 2004 was the lowest yet recorded (Table 1). Figure 1 presents the historical elver monitoring for the Erne and the Shannon (Ardnacrusha).

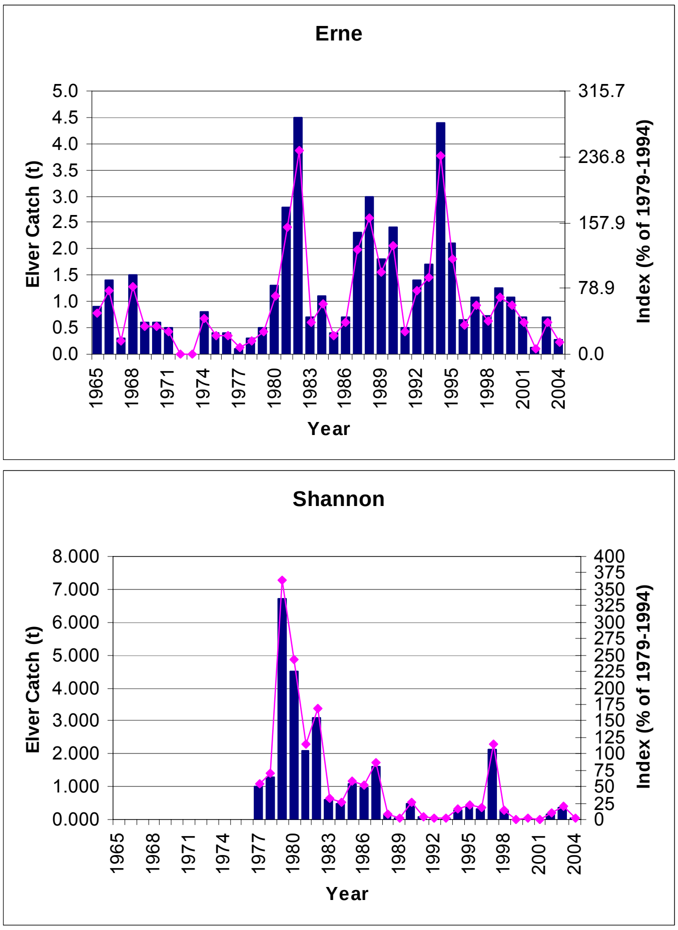

Figure 1. Historical data for catches of elvers at Cathleen's Falls on the Erne and Ardnacrusha on the Shannon.

Table 1: Glass eel, elver and bootlace (Parteen) catches (kgs) from 1985 to 2004 (nf = not fished).

		ERNE	MOY	SHANNON	SHANNON				SH. ESTUARY
Year	**Erne**	**Estuary**	**Estuary**	**Ardnacrusha**	**Parteen**	**R Feale**	**R Maigue**	**Inagh R**	**Glass Eels**
1985	400			1093	984	503			
1986	700			948	1555				
1987	2300			1610	984				
1988	3000			145	1265				
1989	1800			27	581				
1990	2400			467	970				
1991	500			90	372				
1992	1400			32	464				
1993	1700			24	602				
1994	4400			287	125	70	14		
1995	2100			398	799	0	194		
1996	647			332	95	0	34	140	
1997	1087			2120	906	407	467	188	616
1998	723	46		275	255	81	8	11	484
1999	1246	441		18	701	135	0	0	416

		ERNE	MOY	SHANNON	SHANNON				SH. ESTUARY
Year	**Erne**	**Estuary**	**Estuary**	**Ardnacrusha**	**Parteen**	**R Feale**	**R Maigue**	**Inagh R**	**Glass Eels**
2000	1074	188		39	389	174	0	120	43
2001	699		13	27	3	58	2	18	1
2002	113		21	155	648	116	nf	nf	37
2003	580		36	378	873	36	72	111	147
2004	269		0	58	256	0	0	24	1

Enhancement

The capture and possession of juvenile eel in Ireland is forbidden by law and may only be carried out under special authorisation by the Regional Fisheries Boards. Consequently, the quantities of glass eel, elver and bootlace eel reported in Table 1 were all restocked into freshwaters in Ireland for enhancement. Unauthorised stocking has also taken place but data was not available.

IE.1.2 Trend in fishery

In Ireland, commercial fishing for juvenile stages is illegal and capture is restricted by law to that needed for enhancement under special authorisation by the Regional Fisheries Boards. Fisheries for brown and silver eel take place both in freshwater rivers and lakes and in tidal areas.

- *Life stage concerned*

Brown Eel

- *Describe fisheries, information source, area, gear type, etc.*

Brown eel are caught mainly in lakes either by fyke net, or by long-line, with additional fisheries in rivers and tidal waters. There is also some baited pot and trap fishing.

- *Effort*

Reliable information on fishing effort is not available but it is thought that the brown eel fishery supports approximately 130 part-time fishermen. Table 2 details the number of licenses issued in 2002 in each Fishery Region. The number of licenses, however, does not reflect the number of fishermen and not all licenses are actively fished. Data was not available for 2003.

- *Yield*

Reporting of eel catches is not a requirement of many eel licenses and in some cases eel fishermen fail to make accurate returns. Reported catches may be as much as 50% lower than the actual catch. The Regional Fisheries Boards collate the returns from the fishermen and report the catch data to the Marine Institute. Table 3 gives brown eel declared catch for each fishery region for 2001, 2002 and 2003. While historical data is lacking, is generally felt that catches have fallen in recent years.

Table 2. Number and type of licenses (inc. silver eel) issued in 2002 in each Fishery Region.

FISHERY REGION	TYPE	NUMBER	COMMENT
Eastern	Longline	7	
	Fyke	18	
	Coghill	9	
Southern	Fyke	5	140 nets
	Pots	26	442 pots
	Coghill	2	
South Western	Longline	3	not fished
	Fyke/Pot	6	
Shannon	Longline	8	capped @ 10
	Longline	31	to ESB
	Fyke	8	
	Fyke	19	to ESB
	Coghill	6	
	Coghill	34	to ESB
Western	Longline	1	
	Fyke	20	2 are for tot 60 nets x 1m high
	Trap	1	
	Coghill	27	
North Western	Longline	26	or fyke option
	Coghill	2	on trial basis
Northern	Longline	29	Rep., capped @ 32
	Longline	20	On Erne in North
	Fyke	13	20 nets/licence
	Total	**321**	

Table 3. Declared Irish Catches (kgs) for 2001, 2002 and 2003. * = estimated

	2001		2002		2003	
Region	**Brown**	**Silver**	**Brown**	**Silver**	**Brown**	**Silver**
Eastern	14,000	2,500	16,000	4,300	10,700	3,200
Southern	8,555	0	4,800	50	4,685	nr
S. Western	552	0	972	0	97	0
Shannon	16,053	24,107	15,849	25,248	21,851	17,075
Western	8,949	9,363	4,160	13,092	12,378	8,270
N. Western	13,913	1,384	10,983	1,194	12,477	10,599
Northern	4,743	28	8,911	31	8,000*	30*
Total Catch	66,765	37,382	61,675	43,915	70,188	32,902
Approx. Value			€325,644	€164,681	€336,902	€171,090
			(@€5.28)	(@€3.75)	(@€4.8)	(@€5.2)
Overall Total Catch	104,147		105,590		103,090	
Overall Value			€490325		€507,992	

- *Is there information on the impact of this fishery on the stock? Does that provide information by year? If so, report in detail.*

General

There is only sparse information on the impact of fisheries on brown eel stocks and silver eel production. It is also difficult to separate the impact of dropping recruitment, either natural or stocked. A number of examples have been reported on where fisheries have been shown to impact on brown eel stocks or where poor recruitment has had an influence on stock structure these are summarised below and the original reference is cited. It should be noted, however, that the impact of levels of recruitment or commercial fishing on stock size or stock characteristics has not been quantified. These were fully described in the 2003 report.

Erne (Matthews *et al.* 2001)

Matthews, M., Evans, D., Rosell, R. Moriarty, C., and Marsh, I. (2001). Erne Eel Enhancement Programme. EU Programme for Peace and Reconciliation Project No. EU 15. *Northern Regional Fisheries Board, Donegal*; 348pp.

Shannon (McCarthy and Cullen 2000)

McCarthy, T.K., and Cullen, P. (2000). Eel fishing in the River Shannon: Eel population changes, fishery management options and fishery conservation issues. A synthesis report on the River Shannon Eel Management Programme 1992–2000. Report prepared for EFB Fisheries by NUIG; 21pp.

Corrib (Moriarty 2001)

Moriarty, C. (2001). Maintenance and development of the Corrib Catchment eel fishery. Report commissioned by the Western Regional Eel Fisherman's Assoc.; 34pp.

Lady's Island, Co. Wexford. (Moriarty 2002)

Moriarty, C. (2002). The eel fishery of Lady's Island Lake, Co. Wexford. Report commissioned by the Eastern Regional Fisheries Board; 18pp.

- *Tabular data and graph, one record per year, for all years (see comment above)*
- *If more than one data series is available, present each separately, and country-wise totals.*
- *Describe recent development in fisheries, market, etc.*
- *Life stage concerned*

Silver Eel

- *Describe fisheries, information source, area, gear type, etc.*

Silver eel capture takes place during the downstream migration in autumn and winter, mostly at fixed stations or 'weirs'. Fyke netting also takes place near lake outflows and in the larger rivers.

The primary methods used on the larger systems such as Shannon, Corrib and Erne are coghill nets. Regulation of these fisheries is more straight forward and consequently data is more robust.

- *Effort*

Silver eel fishing effort has been dropping over the past few years with many private fishermen and small privately owned fishing weirs closing or ceasing to operate. The main silver eel fisheries are owned either by the state (Galway Weir – Corrib) or by the ESB (Shannon).

- *Yield*

The reported silver eel catch for 2001, 2002 and 2003 for each fishery region is given in Table 3.

- Is there information on the impact of this fishery on the stock? Does that provide information by year? If so, report in detail.

The silver eel fishery does not impact directly on the standing crop within a catchment. It is not known what impact the Irish silver eel fisheries have on the global stock.

- *Tabular data and graph, one record per year, for all years (see comment above)*
- *If more than one data series is available, present each separately, and country-wise totals.*
- *Describe recent development in fisheries, market, etc.*

The silver eel fishery in Ireland would appear to have been more affected by drops in market prices in the last few years than has the brown eel fishery.

Conservation

Since 2001 the ESB has embarked on a programme of transporting silver eels captured in the Shannon silver eel fishery around the dams and releasing them for onward migration to the sea. In 2001, 1,278kg (5.3% of catch); in 2002, 3,884kg (15.4% of catch) and in 2003, 1609kg (9.4% of the catch) were released as part of this conservation measure.

IE.1.3 Trend in the stock

Currently in Ireland, the best indicators of trends in stock are provided by the elver indices data for Shannon (Ardnacrusha) and Erne and the silver eel data for the Shannon, the Corrib (both exploited systems) and for the Burrishoole system (unexploited).

- *What is monitored: life stage, what gear, length composition, etc.*

In these three fisheries, eel catch and eel size is monitored for the coghill and fyke net fisheries on the Shannon and the Corrib. In the Burrishoole the entire silver eel migration is trapped in 'smolt traps', the eels are counted and measured and a sample of otoliths is also taken.

- *Tabular data and graph, one record per year, for all years (see comment above)*

Historical silver eel data is available from a number of fishing stations (Table 4). Data for Galway Weir (Corrib) is based on commercial coghill net catch (t) and the Burrishoole data is for total trap counts from a research facility.

Shannon

Silver Eel

The annual downriver migrations of silver eels have traditionally been exploited in the River Shannon and the three commercial eel weirs, owned by ESB since 1937, have continued this practice with varying success (Fig 3). In many respects the overall pattern of change, with steadily declining silver eel catches at Killaloe/Clonlara, but relatively steady catches at Athlone, mirrors the results obtained by monitoring the Lough Derg fyke net CPUE yellow eel catches versus those in upper catchment lakes.

Table 4. Historical data for Irish silver eel fisheries.

YEAR	GALWAY WEIR	BURRISHOOLE		YEAR	GALWAY WEIR	BURRISHOOLE
	(t)	(number)			(t)	(number)
1971		4567		1987	15.0	2713
1972		3144		1988	8.5	3283
1973		5087		1989	16.5	flood
1974		4642		1990	12.1	3121
1975		6530		1991	7.0	2902
1976	16.5	4595		1992	7.2	3670
1977	11.3	5362		1993	7.1	2570
1978	15.3	1412		1994	8.3	3570
1979	19.7	5196		1995	8.2	5102
1980	20.9	3550		1996	4.1	2251
1981	20.6	4702		1997	7.3	2578
1982	31.3	4234		1998	4.6	2956
1983	13.0	1548		1999	6.1	2969
1984	14.0	1034		2000	7.95	2631
1985	11.4	1958		2001	6.84	3875
1986	7.5	1856		2002	5.81	2863
				2003	6.27	3919

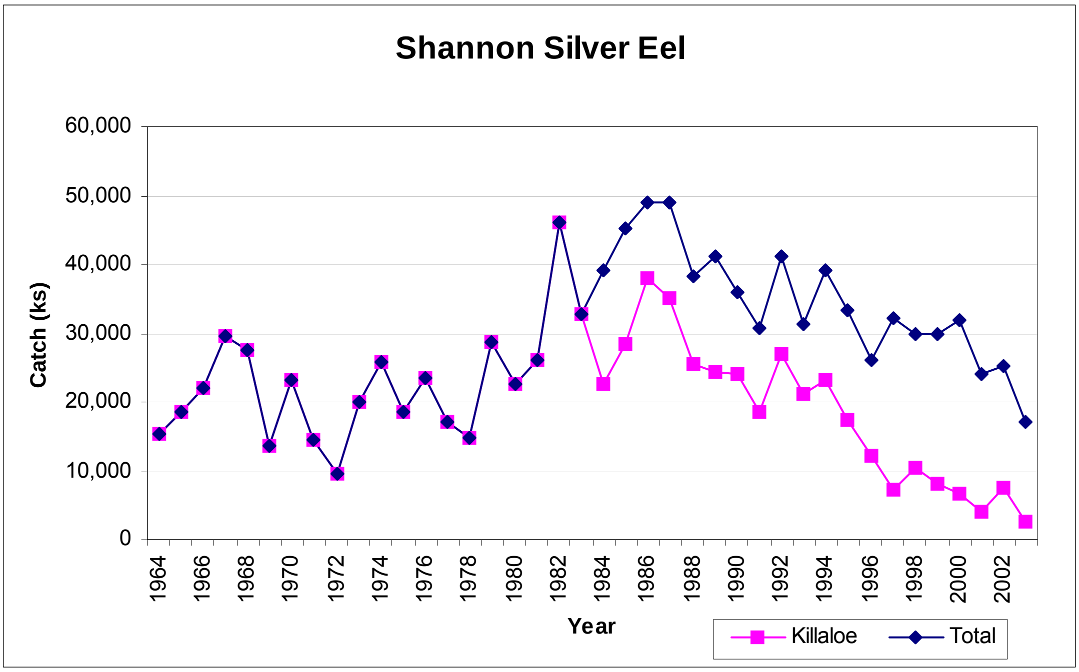

Figure 3. Silver eel catches from the Killaloe eel weir and the Shannon system (1964 to date).

Corrib

Silver Eel

The Galway Fishery comprises an weir with 14 coghill nets. These are fished throughout the dark moon phases and may be lifted during periods of very water. The fishery was purchased by the state in 1978 and has been fished consistently since then. Fishing effort may have increased in later years. The downward trend in silver eel catch (Table 4, Figure 4) therefore probably reflects accurately the decreasing stock in the greater Corrib catchment and falling silver eel escapement.

A study of the Corrib Catchment Eel Fishery (Moriarty 2001) concluded that while fyke netting may have had an impact on size frequencies in the lower Corrib, falling recruitment was probably a more likely cause of changes in stock.

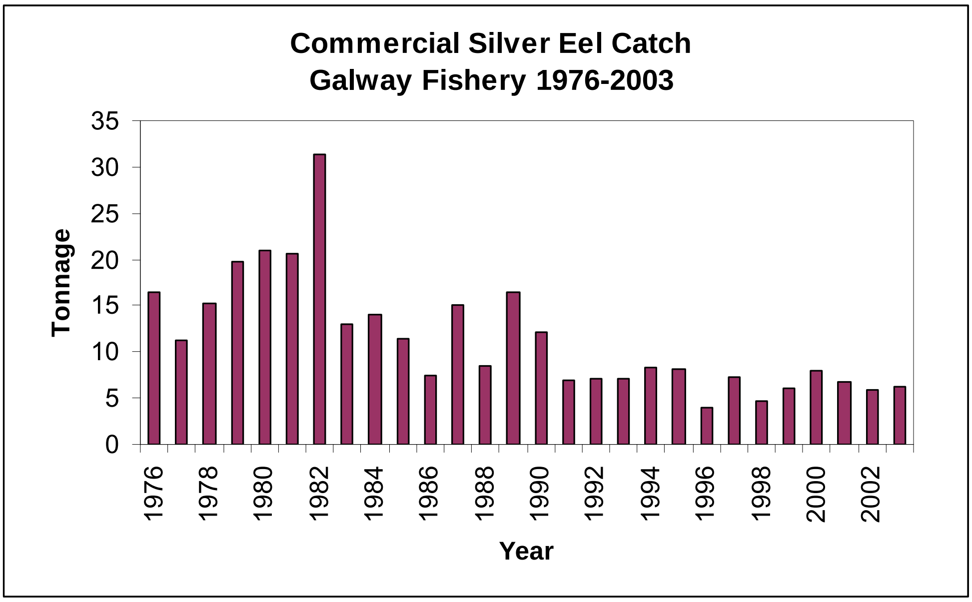

Figure 4. Annual silver eel catch in the commercial Galway Fishery, Corrib System, for 1976 to 2003.

Burrishoole

The Burrishoole System in the West of Ireland is an oligotrophic river and lake system with a catchment area of 8,949 ha. The eel population is unexploited and the total silver eel production is trapped in downstream Wolf type traps.

Catches of silver eel between the years 1971 (when records began) and 1982 averaged 4,400, fell to 2,200 between 1983 and 1989 and increased again to above 3,000 in the '90s (Table 4, Figure 5). There was an above average catch in 1995, possibly contributed to by the exceptionally warm summer. The catch in 2001 of 3875 eel was the second highest recorded since 1982. The average weight of the eels in the catches has been steadily increasing from 95 g in the early 1970s to 215 g in the 1990s (Figure 5). The increase in average weight has been caused, at least in part, by a change from a predominantly male sex ratio to more than 60% females in the more recent years (Poole *et al.*, 1990).

Poole, W.R., Reynolds, J.D.R., and Moriarty, C. (1990). Observations on the silver eel migrations of the Burrishoole river system, Ireland, 1959 to 1988. *Int. Revue Ges Hydrobiol*. **75** (6); 807–815.

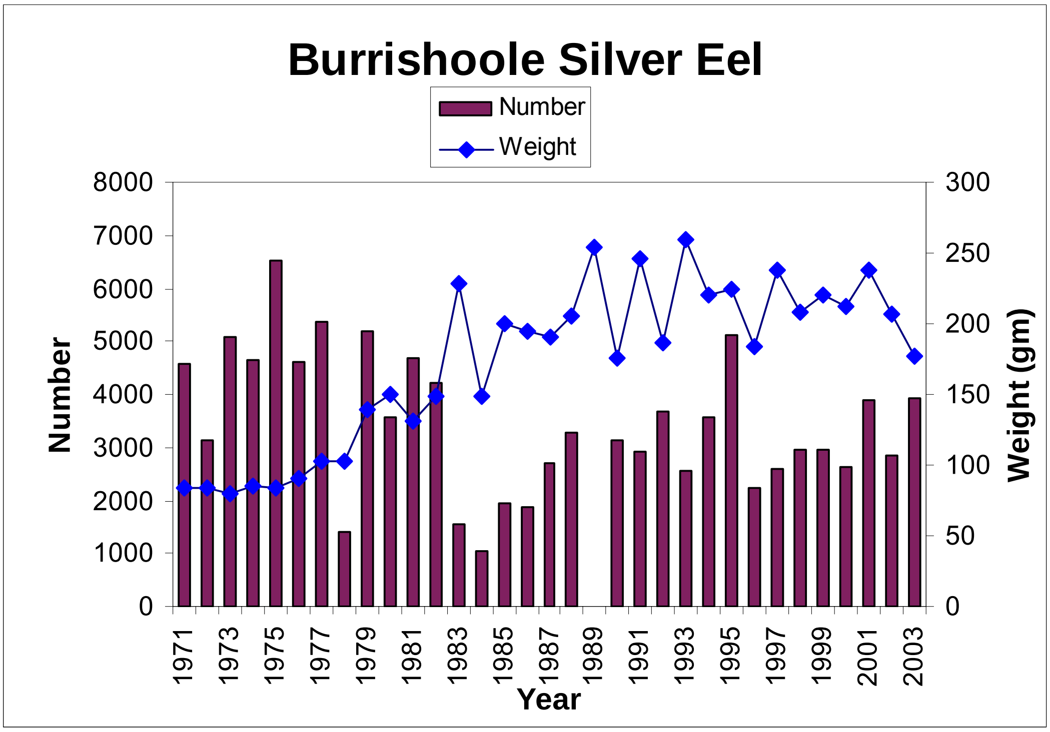

Figure 5. Annual silver eel catch in the Burrishoole System for 1971 to 2003.

IE 2. Research

There is currently no co-ordinated national fisheries strategy or research programme into these concepts. The Marine Institute is responsible for national scientific and technical advice for eel and maintains the national databases and silver eel monitoring in the Burrishoole system. The National University of Ireland, Galway, conducts research into eel stocks, recruitment and migrations on a number of systems in Ireland. The main thrust for stock enhancement comes under Regional Initiatives within ESB or Fisheries Board budgets. The ESB is bound by statute to trap upstream migrating elver and bootlace eel at the hydro-generating dams on the Erne and Shannon and transport these upstream. There has also been a programme of glass eel capture in the Shannon estuary which has met with limited success to date (Table 1). The Erne Eel Enhancement Programme fished the Erne estuary intensively for glass eel in 1998, 1999 and 2000 and transported 46 kg, 442 kg and 189 kg upstream to the Erne catchment and a more modest programme in the Moy catchment undertaken by the NWRFB.

IE.3 Management

- *Is there a national management plan for eel?*

No. The National Review of Eel was completed in early 2004 and a draft management plan was submitted to the Minister for Communications, Marine and Natural Resources. This report will be considered by the Minister and inform the future management and regulation of the fishery.

Major contents

The European Eel is one of the few truly indigenous freshwater fish species found in Ireland. It is embedded in Irish history and tradition and eel fishing has been an integral part of life in rural communities for thousands of years. The complex biology of the eel has hampered the answering of many questions related to its biology and management and more systematic integrated data gathering will have to be an important part of any management strategy. Drastically reduced numbers of juvenile recruits reaching the shores of Europe from the Sargasso Sea over the last 20 years would indicate that the spawning stock is no longer of sufficient size to support the European eel population. The report of the Irish Eel Review Group indicated that development of management plans is urgently needed at both the national and international level with a priority to protect and increase the number of spawners migrating successfully from European waters. The group has taken account of the development of a European Action Plan in its deliberations. The present review has sought, through consultation with relevant stake-holders and compilation of the data available from fishery managers and fishery scientists investigating Irish eel populations, to summarize and interpret all available information on these topics and to formulate a specific set of recommendations that address the issues specified in its terms of reference

- *Is it in prep, accepted, implemented, running*

The report by the National Review Group in December 2003 was presented to the Minister in January 2004.

- *What is managed: effort, yield, what else?*
- *Is a formal target defined?*

No.

Is compliance and efficacy monitored?

No.

- *Is that target conforming to the required silver eel escapement of at least 30% of unexploited pristine state, the 30% SPR rule?*
- *What is missing in national management plan?*

No formal conservation targets are set. The plan as it's drafted being considered by the Minister awaits input from the EU Action Plan which may shape future development of eel management and the eel fishery.

- *What management measures are currently in effect, inside or outside scope of a formal management plan?*

Each Regional Fisheries Board has a local eel management plan or policy. These broadly aim to improve the regulation of eel fisheries and in many cases also include aims towards enhancement of fisheries through upstream transport of glass eel or elvers. The Management of Eel Fishing By-Law No.752, 1998, capped the number of longline licences that a Regional Fisheries Board may issue for long line fishing for eels in any district. In addition to the above, the Fisheries (Amendment) Act 1999 delegated authority to the Regional Fisheries Boards to issue authorisations for the use any fishing engine for the capture of eels including any long line, as it sees fit. Many Fisheries Boards are now promoting the use of fyke net over long-line in a effort to reduce mortality of released undersize eels. The Electricity Supply Board also has statutory responsibility for fisheries regulation and stock enhancement and conservation in waters under its control.

UK – Report on Eel Stocks and Fisheries in the United Kingdom and Northern Ireland, in 2004

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UK.1 Introduction

This working paper has been prepared for the 2004 ICES/EIFAC Working Group on Eel in response to the draft Terms of Reference (TOR) provided by ICES in October 2003. It has been structured to provide the information required by the WG chairman and to address items b), c) and d) in the TOR (a - the EC action plan - will be reviewed at a meeting in Brussels on 17th Sept. 2004). These are to:

a.) assess trends in recruitment, stock and fisheries indicative for the status of the stock;

b.) review national management plans in light of the provisions considered in a)i) to be required by an European recovery plan;

c.) continue work to expand the data bases and knowledge on eels in Europe and North America, to provide a more complete basis for recovery of these stocks/populations.

UK.2 Recruitment, stock and fishery trends in England and Wales

Information and data presented in the report of the 2003 WGEEL meeting to ICES/ EIFAC (ICES, CM 2003/ACFM:03) are updated below. Licence sale and catch return data for glass eels/elver and for yellow/silver eel fisheries are derived from the Environment Agency (EA) and predecessor agencies; other catch and economics information is derived from Customs and Excise export-import data for Great Britain. Analysis of these data has short-comings, but does yield useful information and provides proxy estimates of recruitment and of home and international market trends (Knights *et al.*, 2001; Knights, 2002).

2.1.1 Glass eel fisheries in 2004

As in previous recent years, glass eels were imported into Great Britain (i.e. excluding Northern Ireland) in spring 2004 from France (16.5 t) and Spain (0.3 t) for re-export but, unusually, there were no imports during the Biscay-fishery season in late 2003. Imports were also received via the Netherlands (4.5 t) plus small ones from the Irish Republic and the USA. The average value was ~£83/kg, a level higher than the £50–60/kg pertaining in the mid-1990s and early 2000s, but lower than the average of ~£150/kg pertaining in the late-1990s when demand from Chinese eel farms was at its height. Demand from China has continued to decline because of increased farm efficiency and higher survival rates and the impositions of local controls in attempts to prevent overproduction (as discussed in the UK Report for 2003). Residues of antibiotics and heavy metals in Chinese farmed eels have also affected marketability in recent years (e.g. see www.glasseel.demon.co.uk). In 2003, of a total export of 35.8 t, only ~12% went directly to Hong Kong, the bulk (81%) going to the Netherlands, with smaller shipments to Sweden, France, Germany and Greece, presumably for European farm seed-stock. Although not recorded in export data, shipments of ~1 t were also made to N. Ireland for stocking the L. Neagh fishery. However, unlike other recent years, there appeared to be no exports to Latvia, Lithuania and Estonia, possibly being discouraged by elevated export prices.

By subtracting imports from exports, it is estimated that the GB catch was 14.4 t in 2004, valued at £1.40 million. Figure 1 indicates that annual glass eel/elver catches have increased from the 5–8 t prevailing over 2000–2002 to ~10 t in 2003 (estimate from P. Wood, UK Glass Eel) and to 14.4 t in 2004. The number of licensed dipnets has remained fairly stable, slightly below the numbers prevailing in the 1980s-early 1990s, but less than half the number licensed when catch value was very high in the late 1990s (Figure 2). CPUEs rose to ~11 kg/licensed dipnet/year in 2004 from the previous 6 year average of 7 kg/dipnet/yr.

2.1.2 Glass eel recruitment in 2004

Using evidence from selected monitoring data, it has been claimed that glass eel recruitment in Europe has declined by 99% since the late 1970s-early 1980s. Superficially, the fishery catch return data for 2002–2003 shown in Figure 1 and Table 1 suggest a similar magnitude of decline for England and Wales; returns are only about 4% of the agency estimates for the 1970s (~37 t/y) and about 8% of the average annual catch return in the 1980s (~20 t/y). However, only indirect (and very variable) estimates of total catches were possible in the 1970s and the validity of catch returns in later years is suspect. Following the introduction of licensing, average catch returns were fairly similar to export estimates during the 1980s, but subsequently these became more variable and have been lower than export estimates (Figure 2), reflecting under-claiming by fishermen because of income tax implications (Knights, 2002).

Estimating recruitment using Customs and Excise export-import statistics can be criticised because of (a) data recording and interpretation errors and (b) commercial influences (Knights, 2002). However, the validity of derivations made in this report from Customs and Excise statistics is supported by the comparability to data reported by a commercial glass eel dealer (www.ifrance/euroeel/). This source states the catch in England and Wales averaged 20 t/y over 1996–1999 and this compares favourably with the export estimate of 19.6 t/y over the same period. This represents ~9% of the total European annual catch: French catches comprising 65%, Portuguese 15%, Spanish 11% and Morocco 1%. The total catch of ~about 230 t/y in the Bay of Biscay-SW Britain implies that recruitment is still healthy in these areas facing the main N. Atlantic migration routes.

Accepting that exports are indicative of trends, the average glass eel catch over recent years in England and Wales has been about 28% of the 1980–1984 average. Total catches have, however, been influenced positively by the increase in licensed dipnets during the late 1990s and negatively by low effort during the foot-and-mouth epidemic of 2001. CPUE (kg/net/year) data are more reliable and current values are about 33% of those of the early-1980s. Comparisons of export estimates with EA estimates of catches in the 1970s are not robust, but these suggest a decline of about 19%. Consequently, it would appear that declines in glass eel recruitment in England and Wales have been of the order of about 70%, much less the estimates made from glass eel monitoring sites in less favourable positions relative to the N. Atlantic migration pathways.

2.1.3 Yellow/silver eel fisheries and stocks in 2003

The total GB catch was estimated from 2003 export data, minus N. Ireland catches (52.8 t from Lough Neagh and an estimated 30 t from Lough Erne, to have been ~ 46 t (Figure 3 and Table 2). Catch and total export value followed the declining trend from the peaks of the mid-1990s (Figure 4). Fyke net licence sales have been relatively constant over the last 5 years (Figure 5), and CPUEs (in kg and £/fyke net licence) have, consequently, fallen. The catches from other instruments, such as baited traps, fixed engines and trawls have also tended to fall, although overall catch returns in 2003 were unusual. For example, fyke net catch returns appeared relatively low and only comprised just over 50% of the total declared catch. This was probably due to under-claiming, but also some fishermen did not submit returns. Only two (silver eel) fixed traps and nine racks were officially licensed in England and Wales.

Reports from eel fishermen continue to suggest that eel stocks may now be sparser in some waters, but the main reason for lower catches is that they have reduced their fishing effort because of very variable demand and low prices paid by dealers, especially for yellow eels. Figure 4 shows that the average export value increased slightly from ~£3.65/kg in 2002 to >£4.00/kg in 2003. Fishermen confirm that they typically receive (if dealers are buying) about £2.00–3.00 per kg for smaller yellow eels, more for larger yellow and silver eels, and values have exceeded £4.00/kg for the first time since 1997, but they are still only marginally higher than the values pertaining in the early-1980s. Given declines in the value of the £ and relative increases in boat, fuel, net and other costs, financial returns to fishermen are very poor. Anecdotal evidence suggests that some fishermen only continue fishing because of earnings from by-catches. This is especially so in estuaries and coastal waters, the favoured fishing sites (Knights, 2002), where flatfish, bass and even lobsters can provide extra income. Contacts claim, however, that by-laws requiring the use of otter guards has affected by-catches, helping to explain why some fishermen have ceased activities. Some, however, still derive a seasonal income from selling catches locally, especially of higher value larger yellow and silver eels, e.g. to small smokeries or local Chinese and other ethnic restaurateurs. These catches do not show up in export data (Knights, 2002), but such fisheries appear to be sustainable despite declines in glass eel recruitment. An update on EA data for the Thames Estuary eel fishery is discussed as an example in section 2.1.4.

In the international context, Knights (2003) has argued that declines in catches of yellow and silver eels over the last few decades have been due primarily to competition from cheaper farmed eels rather than reduced recruitment and overfishing *per se.* Eel merchants and processors claim low prices are due to (a) declining home (and mainland Europe) consumption and (b) competition from farmed live eels for smoking and farmed frozen eels for other dishes, exacerbated by periodic overproduction in volatile international markets. Ringuet *et al.* (2002) estimates that European aquaculture production increased from almost nil in 1970 to >10,000 t in 2000, whilst European eel fishery landings fell from 20,000 t to 10,000 t over the same period. In more recent years, increased production and cheaper labour costs in the Far East have severely impacted prices, exacerbated by periodic overproduction. China, for example, now supplies over two thirds of world production (Ringuet *et al.*2002). This is illustrated by recent increases in cheap frozen imports into England and Wales, plus subsequent re-exports (Section 2.1.5).

2.1.4 Thames Estuary eel fishery 1981–2003

This fishery is a fairly coherent one, with a core of licensed fishermen (mainly using fyke nets, with some traps and, in the past, some pair-trawling), plus others who have fished only for one or a few years. Figures 6 and 7 are based on fishery return data collected (currently) by the EA. Although subject to under-claiming of fishing effort, the CPUE is believed to be a realistic measure of the relative health of the fishery, the average being very similar to that achieved in the extensive fyke netting studies of Naismith and Knights (1990, 1993) (see also Knights *et al.* 2001 and Knights 2002). Figures 6 and 7 show that fyke net and total catches were relatively high in the mid-1980s and 1990s, in correspondence with the number of licensees and total (claimed) effort. However, average annual CPUEs have remained fairly constant around a long-term average of 0.45 kg/fyke-end/day, with only two apparently unusually high values (in 1981 and 1983) and one unusually low one in 1989 (when the market was curtailed following health warnings issued about dieldrin levels in Thames eels). Thus it appears that this fishery has been sustainable since the 1980s, in agreement with the modelling study of Naismith and Knights (1990), despite declines in recruitment.

2.1.5 Frozen yellow/silver eel imports

In 2003, ~138 t of frozen eel were imported into GB, compared to 84, 310 and 125 t in the preceding three years respectively. Frozen New Zealand wild-caught eels comprised 60% of imports, the rest being almost totally from China and Taiwan (presumably from excess farm production), as in 2002. The average price was £1.12/kg, a further decline on the average values of £2.72 and £3.10/kg in 2002 and 2001 respectively. Frozen (re?)exports, at ~10.5 t, were <20% of the 2002 values, at an average of £0.96/kg. Cheap frozen eel imports are believed mainly to supply the London jellied eel market.

2.1.6 Conclusions

The above review suggests that;-

- Glass eel recruitment in SW England and Wales is estimated from changes in the commercial fishery CPUE to have declined by about 70% since the peaks of the late-1970s/early-1980s
- However, recruitment appears to have increased in the last few years towards levels pertaining in the late 1980s-early 1990s. If, as predicted (Knights, 2002), recruitment success is correlated with ~25–30 year cycles of the North Atlantic Oscillation, we may be entering a period of Sargasso Sea cooling and changes in N. Atlantic currents that more closely resemble those of the peak recruitment years in the late 1970s-early 1980s. It is however too early to say whether the continuing increase in catches since 2002 represents a consistent trend.
- Demand for glass eels/elvers as seed stock for aquaculture in the Far East appears to have fallen further, with relatively more exports passing to the Netherlands
- Demand for stocking (e.g. in the Baltic countries) appears lower than in recent years, possibly because of relatively high prices
- Although licence sales have remained relatively constant, yellow and silver eel catches and CPUEs in kg/instrument continue to decline in England and Wales, as elsewhere in Europe. Home (and European mainland) consumption continues to decline and over half of European demand now appears to be met by farmed and frozen eel. Catch values in £/kg have changed little in real terms since the 1980s and fishermen have been reducing fishing effort and incomes in £/instrument have continued to fall. Thus export volumes

and values in real terms have continued to decline and it appears that economic factors are the principal cause of declining fisheries, rather than low stocks due to poor recruitment or overfishing *per se*.

- *Eel stocks still appear to be relatively in England and Wales. Stocks are probably being replenished mainly by emigration of elvers and juveniles, rather than glass eels*

2.2 Recruitment, stock and fishery trends in Northern Ireland

2.2.1 Lough Neagh

Lough Neagh/River Bann comprises a 400 km^2 lake-based production system, which produces around 95% of the total Northern Ireland catch. Annual data are available on elver/glass eel stocked and trapped naturally in the River Bann on their way upstream. Annual commercial production figures are divided into outputs of yellow eels (line or draught net catch) and silver eels (caught in traps in the River Bann when migrating downstream from Lough Neagh). The Lough Neagh Fishermen's Co-Operative Society has provided data since the 1960s. Current annual outputs are around 500–600 t in total.

2.2.2 Glass eel and elver data for 2004

Glass eel and elver supply to Lough Neagh in 2004, as recorded by the capture in traps and nets in the Bann Estuary, for transport to Lough Neagh, is given in Figure 8. The 2004 Bann natural run of 08 kg is very near the historical low. Local river flow conditions, with high flows on key nights in March are believed to have played a significant part in suppressing the run.

1.2 Million glass eels were bought in to supplement the stock to Lough Neagh, and low availability and high prices prevented further purchases.

Experimental survey work for additional runs of glass eel within NI were investigated as part of a current research project. Glass eel runs in potentially commercial quantities were recorded to rivers on the Irish Sea coast at Strangford and Carlingford Loughs. Whilst Irish Sea coastal rivers appear to have significant recruitment, there is no long term time series indicating any trend.

2.2.3 Yellow and silver eels – Lough Neagh 2003

Lough Neagh yellow and silver eel catches in 2003 amounted to 414, and 114 t respectively, a total catch similar to that in 2002. The long-term trend in catches is shown in Figure 9. Catches per boat per day in the yellow (longline and draft net) fisheries continue to meet or exceed daily quotas imposed by the cooperative, implying that stocks in the Lough are being maintained. Actively fished licences are down from 200 active boats in 1990 to around 100 boats 2004, and this declining effort is a significant cause of the long-term decline in catches. Information from the fishery cooperative indicates that this trend is due more to low prices available for yellow eels rather than declining stocks.

Age profiles of the yellow and silver eels for 2003 were obtained in 2004 (Figures 10 and 11). Mean age in the yellow eel fishery (almost entirely female due to market grading) was 15 years. Mean ages of male and female silvers were 12 and 18 years respectively.

Sex ratio in the silver eels 2003 was 30% male:70% female. Taking account if differing sizes and weights of males and females, over 80% of the silver eel biomass is now female. This contrasts with previous male silver eel percentages of 80% or more that were associated with higher stocking densities, and implies that lower densities in L. Neagh are now favouring production of females.

The overall mean age of all fished eels is around 17 years, suggesting that all those above the mean age are derived from glass eels stocked before 1989. During the 1980s, the Lough Neagh Cooperative bought glass eels for stocking in large quantities (Figure8), temporarily averting the effects of the European crash in glass eel recruitment. After 1989, stocks became more difficult to obtain and the effect of lower stocking levels in Lough Neagh is likely to become evident from 2006/2007. Updated input/output modelling implies that Lough Neagh should be able to sustain catches close to present levels for perhaps another 5 years, to 2008.

Length frequencies in un-graded catches from Lough Neagh consistently show numbers of undersized eels, normally returned to the Lough at below the market grade of 42 cm. This indicates some future contribution to fishable stocks. However, eels below 30cm are rarely caught, due to factors such as hook size and habitat considerations. At a growth rate of 2–2.5 cm/year, undersize eels of 30–42 cm in catches can only indicate future availability of eels for 4 in advance. Other methods would be required to survey the 10 to 30 cm component of the stock.

2.2.4 Lough Neagh Escapement estimation by silver eel tagging studies 2003

Escapement of silver eels past the intercepting weirs is ensured by legal provisions for a trap-free gap in the river channel, part-time fishing (concentrating only on the peak runs), a three month fishing season (some silver eel movement occurs outside this season), and inefficient fishing when river flows are very high.

A pilot scale silver eel tagging exercise was conducted in October 2003. 189 silver eels were tagged in Lough Neagh, upstream of the eel weirs. Of these, 33 tags were returned from the fisheries, two from the spring 2004 yellow eel fisheries (reversion), and one from a Netherlands eel dealer. This implies a maximum possible escapement of circa 80% of emigrating silver eels, though this must be lowered due to non-returned tags, tag loss, mortality, and potential carryover to the 2004 silver run. Escapement is provisionally estimated at over 50% of emigrating eels, implying escapement in the region of 100 to 200 t. A more extensive tagging experiment is planned for 2004, and any reversion and carryover of 2003 to 2004 silver eels will also be documented.

2.2.5 Socio-economic factors interacting with scientific considerations.

Interviews and discussions with the Lough Neagh Fishermen's Co-operative emphasised the fishery's non-profit nature. The fishermen are paid for yellow eel fishing, at a price reflecting that obtainable on the market minus the central handling and transport costs. This is rapidly becoming insufficient inducement on its own to fishermen to stay in fishing, due to static of prices, being eroded in value by inflation. However, the profits of the highly efficient silver eel fishing provide a second annual payment to fishermen shareholders in the Co-operative, and also fund its running costs and administration. This payment to active fishermen is currently preventing many more leaving the fishery.

It is feared that a ban on silver eel fishing, without adequate compensation measures, would destabilise the whole cooperative venture. It would cause a rapid decline in the fishery and eliminate the funding for stocking and elver transport activity, with the result that the current production of silver eel (and hence catch and escapement) could collapse due to absence of management. The time series data would also be lost.

2.2.6 Northern Ireland Eel populations/fisheries other than Lough Neagh

The elver run to the Erne in 2004 was 269 kg, monitored by capture at a box at the tidal head and transported to upper and lower Lough Erne (See Republic of Ireland report)

The declared catch in the Lough Erne line and fyke net fishery in 2003 was 15 t, though the accuracy of this figure is unknown.

Silver eel fisheries let by the State on Lower Lough Erne were suspended. Two minor fisheries on the Irish republic/NI border on the Erne river were fished, but there is no catch data.

2.3 Scotland

There is currently no regulation of commercial eel fisheries in Scotland. As no licenses are issued there is therefore no means of collecting catch return data. There is no export of any eel product and therefore no proxy values for recruitment or home or international market trends.

2.3.1 Glass eel recruitment and fisheries in 2003 and 2004

No licenses are issued for exploitation of eels in Scotland and there is no means of collecting data from the few glass eel/elver fisheries. In a survey conducted by Williamson in the early 1970s, no elver fisheries were recorded in the Scottish Highlands and Islands (Williamson *et al*. 1976). During the mid-late 1990s there was a short period of exploitation, estimated at 1–2 t per annum, in response to the rise in demand and thus prices. Much of the fishing for glass eels occurred on the West Coast. Fishing has since declined markedly and despite extensive enquiries, no commercial elver fisheries are believed to have operated in Scotland during 2003 or 2004.

There have been no studies of glass eel recruitment in Scotland, although there is some interest in establishing traps on some systems as a means of monitoring recruitment.

2.3.2 Yellow eel and silver eel fisheries

During the 1960s–1970s, eel catches in Scotland were estimated at around 10–40 t per annum. A survey carried out in 1989 showed only 17 eel fisheries in operation, eel catches ranging from 0.25 to 10.76 t (total: 23 t) (I. McLaren, FRS, unpublished data). In a recent assessment, in which proprietors of eel fisheries were contacted, it was estimated that eel fisheries took less than 2–3 t per annum. As in the past, most of the fisheries were for yellow eels, with silver eels contributing less than 100 kg per annum, mostly from traps in mill-races. Although there are few comprehensive records, one fishery owner has data showing declines in catches in the order of 90% between the early 1990s and 2002, although during the same period a yellow eel fishery was established in the upstream loch. Today, catches of silver eels are largely destined for research purposes.

Commercial fisheries for yellow eels are largely based in low-lying productive lochs, the eels largely being sold to local smoke houses. There is no tradition of eel consumption in Scotland.

There are no long-term data sets on the status of yellow eel stocks in Scotland, although the FRS Freshwater Fisheries Laboratory has a several short-term datasets. In Figure 8, data from an annual electrofishing survey carried out in a small stream in north Argyll shows declines in yellow eel densities in the order of 40% between the early 1990s and the early years of the present century.

2.3.3 Conclusions

The review of fisheries activities suggest that eel exploitation in Scotland is at lowest in recent historical past, with fishing for silver eels and glass eels/elvers in particular being less than a few hundred kg per annum. Fisheries for yellow eels probably amount to little more than 2 t per annum, catches being destined largely for local markets.

UK.3 Management

3.1 England and Wales

3.1.1 Reduction in exploitation

Restrictions on eel netting have been imposed by the Environment Agency in the Fens and Lincolnshire. Since the early 1980s, recreational and commercial netsmen could bid for permission to net eel on approximately 200 miles of Agency-owned riverbank throughout Lincolnshire and parts of Cambridgeshire: including Louth Canal, Great Eau, East Coast Drains, River Steeping, South Forty Foot Drain, River Witham, Maud Foster, East and West Fen Catchwaters, River Ancholme, River Welland, River Nene, Moretons Leam, Coronation Channel, River Folly and Maxey Cut. However, largely due to declining eel stocks, there has been no interest in the waters from licensed netsmen for the past few years and the decision was taken not to lease the netting rights for the foreseeable future as a conservation measure.

3.1.2 Legislative changes – England and Wales

Consultation on a new national system of licence duties for eel fishing (other than by rod and line) and revisions to byelaws has now been completed. The revisions are in line with the National Eel Strategy and the byelaws reflect international scientific advice on the status of eel stocks in Europe. While focused on supporting the introduction of a national eel licensing system, the proposed byelaws both constrain and reduce exploitation of eels and elvers by introducing the following new regulations:

- *Constraining elver fishing to where it is currently practised, with the exception of the East Coast, where elver fishing is not sustainable and is now banned.*
- *Reducing elver exploitation by banning the use of elver dip nets on weirs and sluices.*
- *Constraining eel trawling to the outer Thames Estuary.*
- *Constraining eel trapping and fyke netting to where it is currently practised.*
- *Requiring all eels of less than 30 cm to be returned (other than in elver fisheries).*

It is intended that the second phase of the eel fishing byelaw review will examine the need for measures to further restrict exploitation.

The introduction of a single, national system of licensing eel net fishing will allow the EA to be more cost effective in licence administration. A single eel-licensing centre will be established, with a national database of eel fishermen, the instruments that they use, where they fish and what they catch. The enforcement of a single set of regulations backed up by a national database will result in improvements in enforcement and ability to manage exploitation of eels. Note that it is now compulsory for all fishermen to make catch and effort returns.

The byelaws contain definitions and design specifications of gear types that are legal. For example, the description of fyke nets was simplified, with reference only to a maximum mesh size for wings/leaders to stop them being used as gill nets, and the maximum size of elver dip nets is increased to the largest size currently in use (1 m by 1.25 m), with no restriction on the length of the handle.

3.1.3 Guidelines

As part of its National Eel Management Strategy, the EA has produced handbooks for practicing fishery managers, on the use of passes, effective screening, and stocking (with reference to preventing disease transfers).

a.) Fish passage

Solomon D. J., and Beach, M. H. (2004) Fish pass design for eel and elver (*Anguilla anguilla*). R&D Technical Report W2–070/TR1. Environment Agency, Bristol, 92 pp.

Solomon, D. J., and Beach, M. H. (2004) Manual for provision of upstream migration facilities for eel and elver (*Anguilla anguilla*). R&D Technical Report W2–070/TR2. Environment Agency, Bristol, 63pp.

These reports present a detailed review of those aspects of the biology and life history of the eel that influence migratory behaviour. These include the seasonal timing of migration, effects of water temperature, river discharge, light, tide, lunar cycle and time of day on migratory activity, climbing ability, dispersion and rate of upstream migration, vulnerability to predation, sizes of fish involved, and swimming ability. From this, a series of biological and non-biological design criteria are developed for upstream passage facilities for eels and elvers. A similar approach is used to develop design criteria for the protection of downstream migrants.

Basic design guidelines are produced from a synthesis of the review of eel migratory behaviour and the analysis of existing eel passes. These include fundamental design considerations, siting of facilities, facilities based on substrates, facilities based on easements and "natural" channels, pipe passes, lifts and locks, upstream outlet arrangements, monitoring facilities, trap and transport, passage of eels through passes designed for other species, attraction flows, constraints at flow gauging structures, tidal barriers, maintenance and health and safety considerations, and protection of downstream migrants.

Existing installations at about 35 sites in England, France and North America are described and details of their approach to providing benign conditions for passage, construction and operation are presented, with an assessment of their strengths and weaknesses.

Three new fish passes were built in 2003. An elver pass was installed on the new tilting weir structure at Seasalter on the North Kent coast. No monitoring has taken place in 2004, but is intended for 2005. A pump fed elver pass was installed on the Winstead Drain, at Patrington Haven, which is on a minor watercourse flowing straight into the Humber estuary. The success of the pass was apparent in late March when a number of eels measuring between 90 – 300 mm were caught in the trap. Catches of larger eel continued and were later supplemented with the first elver/glass eel captures in May. Captures of elver/glass eel dominated during May and most of June, with larger eels once again dominating in the last week of June and the first week of July.

Third, in Oct. 2003, two elver passes were completed either side of the larinier pass in the centre of an eel pass on the town Weir, R. Western Cleddau, Haverfordwest, SW Wales. Each consists of a metal cage with Enkamat extending from the upstream bed of the river over the crest of the weir and down into the tail. The water supply is simply that crossing the weir, in which they are immersed..

b.) Screening.

The aim is to provide guidance on the best methods of screening eel (as well as other fish) from intakes. It is funded by The EA, English Nature and the Countryside Council for Wales.

A. W. H.Turnpenny, A. W. H. and O'Keefe, N. (2004). Best practice guide for intake and outfall screening. R&D Technical Report W6–103. Environment Agency, Bristol, 139pp.

The Guide updates the Solomon review (NRA R & D Technical No. 1, 1992) and provides a description of the legal responsibilities of operators of water intakes and outfalls and, from a review of current, worldwide examples, to present a synopsis of methods that are known to work best for different species and life stages of fish in different situations. A review of the wide range of technologies that are in common use for fish screening is provided, including physical and behavioural screening technologies. The review will help to guide users towards current best practice to assist in the task of screen selection and specification.

c.) Stocking

"Guidelines for the stocking of eel and elver (*Anguilla anguilla*)" is a collaborative project with Kings College London, and aims to produce guidelines on best practice for the stocking of eel and elver for Agency officers and other organisations involved in fisheries management. It will critically review published and unpublished literature on eel and elver stocking in Europe. The draft guidelines have not yet been finalised.

UK.4 Research

4.1 England and Wales

4.1.1 Establishment and Implementation of Biological Reference Points for the Management of the European Eel, *Anguilla anguilla* L.

This 4-year DEFRA-funded R&D project (2002–2006) was introduced to WGEEL in 2002, and is being carried out by Tony Bark, Beth Williams and Heidi El-Hossaini of King's College London, with inputs from Brian Knights (University of Westminster) and Geoffrey Kirkwood (Imperial College).

Main Project Objectives:

- *To develop, program and test models for population dynamics, stock assessment and management strategies.*
- *To research and develop methods for establishing biological reference points (BRPs as limits and targets) to inform practical and sustainable management of eel stocks and fisheries within appropriate management units in England and Wales (with potential for application elsewhere in Europe and to anguillids in other continents).*
- *To develop recommendations for appropriate decision structures, management approaches and harvest strategies, within the context of the precautionary approach.*
- *To specify data requirements and practical monitoring options for assessing compliance of eel stocks with BRPs.*
- *To provide a practical demonstration of the application of BRPs and monitoring approaches in test catchments.*

Modelling Population Dynamics

In order to develop Biological Reference Points and to facilitate management decisions, a comprehensive length-based population-dynamics model for the continental life phases of the eel has been developed and written. The model has been designed to predict future trends in silver eel output based on current population structure and changing recruitment levels. In order to calibrate the model for use in data-poor situations and to define BRPs for a range of catchment types, a programme of detailed eel surveys of a series of test catchments in England and Wales is being undertaken. Parameterisation and validation of the model has commenced, utilising data collected from those test-catchments surveyed during 2003 and 2004. Documentation and the user manual are being written. Model integration with the GIS database and resulting outputs are expected to be completed by Spring 2005, at which point model testing/refining and the identification of BRPs can begin.

Field work in 2003

The table below summarises the catchments sampled in 2004 in the eel-specific survey programme, the method of capture and the timing of the survey. Three new catchments were included: River Ellen (NW England), River Darent (SE England, Thames Estuary) and the Rivers Colne and Blackwater (East England). At least one northeast system will be surveyed in 2005 so that data will have been collected for most parts of England and Wales in relation to glass eel recruitment pathways (see map below, where open circles indicate planned test-catchments for 2005).

System/Location	Date	Gear used
Essex Rivers †	June	Electric Fishing
Poole Harbour	June	Fyke nets
River Darent	July	Electric Fishing
River Severn	July	Electric Fishing
Mawddach Estuary	July	Fyke nets
River Ellen	August	Electric Fishing
River Piddle/Tadnoll Brook	September	Electric Fishing

† River Colne and the Blackwater.

The data from the 2003 and 2004 surveys show major differences in eel population status (population density and biomass, length/age frequency and sex ratio) between catchments. On the west coast, recruitment still appears to be sufficient to meet local carrying capacity, typified by high-density male-dominated populations with a high proportion of small eels. However, in the south and east coast rivers, low population densities dominated by large females and with relatively few small eels strongly suggest declining recruitment and potential recruitment failure.

A third annual survey of tributaries of the lower River Severn was undertaken in 2004, following the significant reduction in glass eel exploitation in 2001 due to access restrictions resulting from the Foot and Mouth outbreak. Although the data gathered have not yet been fully analysed, they appear to indicate that the glass eel fishery has no major effect on eel populations in the lower River Severn. The system appears to be still at carrying capacity, even with the current levels of recruitment and exploitation.

Existing eel data held by the EA are being gathered. Due to the replication of sampling sites on the Rivers Colne and Blackwater, it is hoped to make a comparison between eel population data from the EA's multi-species surveys and the DEFRA project's eel–specific surveys.

Northern Ireland

Length-frequency data for the Lough Neagh fishery are now available for the first time since the 1970s (Figs 8 and 9). Mean length of the un-graded commercial catch samples is circa 45 cm and the stock is female dominated by females. 30% of the stock is under the applied landing size of 42 cm – these are graded out and released alive. The 2003 samples had a bimodal length – frequency data. These observations suggest that the local stock is being sustainably fished at least in the short term. Further data will become available over the next two years of the present Lough Neagh fishery study.

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Turnpenny, A. W. H. and O'Keefe, N. (2004). Best practice guide for intake and outfall screening. R&D Technical Report W6–103. Environment Agency, Bristol, 139pp.

Fig.1 GB glass eel annual catches (tonnes), from fishery agencies catch estimates/fishery returns and nett export estimates, 1972-2004

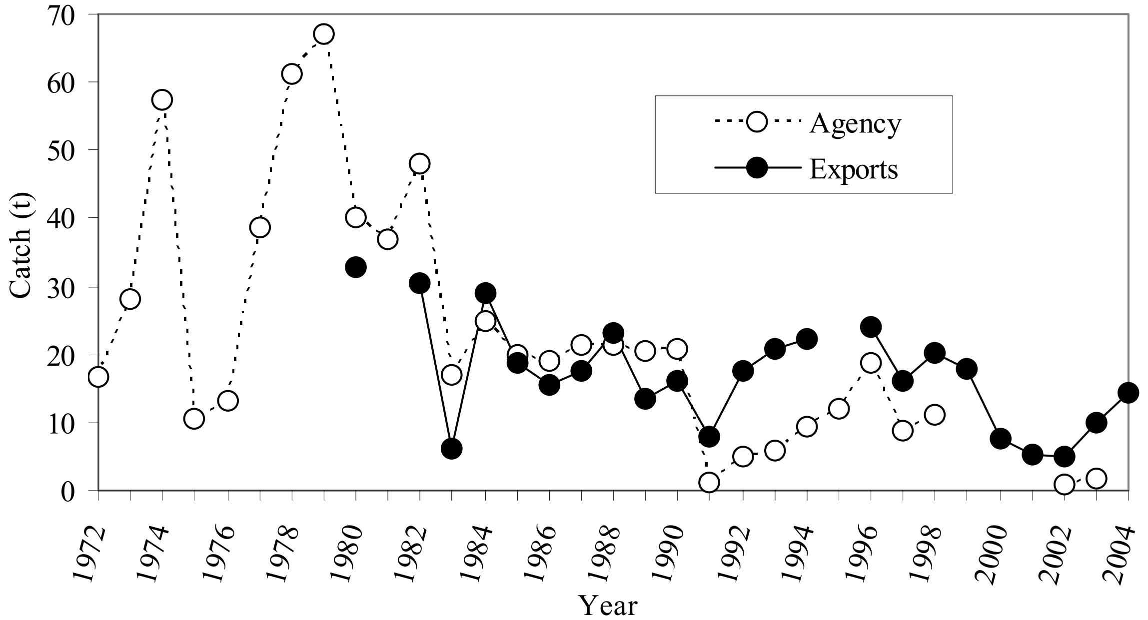


Fig. 2 GB glass eel fishery effort as number of licensed dipnets per year and CPUE as catch (from export estimates) in kg/net, 1980-2003

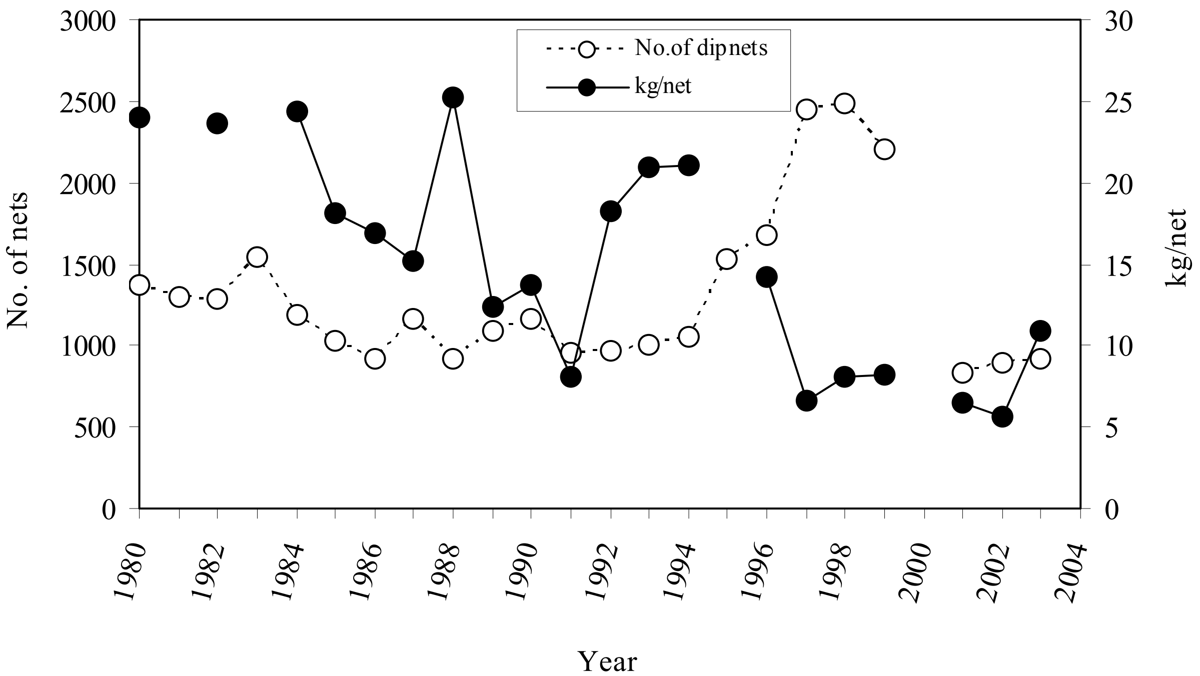


Table 1. Glass eel/elver export data 1972–2004.

	MAFF/ NRA/EA estimates	Customs Exports	Licence sales	CPUE	CPUE
Year	t/yr	t/yr	No. of dipnets	kg/net	£/net
1972	16.7				
1973	28.2				
1974	57.5				
1975	10.5				
1976	13.1				
1977	38.6				
1978	61.2				
1979	67				
1980	40.1	32.8	1367	24.0	121
1981	36.9		1303		
1982	48	30.4	1288	23.6	187
1983	16.9	6.2	1537		49
1984	25	29	1192	24.3	162
1985	20	18.6	1026	18.1	245
1986	19	15.5	917	16.9	330
1987	21.3	17.7	1162	15.2	384
1988	21.4	23.1	918	25.2	861
1989	20.6	13.5	1087	12.4	804
1990	20.9	16	1169	13.7	986
1991	1.1	7.8	960	8.1	625
1992	5	17.7	969	18.3	1335
1993	5.73	20.9	1000	20.9	1959
1994	9.5	22.3	1058	21.1	1304
1995	11.9		1530		
1996	18.8	23.9	1682	14.2	1480
1997	8.7	16.2	2450	6.6	821
1998	11.2	20.1	2480	8.1	1113
1999		18	2207	8.2	1012
2000		7.6			
2001		5.4	838	6.4	
2002	1.5	5.1	899	5.7	1724
2003	1.7	10	922	10.8	
2004		14.4			

Fig.3 GB yellow and silver eel catches (t) from exports and catch returns and export value, 1979-2003

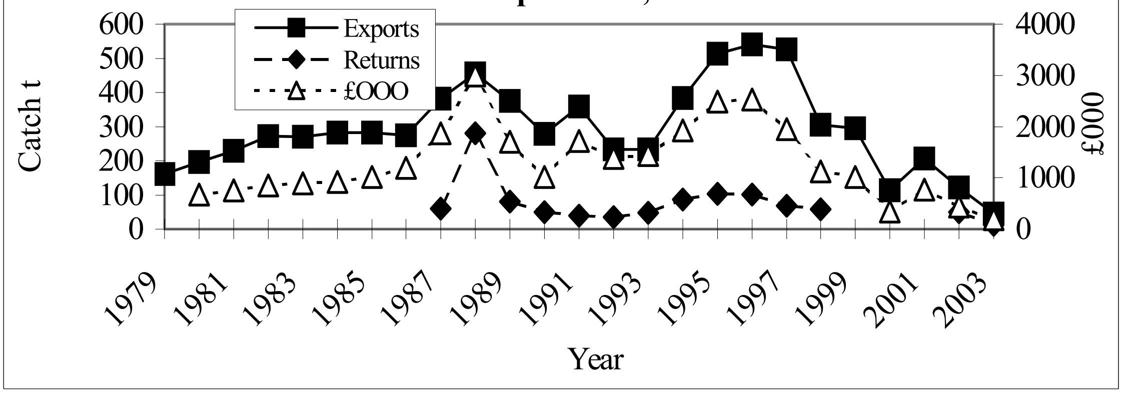


Fig.4 GB yellow and silver eel catches (t) from exports and value in £/kg, 1979-2003

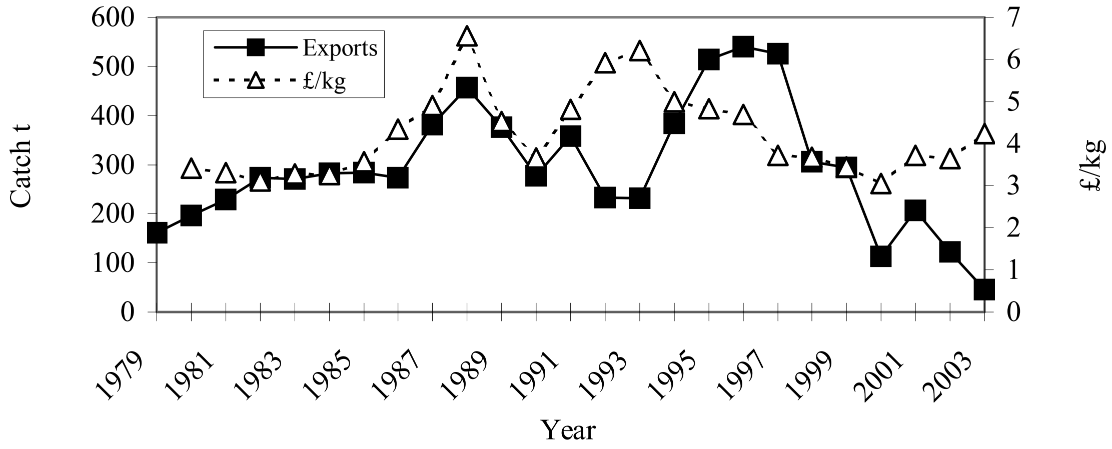


Fig.5 GB yellow and silver eel catch data: no. of instruments and kg and £/instrument (from exports), 1983-2003

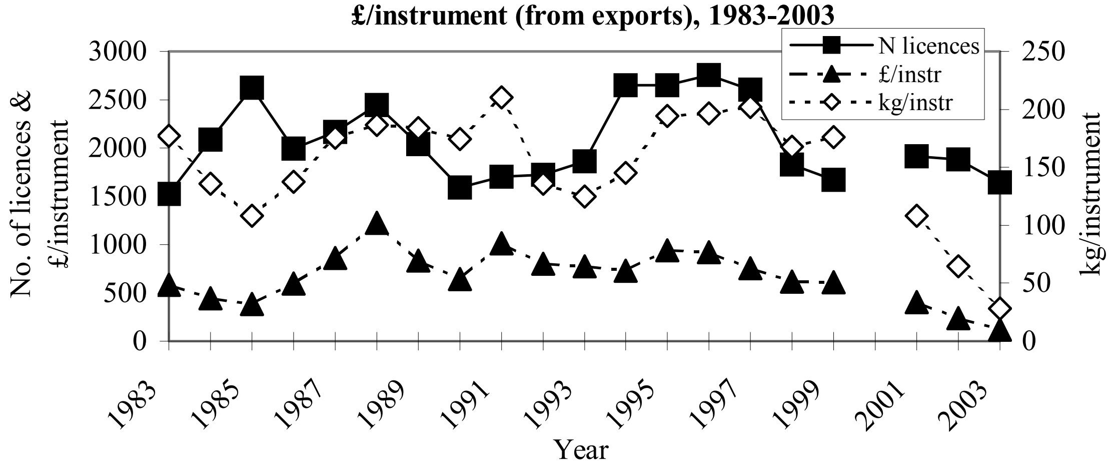


Table 2. Yellow and silver eel data for England and Wales.

	Total Exports	Catch Returns	Export value		Licence nos.	CPUE/instrument	
Year	**tonnes**	**tonnes**	**£OOO**	**£/kg**	**N licences**	**kg/instr**	**£/instr**
1979	162						
1980	196		670	3.41			
1981	229		759	3.31			
1982	273		850	3.11			
1983	270		888	3.29	1523	177	583
1984	283		922	3.26	2085	136	442
1985	283		1012	3.57	2624	108	386
1986	274		1190	4.35	1994	137	597
1987	381	60.41	1869	4.91	2168	176	862
1988	456	280.58	2992	6.56	2443	187	1225
1989	376	80.63	1699	4.52	2041	184	832
1990	277	48.74	1016	3.66	1589	175	639
1991	358	38.26	1724	4.82	1704	210	1012
1992	234	35.63	1383	5.92	1724	135	802
1993	232	46.62	1442	6.22	1859	125	776
1994	384	86.79	1920	5.00	2647	145	725
1995	514	103.76	2484	4.83	2648	194	938
1996	540	100.51	2532	4.69	2752	196	920
1997	526	68.04	1956	3.72	2602	202	752
1998	306	58.31	1126	3.68	1825	168	617
1999	294		1012	3.44	1670	176	606
2000	113		345	3.05			
2001	207		771	3.72	1916	108	402
2002	122	50	445	3.65	1882	65	236
2003	46	11.9	195	4.24	1640	28	119

Fig.6 Total and fykenet catches and no. of licensees in the Thames Estuary eel fishery 1981-2003 (from EA returns)

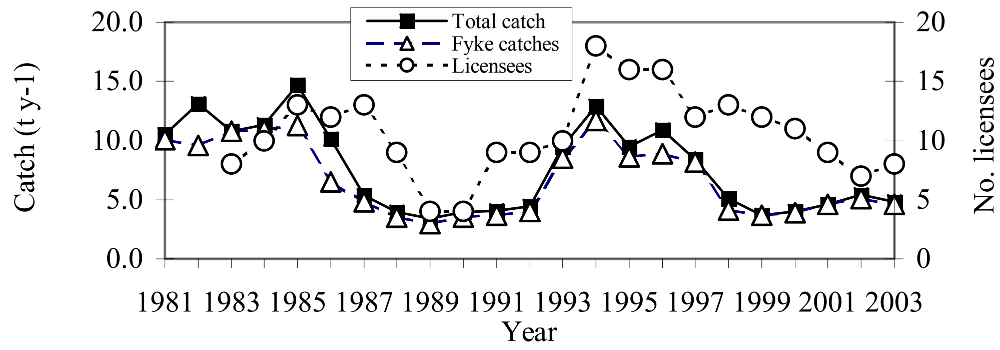
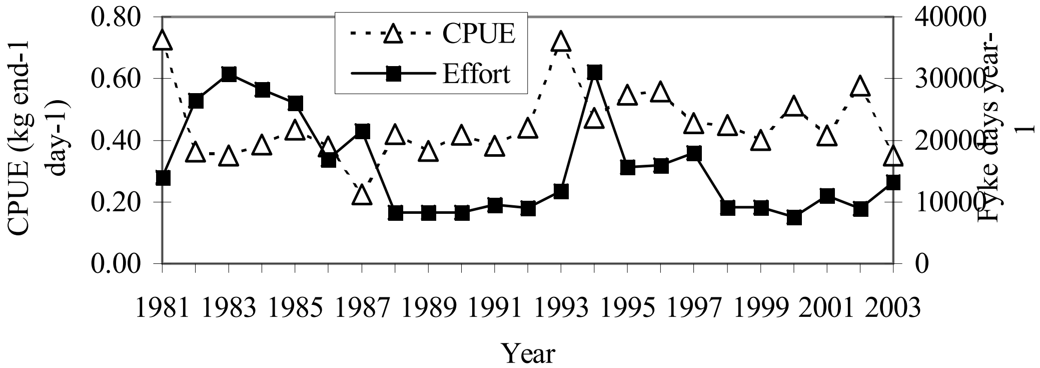


Fig. 7 Fykenet CPUE and total effort in the Thames Estuary eel fishery 1981-2003 (data from EA returns)



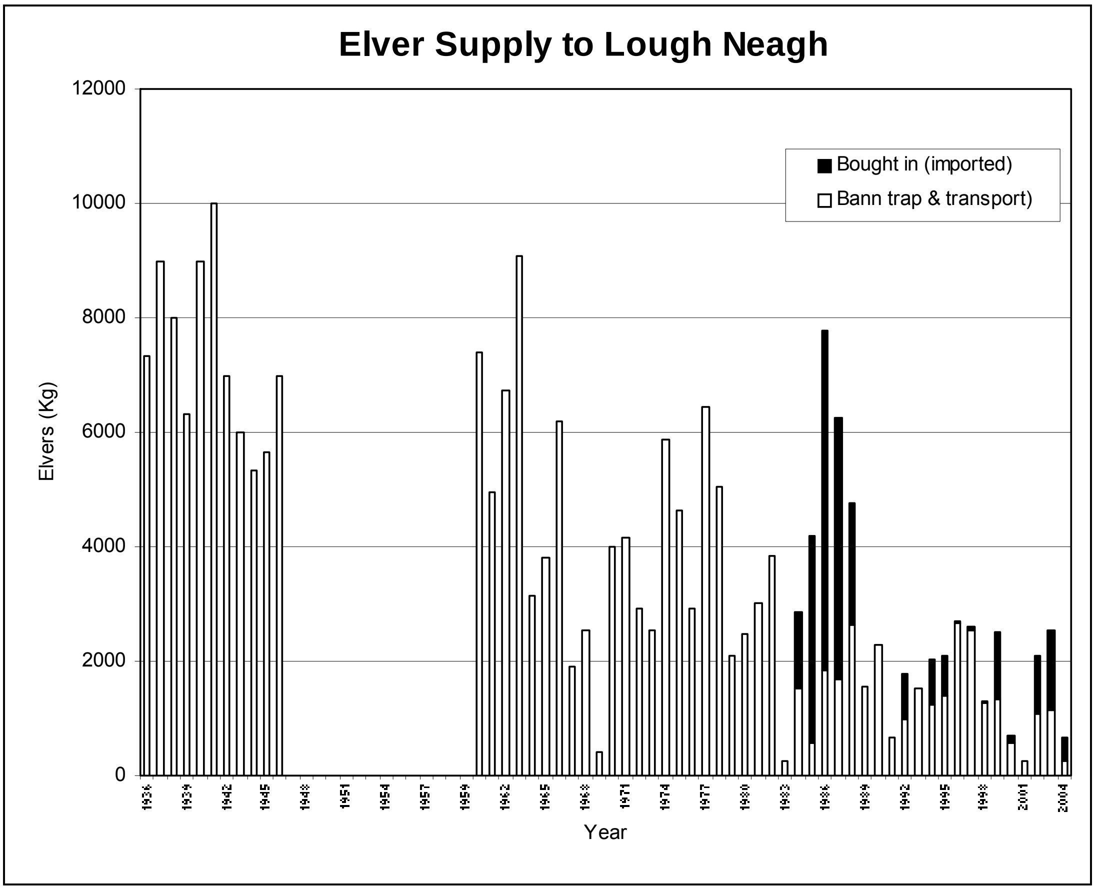


Figure 8. Elver supply to Lough Neagh.

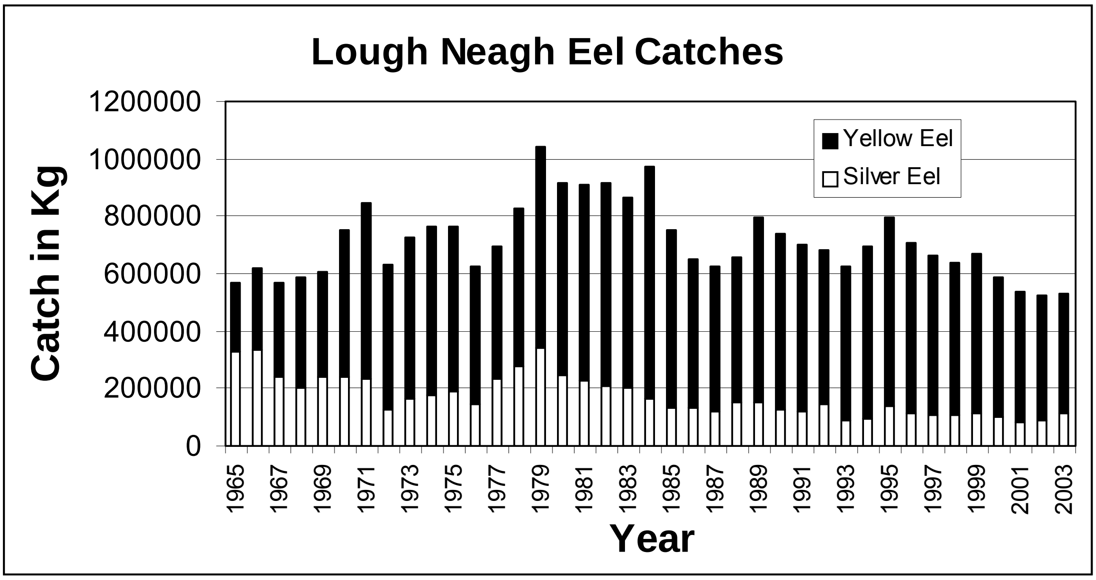


Figure 9. Yellow and silver eel catches – Lough Neagh.

Figure 10. Ages of silver eels from Lough Neagh, 2003.

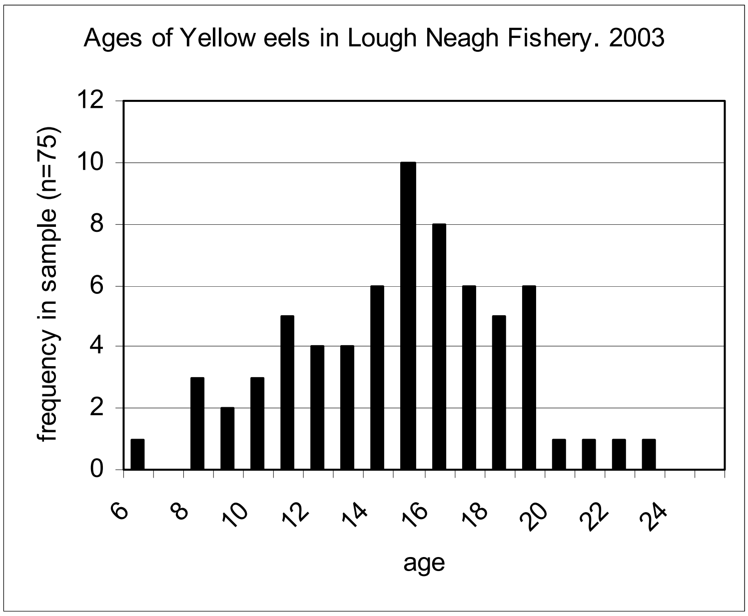


Figure 11. Yellow eel age profile.

DE – Eel stock and fishery in Germany in 2003

Country: Germany

Authors: R. Knoesche, U. Braemick

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Reporting date (10 September 2004) and last reported year: 2003

DE.1 Data

DE.1.1 Trend in recruitment

Monitoring methodology, life stage and gear type

- *Pigmented young eel, scientific monitoring at eel ladders with traps in river Elde (tributary of the Elbe) and River Warnow (Baltic sea)(Lemcke 2003)*

First results: River Elde:	1958	157,000 elvers
	2002	6,900 elvers
	2003	
River Warnow:	1931	90,000 elvers
	1932	240,000 elvers
	1933	196,000 elvers
	2002	448 elvers

- *2005: starting point of a comparable monitoring program for elvers in additional rivers*
- *Glass eel, commercial catches for restocking at Herbrum/Ems (Schuchert 2000; Schmeidler 1957) (Table 2, Figure 1).*

Table 2: Glass eel catches for restocking in German waters in the river Ems at Herbrum.

JAHR	KG
1928	102
1929	598
1930	813
1931	
1932	
1933	
1934	
1935	1615
1936	
1937	
1938	
1939	
1940	429
1941	594
1942	992
1943	1989
1944	
1945	
1946	600
1947	1438
1948	1640
1949	1182
1950	875
1951	719
1952	1516
1953	3275
1954	5369
1955	4795
1956	4194
1957	1829
1958	2263
1959	4654
1960	6215
1961	2995
1962	4430
1963	5746
1964	5054
1965	1363
1966	1840
1967	1071
1968	2760
1969	1687
1970	683
1971	1684
1972	3894
1973	289
1974	3669
1975	10312
1976	3785
1977	2172

JAHR	KG
1978	1819
1979	2774
1980	3195
1981	962
1982	674
1983	392
1984	352
1985	260
1986	102
1987	10
1988	16
1989	5
1990	30
1991	9
1992	6
1993	20
1994	70
1995	23
1996	2
1997	9

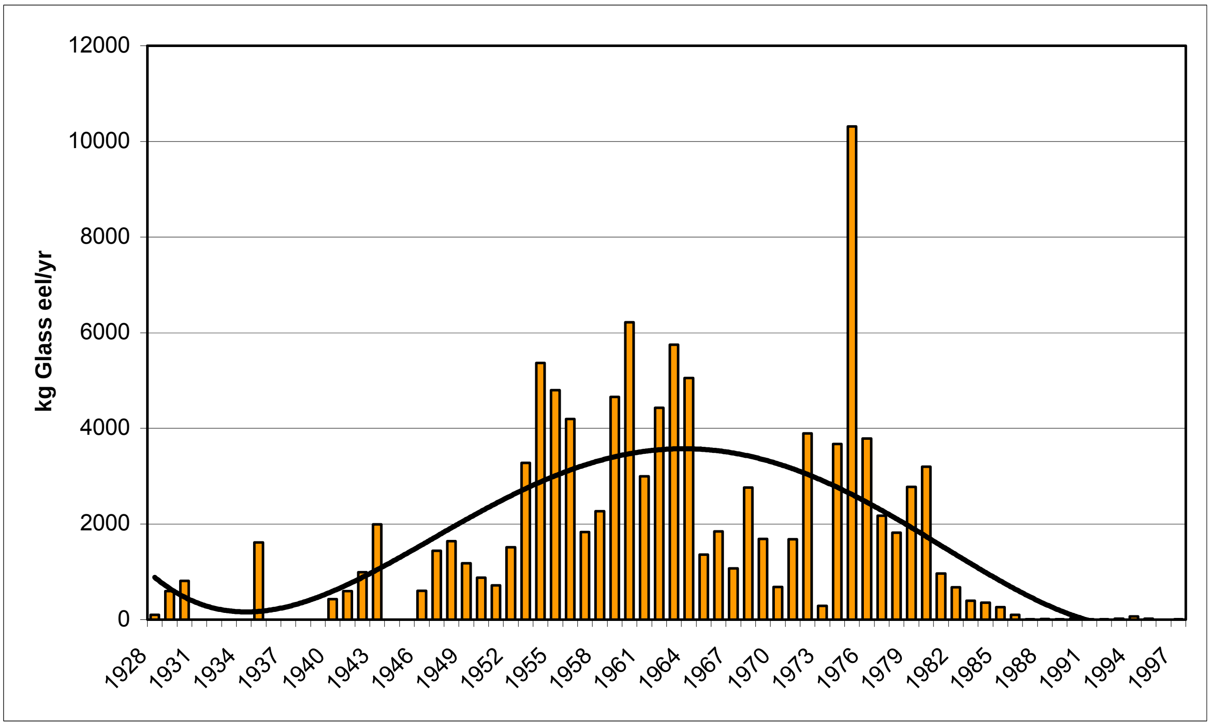

Figure 1: Glass eel catches in the river Ems at Herbrum.

DE.1.2 Trend in fishery

Germany had no relevant eel immigration for the last 20 years. The immigration rate was even low before 1980. Thus, restocking has been the main recruitment source for the German eel stocks for about 100 years (Tables 3–5, Figures 2–4).

Table 3: Eel restocking in Germany 1908–1965 (sources: Röhler 1939; 1942; statistics)

	PC. GLASS EEL/HA	PC. BOOT-LACE/HA	GLASS EEL EQUIV./HA
1900			
1901			
1902			
1903			
1904			
1905			
1906			
1907			
1908	1,7		1,7
1909	8,2		8,2
1910	17,0		17,0
1911	18,8		18,8
1912	12,4		12,4
1913	19,4		19,4
1914	18,0		18,0
1915			
1916			

	PC. GLASS EEL/HA	PC. BOOT-LACE/HA	GLASS EEL EQUIV./HA
1917			
1918			
1919			
1920			
1921			
1922			
1923			
1924	2,9		2,9
1925	4,1		4,1
1926	6,6		6,6
1927	10,5		10,5
1928	18,3	4,6	41,4
1929	16,8	5,6	44,6
1930	19,4	5,0	44,4
1931	22,5	5,0	47,5
1932	21,4	5,0	46,4
1933	15,3	5,0	40,3
1934	14,5	5,0	39,5
1935	18,4	5,0	43,4
1936	18,4	5,0	43,4
1937	19,1	5,0	44,1
1938	24,6	5,0	49,6
1939	26,3	5,0	51,3
1940	1,1	5,0	26,1
1941	7,3	6,6	40,3
1942	5,8	6,3	37,5
1943	19,4	5,0	44,4
1944	4,7	5,0	29,7
1945	0,0	0,0	0,0
1946	8,8	8,3	50,4
1947	20,9	8,3	62,6
1948	23,9	8,3	65,6
1949	17,2	8,3	58,9
1950	12,8	8,9	57,0
1951	10,5	8,3	52,2
1952	22,6	7,8	61,7
1953	55,4		55,4
1954	85,1		85,1
1955	70,4		70,4
1956	71,8		71,8
1957	25,9		25,9
1958	33,0		33,0
1959	67,9		67,9
1960	90,6		90,6
1961	43,7		43,7
1962	64,6		64,6
1963	83,8		83,8
1964	73,4		73,4
1965	19,5		19,5

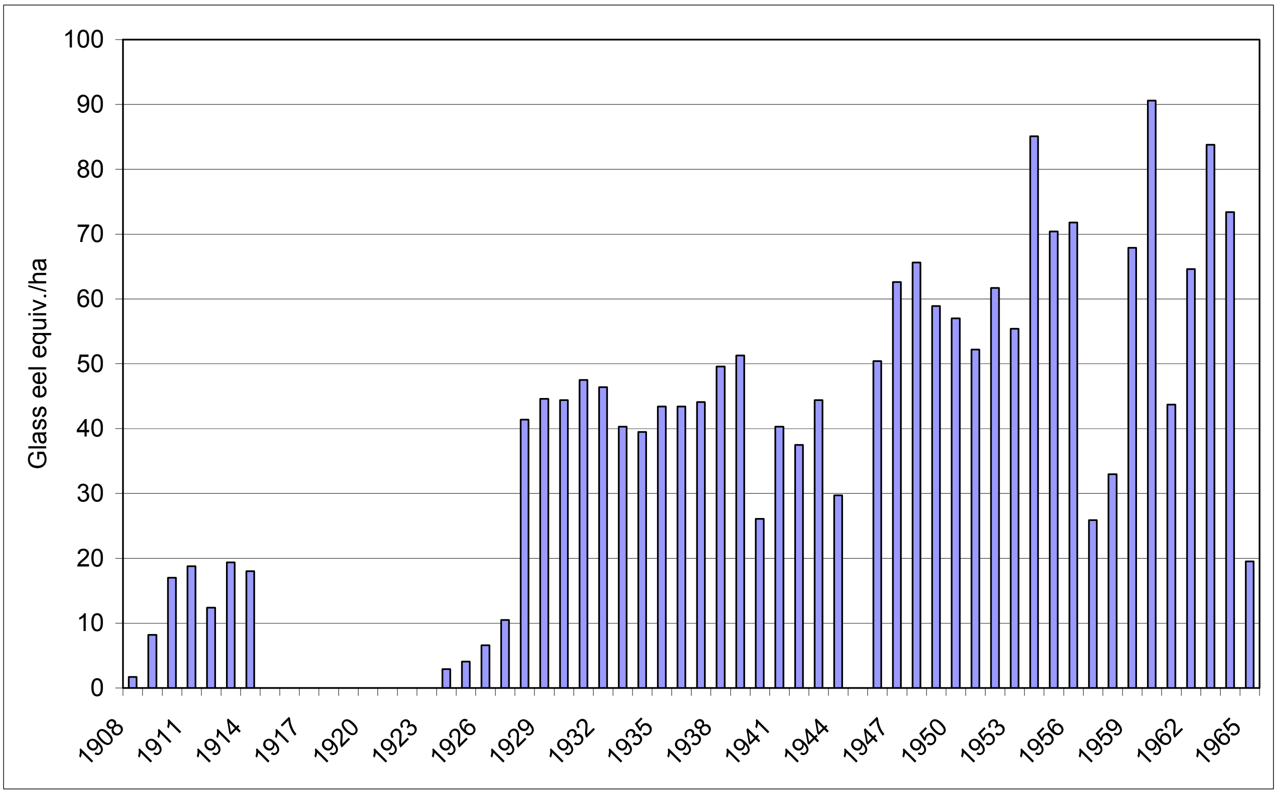

Figure 2: Eel restocking in Germany 1908–1965 (1 bootlace = 5 Glass eels) (total area 120,000 ha)

Table 4: Eel restocking in East Germany 1950–1989.

	GLASS EELS (KG)	BOOTLACE (KG)	GLASS EEL EQUIV./HA
1950	0	18063	38
1951	0	18942	39
1952	0	11371	24
1953	735	30019	81
1954	0	21705	45
1955	3284	25000	134
1956	1600	25000	92
1957	360	26444	64
1958	1900	34000	118
1959	3555	38548	169
1960	4577	15978	148
1961	2536	36602	140
1962	4741	15140	150
1963	6835	13886	200
1964	3960	16465	133
1965	9275	19410	272
1966	7275	25703	235
1967	7589	18810	229
1968	8447	29485	273
1969	6456	46995	259
1970	9155	14965	260

	GLASS EELS (KG)	BOOTLACE (KG)	GLASS EEL EQUIV./HA
1971	8085	11705	227
1972	10493	37380	340
1973	8941	6305	237
1974	12001	50730	406
1975	10132	61709	382
1976	13833	50770	452
1977	12857	57302	441
1978	13123	59303	452
1979	13070	30215	390
1980	13241	20380	373
1981	8730	54413	332
1982	10160	46548	351
1983	8400	45500	305
1984	10500	34100	334
1985	1995	22395	97
1986	7925		198
1987	8754		219
1988	8878		222
1989	4764		119

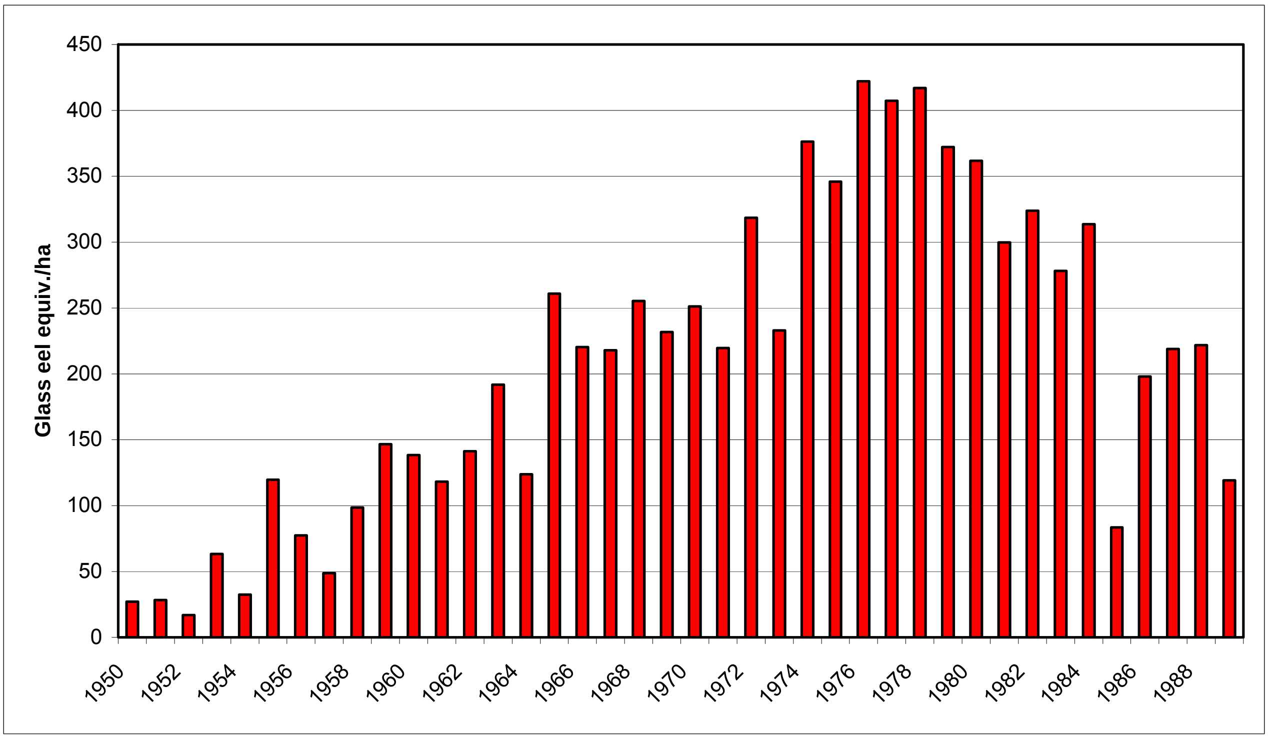

Figure 3: Eel restocking in East Germany 1950–1989 (1 bootlace = 4.5 glass eels, 1 adv. farm eel = 3.0 glass eels).

Table. 5: Eel restocking in Brandenburg 1990 – 2002 *) (total water surface area: about 60,000 ha).

YEAR	REPORTED AREA, HA	KG		
		glass eel	advanced farm eel	bootlace
1990	20514	3550	74	2156
1991	18742	672	157	3695
1992	38342	2120	50	4954
1993	45990	2541	133	7663
1994	46493	2467	180	7223
1995	9925	2075	220	7631
1996	8994	160	1556	16473
1997	54853	126	2787	39553
1998	60193	0	3867	38734
1999	60042	8	6171	29712
2000	54155	0	7357	28198
2001	55071	0	3440	37954
2002	55291	0	5896	23492
2003	51454	0	7357	28198

*) figures given refer to subsidized eel restocking; the unknown non-subsidized part is very small and can be neglected.

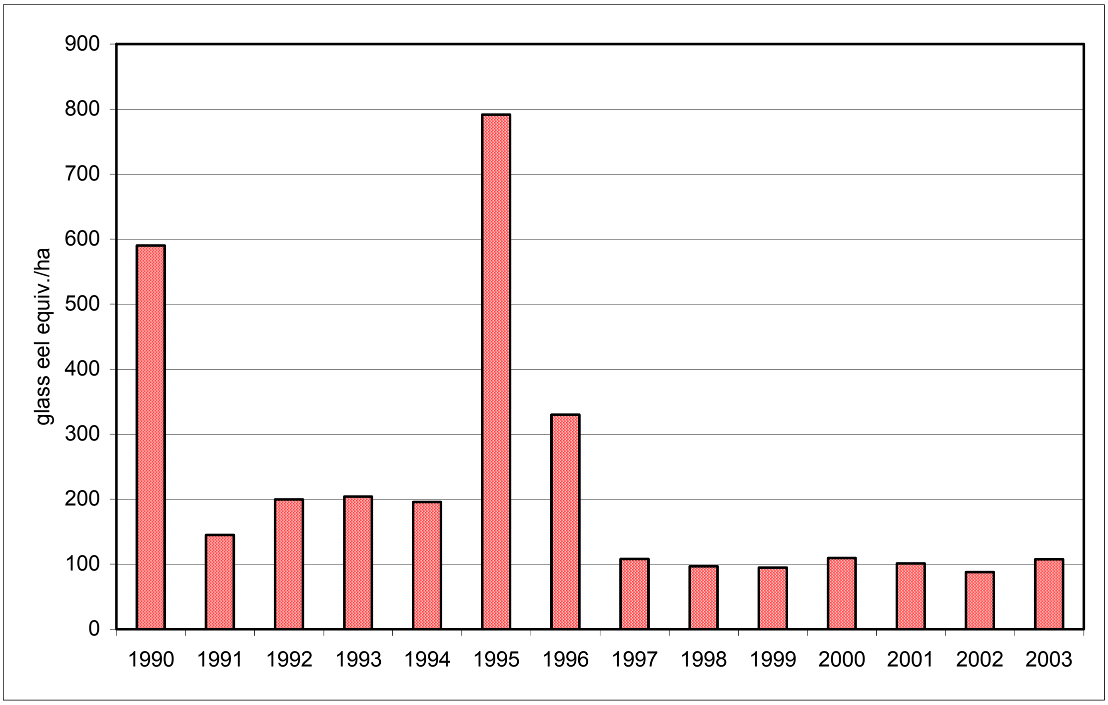

Figure 4: Eel restocking on Brandenburg 1990–2003 (1 bootlace = 4.5 glass eels, 1 adv. farm eel = 3.0 glass eels).

The restocking rate in East Germany increased significantly after World War II. The mean rate between 1960 and 1989 amounted to 272 glass eel equivalents/ha. After 1990 the mean re-stocking rate in Brandenburg firstly remained at a similar level – 245 glass eel equivalents/ha but revealed later a decreasing tendency. The mean restocking rate in Mecklenburg-

Vorpommern (about 65,000 ha) 1995 – 2000 was 162 glass eel equivalents/ha with a constant tendency.

This ensures a significant additional silver eel emigration, as an eel stock model for the East Germany and Brandenburg waters is showing (Tables 6 and 7).

Table 6: Eel stock model for East Germany 1970 – 1989 (mean time lag between restocking and catch: 8 years).

RE-STOCKED (MEAN): 293 GLASS EEL EQUIV./HA			MEAN YIELD (REPORTED): 5,88 KG/HA		
year	weight (g)	M (a^{-1})	n	F =0,22 a^{-1}	
1	0,3		293		
2	8,13	0,56	128		
3	29	0,38	79		
4	65	0,29	56	yield	
5	105	0,23	43	pieces/ha	kg/ha
6	153	0,20	25	9,34	1,78
7	209	0,17	16	5,49	1,45
8	264	0,15	10	3,37	1,13
9	316	0,13	6	2,15	0,87
10	362	0,12	4	1,40	0,65
total				21,74	5,88

Table 7: Eel stock model for East Germany 1960 – 1989 (mean time lag between restocking and catch: 10 years).

RE-STOCKED (MEAN)	294	GLASS EEL EQUIV./HA	MEAN YIELD (COMM. + ANGLING): 3,1 KG/HA				
year	weight (g)	M (a^{-1})	n	F= 0,21 a^{-1}		M-Corm. = 0,08 a^{-1} *)	
0			294				
1	4,9	0,56	129				
2	14,6	0,38	79				
3	30,5	0,29	56				
4	52	0,23	43				
5	80	0,20	35	yield		pieces/ha	kg/ha
6	116	0,17	27	pieces/ha	kg/ha	2,78	0,22
7	160	0,15	21			2,13	0,25
8	210	0,13	17	4,32	0,91	1,67	0,27
9	268	0,12	10	3,45	0,92	1,33	0,28
10	334	0,11	4,91	2,01	0,67	0,78	0,21
11	408	0,10	2,25	1,02	0,41	0,39	0,13
12	488	0,09	1,13	0,37	0,18		
total				**11,17**	**3,10**	**9,08**	**1,36**

*) Stomach analysis (n = 152): Summer stocks of cormorant (n = 102) eat 34 weight-% of eel; 8,9 cormorant-days/ha * 0,45 kg/d * 0,34 = 1,36 kg/ha Approximately 7 silver eels per hectare (= 850,000 pieces from all East German waters) could escape at the high restocking and immigration rate 1970–1989 and at no or moderate cormorant predation (≈ 33% of the potential escaping at F = 0). This figure is reduced to 4.5 at substantial cormorant predation (1990–2002). When F = 0 the number of ecapees would increase to 9,5 (= 62% of the potential escaping at F = 0 and $M_{corm.}$ = 0).

Description of fisheries, information sources, gear types

A substantial commercial eel fishery exists in the lake areas of Mecklenburg-Vorpommern, Brandenburg, Schleswig-Holstein and Niedersachsen (144,000 ha). The main fishing gears are different types of trap nets and double fyke nets.

The river eel fishery is located in the lower stretches of the big rivers Rhine, Weser, Elbe and Oder. The most riverine fishermen are fishing with small fyke nets. In the river Rhine some fishermen use twin stow nets (Schokker). In the River Elbe two fishermen run 3–5 otter board stow nets near Stendal (one), Gorleben (max. two) and Gorleben-Geesthacht (max. two). In the river Oder one fisherman runs one otter board stow net.

A substantial coastal eel fishery (mainly silver eel) exists in the shallow Bodden waters of the Baltic Sea with pound nets.

Effort: There is only little information about fishing effort. The response of the fishermen to the eel yield decrease is different. In Brandenburg the fishing effort on eel has remained nearly constant during the last decades (Figure 5). A study in 5 Brandenburg districts (11,000 ha) 1999 showed a trap net fishing effort of 12.5 trap nets per 100 ha (Knösche and Rümmler 1999). A trap net effort of 4.3 gears per 100 ha was found in two counties of NE-Brandenburg (15,100 ha) (Rümmler and Fladung 2004). An effort of 6.1 trap nets per 100 ha was estimated in another study in Schleswig-Holstein 2002 (14,500 ha) (Knösche 2003). The fishing effort in Mecklenburg-Vorpommern (55,800 ha) was 3.3 trap nets per 100 ha in 2001 (Hiller and Wichmann 2003). 10 trap nets per 100 ha are used in three large lakes (4770 ha) in Niedersachsen.

- The mean fishing effort in the inland waters of the North-German lowlands with commercial eel fishery (200,000 ha) is assumed to be about 5 trap nets per 100 ha.
- There is no information about the fishing effort in the Baltic coastal waters and in the estuaries of the rivers Elbe and Weser.

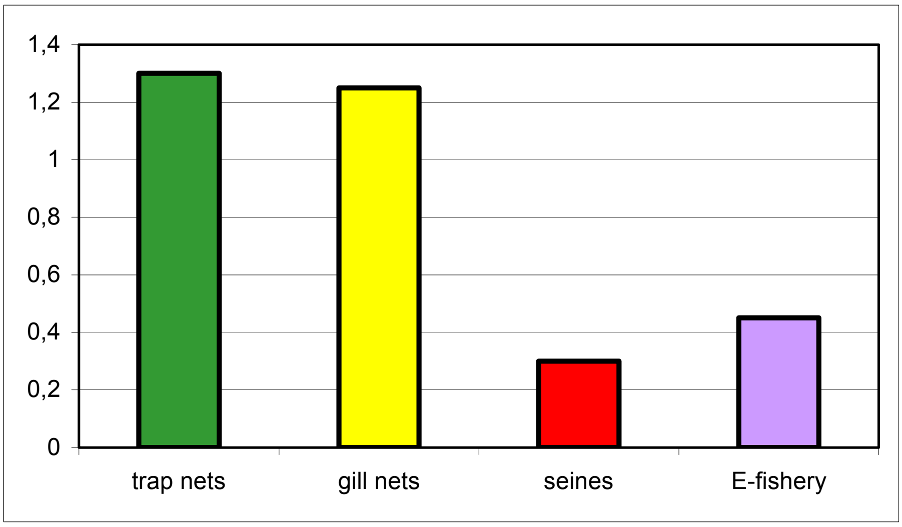

Figure 5: Fishing effort with different gears in 122 Brandenburg lakes after/before 1990.

- *Yield: There are some yield reports. The East German reports until 1989 can be considered exactly because the allowance of the fishermen depended on the delivery of catches. An over-reporting was impossible. The West German and the East German (after 1990) reports must consider more or less as lowing (how much?).*

Figure 6 shows the eel yield from East German inland fishery (120,000 ha) until 1990, Figure 7 the reported yields in Brandenburg and Mecklenburg-Vorpommern (122,000 ha) since 1991, Figure 8 the reported yields in Niedersachsen, and Figure 9 in Schleswig-Holstein.

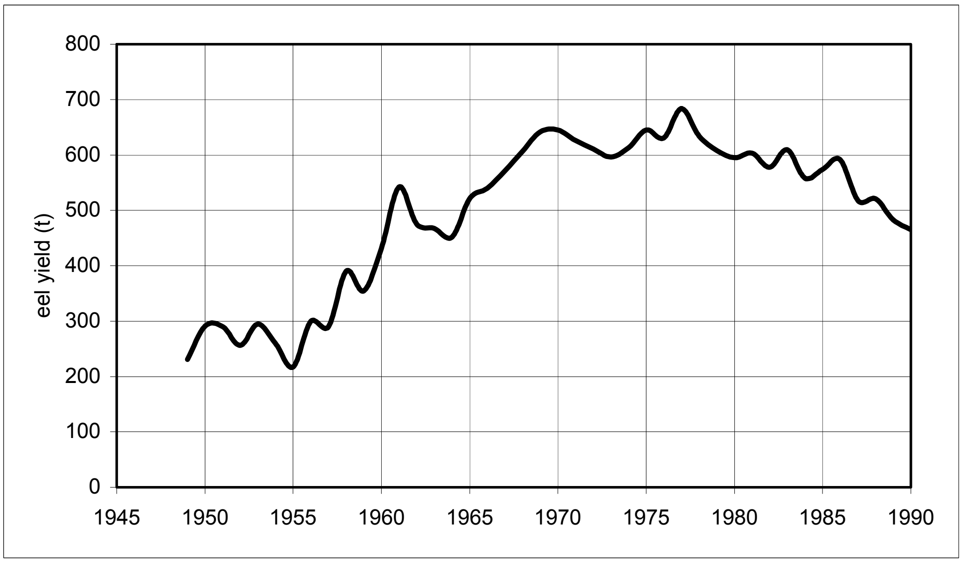

Figure 6: Commercial Eel yield in East Germany 1949–1990.

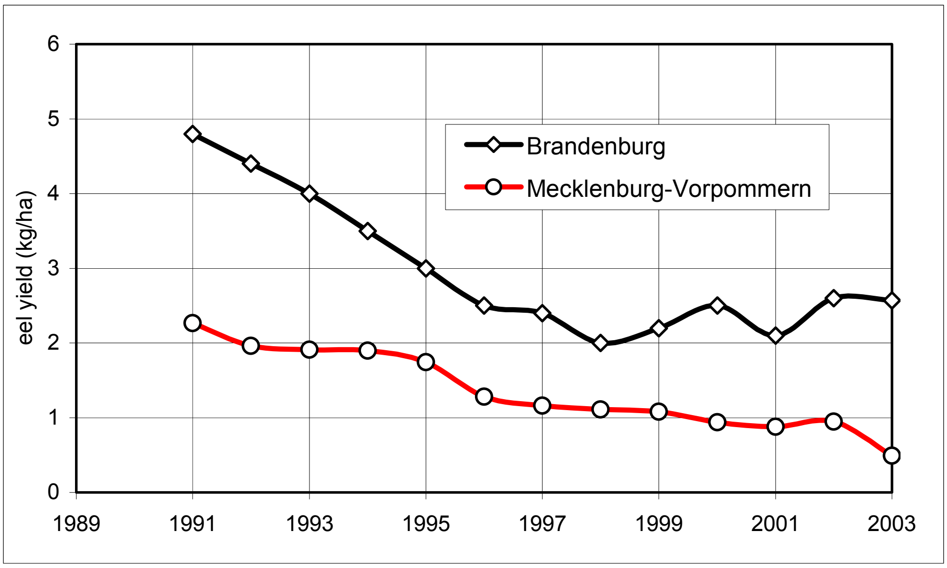

Figure 7: Reported commercial eel yield in inland waters of Brandenburg and Mecklenburg-Vorpommern 1991–2003.

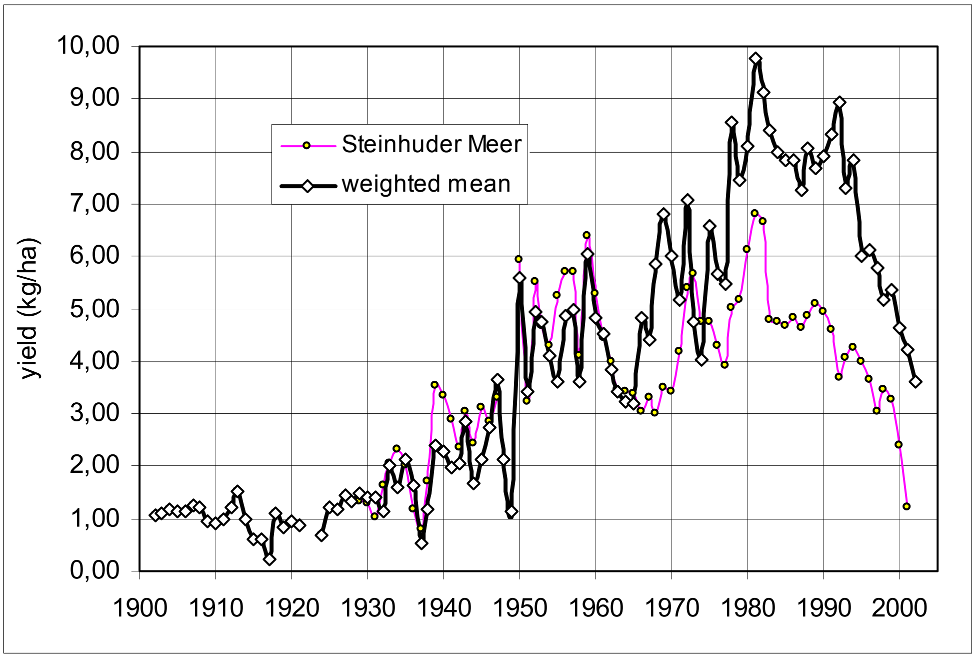

Figure 8: Reported commercial eel yield in inland waters of Niedersachsen (10,135 ha).

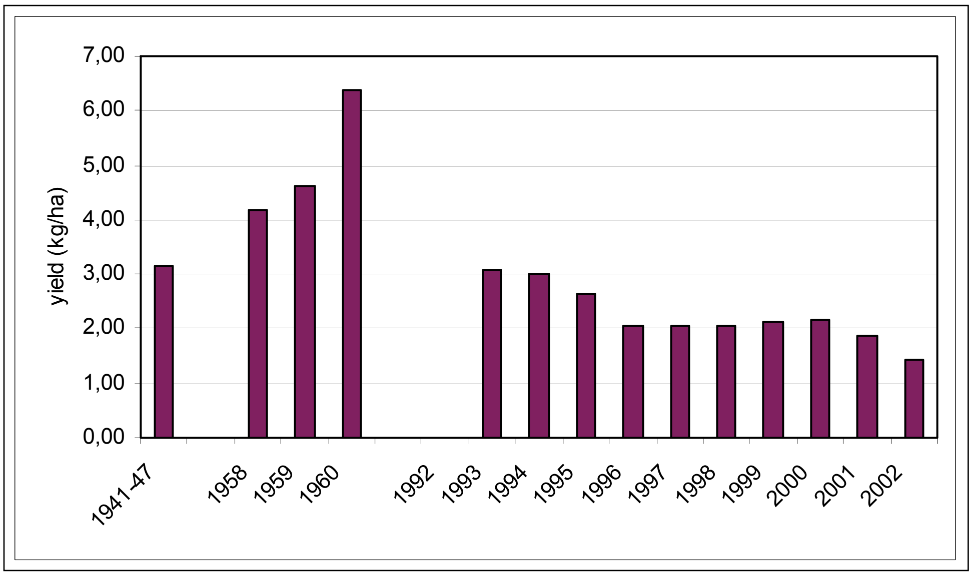

Figure 9: Reported commercial eel yield in inland waters of Schleswig-Holstein (15–17,000 ha) (no figures available for 2003).

The figures about eel landings from coastal waters are even less reliable, because they are reflecting only the part which is offered to the public fish wholesale market. The part of the coastal eel yields which has been smoked by the fishermen and sold to tourists and other private persons has been increasing year by year. Figure 10 shows the eel yield in brackish waters of Mecklenburg-Vorpommern and Figure 11 the eel landings from Schleswig-Holstein coastal waters.

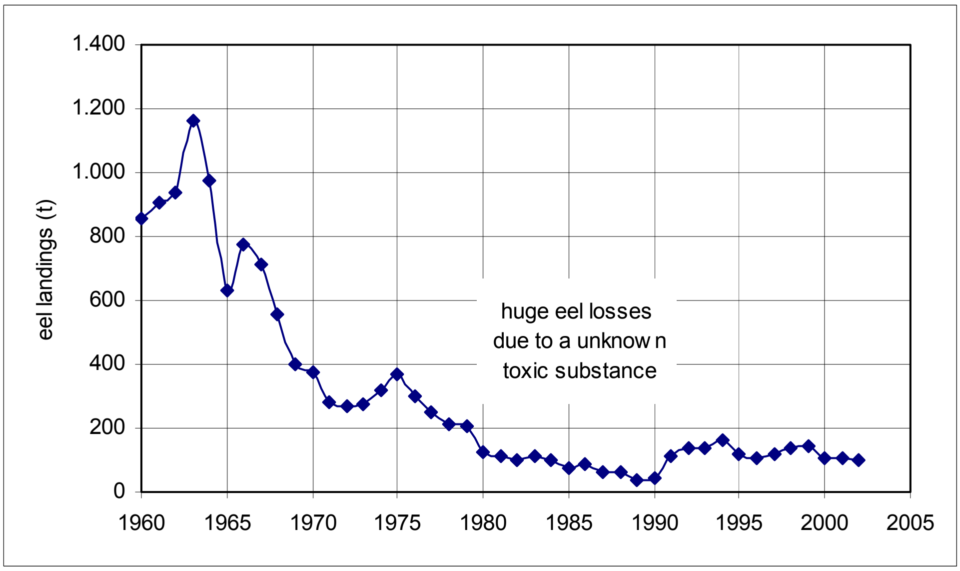

Figure 10: Reported eel landings in brackish waters of Mecklenburg-Vorpommern 1960–2002.

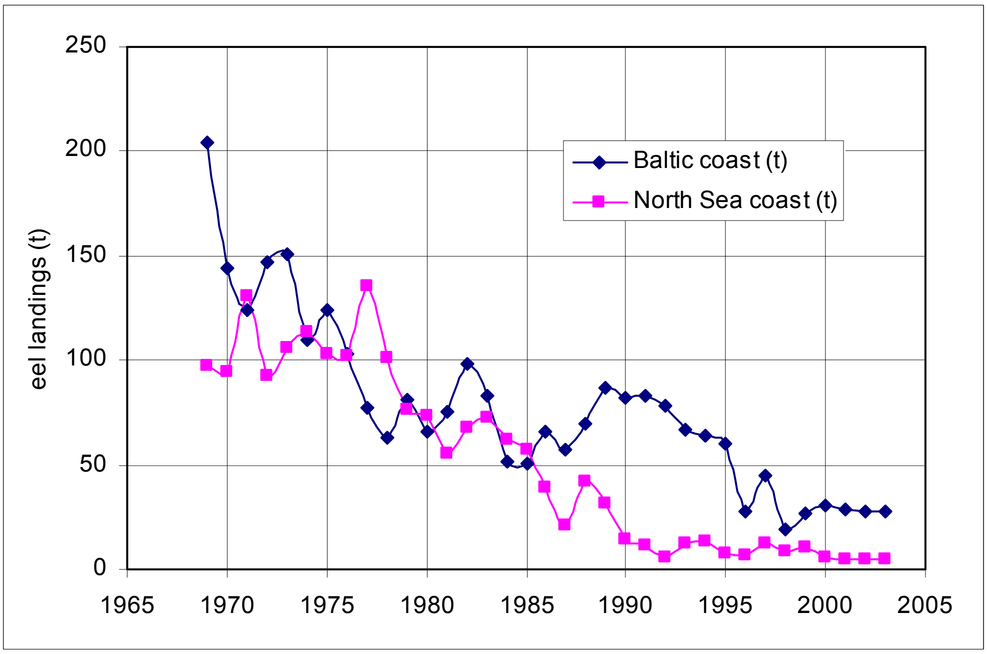

Figure 11: The eel landings from Schleswig-Holstein coastal waters

The longest yield report comes from the 750 ha Lake Grimnitz north east of Berlin (Table 8; Figure 12).

Table 8: Eel yield of the lake Grimnitz (kg/ha).

1900	1,53
1901	1,66
1902	2,13
1903	1,18
1904	1,45
1905	2,57
1906	4,75
1907	4,79
1908	1,38
1909	3,57
1910	8,01
1911	7,27
1912	8,00
1913	7,96
1914	6,67
1915	6,52
1916	7,75
1917	5,47
1918	15,32
1919	8,38
1920	8,42
1921	6,19
1922	9,16
1923	9,46
1924	8,93
1925	8,32
1926	8,81
1927	9,21
1928	7,52
1929	11,20
1930	9,57
1931	10,04
1932	7,86
1933	4,65
1934	6,82
1935	5,69
1936	
1937	
1938	
1939	4,77
1940	2,94
1941	2,57
1942	1,95
1943	3,16
1944	
1945	
1946	
1947	
1948	
1949	
1950	1,27
1951	1,65

1952	1,52
1953	2,03
1954	1,84
1955	2,72
1956	2,77
1957	2,78
1958	3,39
1959	4,67
1960	4,38
1961	6,20
1962	3,44
1963	7,12
1964	3,15
1965	2,65
1966	7,02
1967	6,51
1968	11,29
1969	12,09
1970	13,26
1971	12,18
1972	13,64
1973	12,66
1974	13,06
1975	8,76
1976	10,61
1977	12,58
1978	10,89
1979	11,04
1980	12,48
1981	14,71
1982	12,92
1983	11,96
1984	14,06
1985	15,71
1986	12,73
1987	13,41
1988	12,54
1989	15,45
1990	10,54
1991	7,51
1992	11,13
1993	2,53
1994	1,86
1995	1,23
1996	0,38
1997	0,17
1998	0,04
1999	0,18
2000	0,31
2001	0,09
2002	0,39
2003	0,23

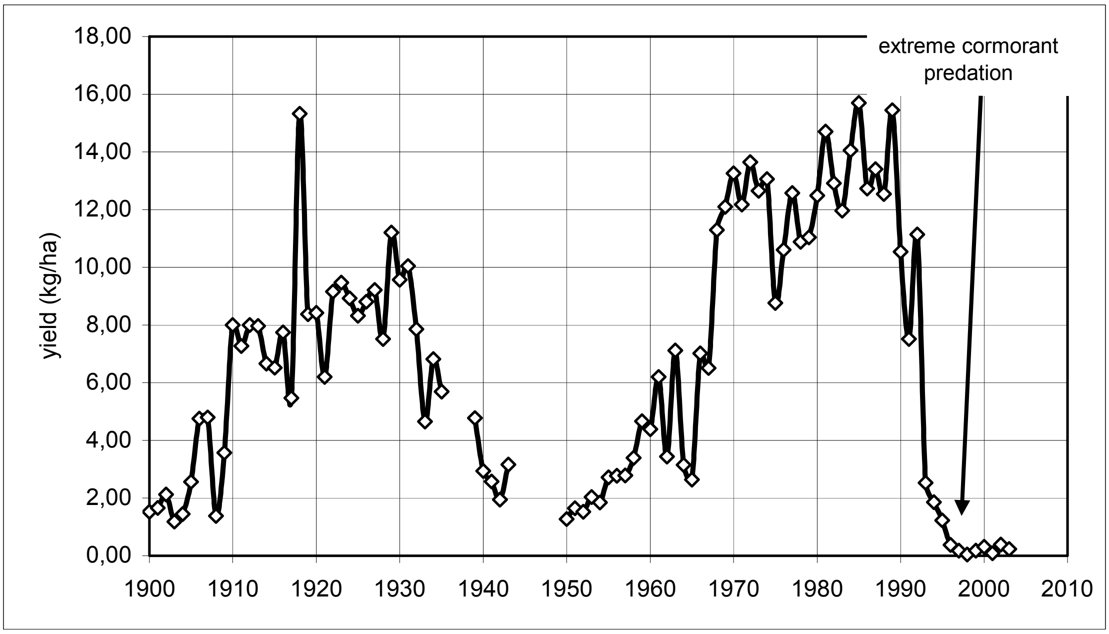

Figure 12: Eel yield of the Lake Grimnitz.

The impact of the fishery on the eel stocks computed by stock models is reported in Table 6 and 7. There are no significant differences in CPUE at two or three subsequent otter board stow nets (mouth width 32 m, longitudinal distance < 1000 m) in the river Elbe (width 200…220 m) what indicates a rather low catch rate (Köhtke, pers. comm.). Thus, the catch rate must be ≤ 5%.

According to marking-re-catch-experiments with a beam stow net set up in the free flowing river Weser the catch rate amounted to 7.5–11.5%. Beam stow nets immediately at weirs should catch more effectively – approximately up to 50%.

DE.1.3 Trend in the stock

Yellow and silver eel were monitored using CPUE of a eel trap at a weir in the river Eider (1850–1962) (Table 9, Figure 13) and of a otter board stow net in the river Elbe (1966–2002) (CE constant) (Table 10, Figure 14).

Table 9: Eel yield (=CPUE) at the stationary eel trap Achterwehr (River Eider/Schleswig-Holstein).

YEAR	YIELD (PIECES)
1850	21272
1851	13590
1852	22705
1853	15885
1854	17180
1855	17676
1856	10974
1857	16119
1858	15145
1859	21746

YEAR	YIELD (PIECES)
1860	19499
1861	17582
1862	12116
1863	13094
1864	16501
1865	17939
1866	15656
1867	19153
1868	22755
1869	16029
1870	19767
1871	13463
1872	16031
1873	18128
1874	15374
1875	20091
1876	22447
1877	26501
1878	18696
1879	25417
1880	25165
1881	23628
1882	20065
1883	23628
1884	25180
1885	23695
1886	22403
1887	19949
1888	29708
1889	28809
1890	12988
1891	22489
1892	16981
1893	25103
1894	26859
1895	28860
1896	26955
1897	26801
1898	23699
1899	33883
1900	18658
1901	22715
1902	14112
1903	21758
1904	15224
1905	13868
1906	14600
1907	11156
1908	21709
1909	13955
1910	23135
1911	19287

YEAR	YIELD (PIECES)
1912	20386
1913	14571
1914	31485
1915	16938
1916	22257
1917	29434
1918	16408
1919	15828
1920	23601
1921	8569
1922	12554
1923	11918
1924	14772
1925	9316
1926	12913
1927	12900
1928	7712
1929	4963
1930	13629
1931	5526
1932	13392
1933	10339
1934	16300
1935	19876
1936	15968
1937	15705
1938	10736
1939	10364
1940	8910
1941	4509
1942	4211
1943	4441
1944	
1945	6250
1946	8187
1947	4525
1948	2442
1949	5082
1950	3544
1951	3425
1952	2428
1953	1880
1954	5010
1955	2613
1956	1736
1957	4482
1958	3001
1959	3388
1960	5498
1961	8658
1962	7630

Table 10: CPUE of the otter board stow net near Gorleben (River Elbe).

YEAR	CPUE (KG/STOW NET DAY)
1966	15,9
1967	11,9
1968	7,5
1969	13,0
1970	12,7
1971	6,7
1972	5,4
1973	4,3
1974	5,8
1975	9,7
1976	5,8
1977	11,0
1978	13,0
1979	10,2
1980	16,5
1981	12,3
1982	10,7
1983	9,5
1984	8,2
1985	5,1
1986	15,6
1987	
1988	
1989	
1990	
1991	
1992	6,1
1993	5,2
1994	10,2
1995	10,9
1996	4,1
1997	3,0
1998	4,4
1999	3,6
2000	3,5
2001	3,5
2002	10,2

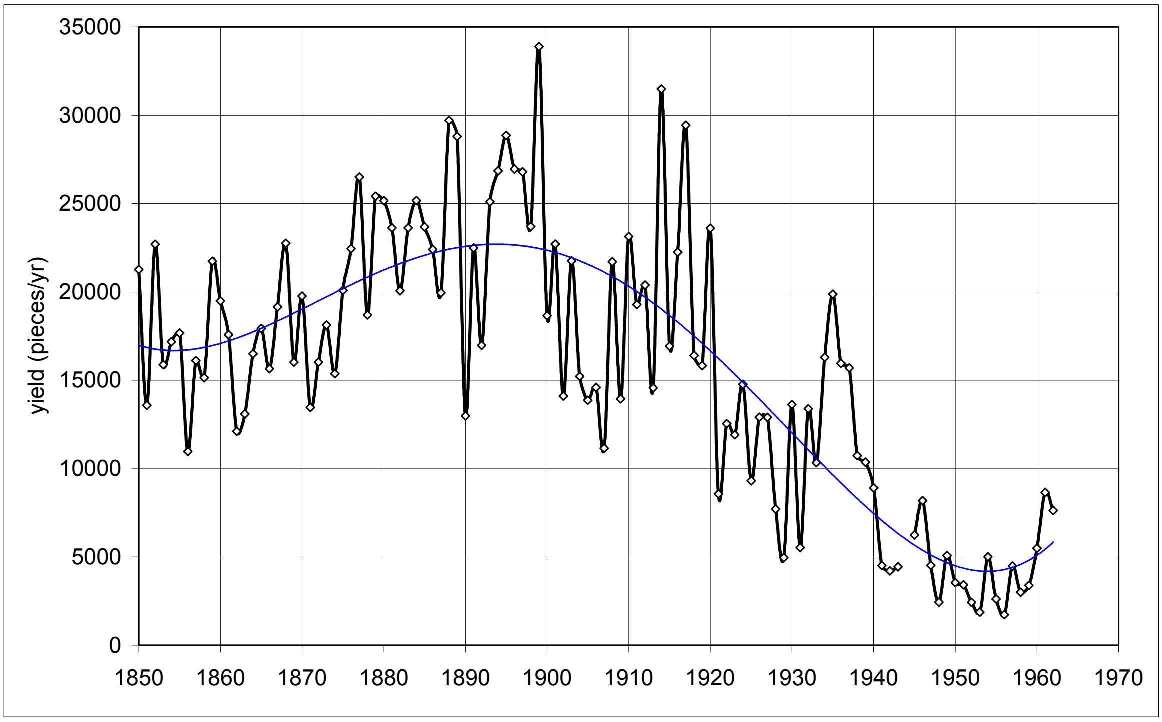

Figure 13: Eel yield (=CPUE) at the stationary eel trap Achterwehr (River Eider/Schleswig-Holstein).

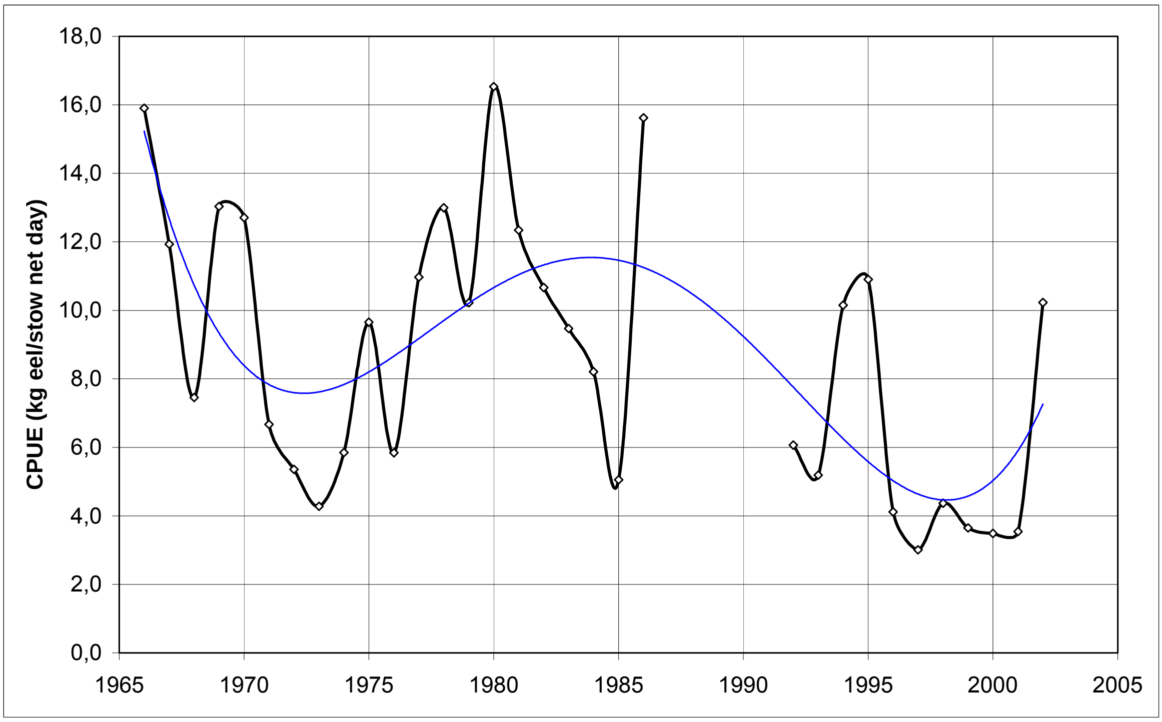

Figure 14: CPUE of the otter board stow net near Gorleben (River Elbe).

Figures 13 and 14 show that the eel stock naturally fluctuates by a factor of about 4.

DE.2 Management

There is no national management plan for eel stocks and fisheries in Germany.

A special task group was founded for the preparation of a national management plan and a co-ordinated research program in Brandenburg and Mecklenburg-Vorpommern is running.

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NL – Report on eel stock and fishery in the Netherlands in 2004.

Country: Netherlands

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Reporting date and last reported year: August 2004, most data through 2003

NL.1 Data

NL.1.1 Trend in recruitment

Monitoring methodology, life stage, gear type

Monitoring of glass eel, immigrating through the sluices at Den Oever, sampling by means of lift net, scientific effort. See Dekker 2002 for details.

Recruitment monitoring results

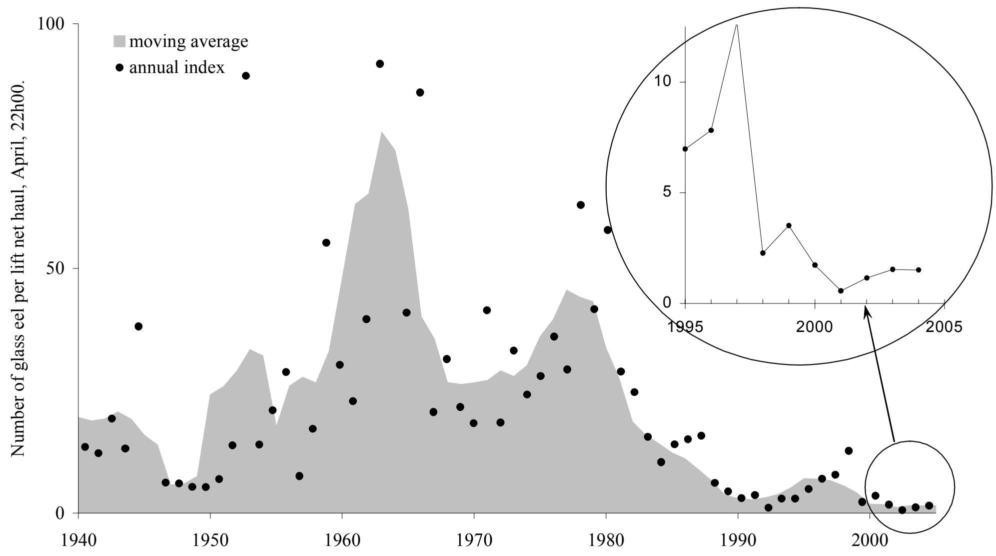

Figure 6.4–1. Long-term trend in the glass eel catches in the experimental fisheries at Den Oever.

Table 6.4–A. Number of glass eel caught per lift net haul. All observations in a year have been corrected for time of day and month of sampling, and averaged.

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000
0		13.48	6.92	22.87	41.43	28.92	3.66	1.73
1		12.24	13.84	39.62	18.49	24.72	1.12	0.57
2		19.30	89.37	91.79	33.20	15.59	2.96	1.15
3		13.16	13.97	131.13	24.22	10.43	2.96	1.54
4		38.13	20.99	40.95	27.97	14.02	4.93	1.52
5			28.82	85.94	36.07	15.08	6.98	
6		6.24	7.58	20.63	29.33	15.83	7.82	
7		6.09	17.20	31.46	62.94	6.17	12.70	
8	16.48	5.38	55.22	21.66	41.66	4.43	2.27	
9	36.32	5.29	30.26	18.37	57.84	3.04	3.53	

Development during the last season

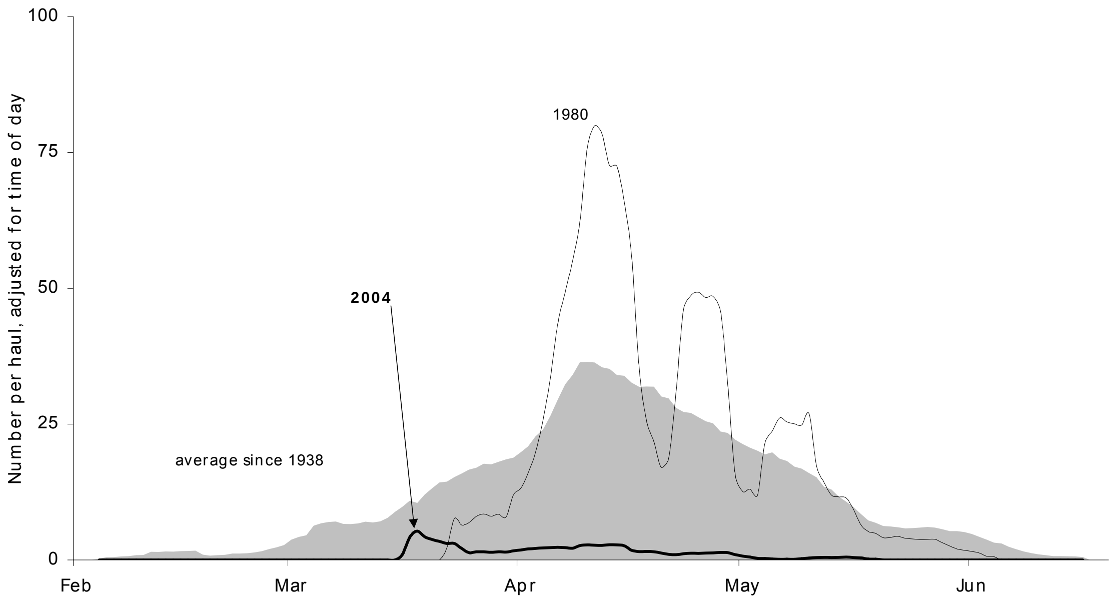

Figure 6.4–2. Short-term trend in the glass eel catches in the experimental fisheries at Den Oever.

The winter was rather mild, so we expected an early start of the migration season. Unfortunately, the organisation of the monitoring was quite unsure for a long time, so monitoring only started on March 21st. In the very first days following, considerable catches were made.

In 2003, the very first glass eel was caught in Den Oever on 20 March 2003; due to organisational problems, the first catch was not reported in 2004.

Long term monitoring at 10 stations (other than Den Oever): see table below and Dekker 2002 for details. At these stations, sampling is much less intensive as at Den Oever, but otherwise, the same methodology is used. A less labour demanding sampling gear is urgently required; research for alternative approaches (passive gear, automatic sampling) is scheduled for spring 2005.

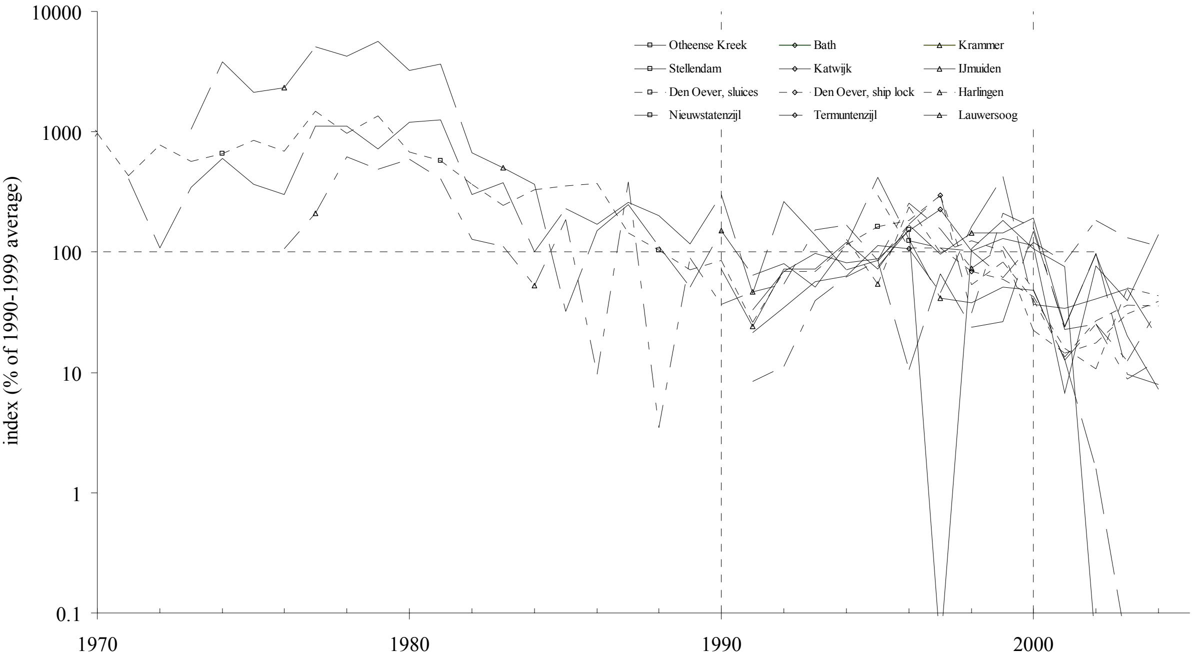

Figure 6.4–3. Long-term trends in the glass eel catches in the experimental fisheries at various places along the Dutch coast.

In the northern provinces of the Netherlands, a detailed monitoring programme for glass eel and other migratory fish has been running over the years 2001–2003, using an identical procedure, but sampling just before high tide every fortnight. This programme has produced its end-report in 2004 (Wintermans and Jager 2004), and has now been discontinued.

Table 6.4–B Annual indices of glass eel recruitment at places in the Netherlands, other than Den Oever. Annual indices are expressed as the mean catch per lift net haul, at whatever time in the night. Most hauls are made in the evening, just in the dark.

Year	Otheense Kreek	Bath	Krammer	Stellendam	Kat wijk	IJmuiden	Den Oever, Ship Lock	Har-lingen	Nieuw-staten-zijl	Ter-munten-Zijl	Lau-wer-soog
1969						47.3					
1970						31.5					
1971				15.4							
1972				4.1							
1973				13.1		32.8					
1974				22.8		119.3					
1975				13.9		66.8					
1976				11.3		73.1					14.4
1977				42.1		159.2					28.4
1978				42.1		131.7					83.9
1979				27.3		176					66.2
1980				45.1		101.5					80.3
1981				47.3		113.9					55.1
1982				11.3		20.8					17.4
1983				14.3		15.6					15.1
1984				3.8		11.4					7.1
1985				8.7		1					25.2
1986				6.4		4.7					1.3
1987				9.8		7.7					52.0
1988				7.6		3.5					0.5
1989				4.4		1.6					12.1
1990			0.3	11.3		4.7					5

Year	Otheense Kreek	Bath	Krammer	Stellendam	Kat wijk	IJmuiden	Den Oever, Ship Lock	Har-lingen	Nieuw-staten-zijl	Ter-munten-Zijl	Lau-wer-soog
1991		5.9	0.1	1.7	5.1	2				0.3	6.3
1992		12.3	0.3	9.9	8.2	2.5		14.8		0.4	7.3
1993		17.5	0.3	5.2	13.5	1.6				1.4	20.8
1994		14.6	0.5	2.7	15.1	3.6		16		2.2	22.5
1995	0.5	15.7	0.3	3.2	27.1	13.1	27.8	6.8		3	11.6
1996	1	26.8	0.7	0.4	25.4	4	10.2	29.7	24	6	34.4
1997	0	40.4	0.4	2.5	10.9	1.3	10.2	12.4	21	10.6	20.9
1998	0.7	18.3	0.6	0.9	38.8	1.2	6.5	15.4	19.9	1.1	9.9
1999	1.2	23.1	0.6	1	101.3	1.6	5.6	12.7	11.8	7.5	15.1
2000	0.7	20.1	0.8	5.6	8.8	1.5	4	2.8	23.3	5.7	6.6
2001	0.5	1.2	0.1	0.9	8.1	0.4	1.5	1.8	16.1	0.8	1.7
2002	0	13.6	0.4	3.7	9.8	0.05	1	2.2	35.3	0.9	3.4
2003	0	7.0	0.1	0.4	11.8	0	4.7	3.8	25.5	0.4	1.2
2004	0	(24.9)	0.03	0.3	4.5	0.105	4.1	(4.9)	21.7	1.2	1.7

NL.1.2 Trend in re-stocking

Glass eel and young yellow eel have been used for re-stocking inland waters since time immemorial, mostly by local action of stakeholders. Although a minimum legal size for capture, holding and transport of eels is set in a byelaw, the existing practice of short-range transports has never been prosecuted. Since World War II, the Organisation for the Improvement of Inland Fisheries has organized a re-stocking programme, importing glass eels from France and England, and buying yellow eel from commercial fishermen fishing in the Waddensea. Data on re-stocking quantities are listed in Table 6.4–C. Average weight of the young yellow eel amounts to approx. 33 gr.

Table 6.4–C. Re-stocking of glass eel and young yellow eel in the Netherlands, in millions re-stocked.

	1940		1950		1960		1970		1980		1990		2000	
	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel	glass eel	young yellow eel
0			5.1	1.6	21.1	0.4	19.0	0.2	24.8	1.0	6.1	0.0	2.8	1.0
1			10.2	1.3	21.0	0.6	17.0	0.3	22.3	0.7	1.9	0.0	0.9	0.1
2			16.9	1.2	19.8	0.4	16.1	0.4	17.2	0.7	3.5	0.0	1.6	0.1
3			21.9	0.8	23.2	0.1	13.6	0.5	14.1	0.7	3.8	0.2	1.6	0.1
4			10.5	0.7	20.0	0.3	24.4	0.5	16.6	0.7	6.2	0.0	0.3	0.1
5			16.5	0.9	22.5	0.5	14.4	0.5	11.8	0.8	4.8	0.0		
6	7.3		23.1	0.7	8.9	1.1	18.0	0.5	10.5	0.7	1.8	0.2		
7	7.6	1.6	19.0	0.8	6.9	1.2	25.8	0.6	7.9	0.4	2.3	0.4		
8	1.9	2.0	16.9	0.8	17.0	1.0	27.7	0.8	8.4	0.3	2.5	0.6		
9	10.5	1.4	20.1	0.7	2.7	0.0	30.6	0.8	6.8	0.1	2.9	1.2		

NL.1.3 Trend in fishery

Eel fisheries occur in coastal areas and all inland waters. Only a minor part of these waters is actively managed under governmental control. Latest guestimates of production are:

AREA	ANNUAL YIELD (T)	MONITORING	LANDING STATISTICS
IJsselmeer	<279	Yes	Yes
R. Rhine and Meuse	150	Yes	No
Other inland waters	375	No	No
SE Delta, Zeeland	75	No	No
Waddensea	40	Yes	No
Along west coast	30	Yes	No
Indoor aquaculture	4000	No	Yes

IJsselmeer

- *Life stage concerned: 90% yellow eel, 10% is silver eel, but the share of silver eels seems to be increasing the last few years, up to 25%.*
- *Description of fisheries, information sources, gear types*
- *Former estuarine area, 1820 km^2, closed off from the sea in 1932. Lake eel fisheries, using fykenets (most), eelboxes and longlines. Governmental management, auction statistics, research sampling and surveys. Fishermen's organisation has become co-responsible for management in last decade, and has instituted internal obligation to land catch at auctions. Results are not public.*
- *Effort. Number of fyke nets rose from an estimated 5000, to 45,000 in mid 1980s (counted, and subsequently licensed), in late 1980s reduced to 60% and additional constraints in time and space. Subsequent co-management, by which the quantification of effective fishing effort is now rather obscure.*
- *Yield*

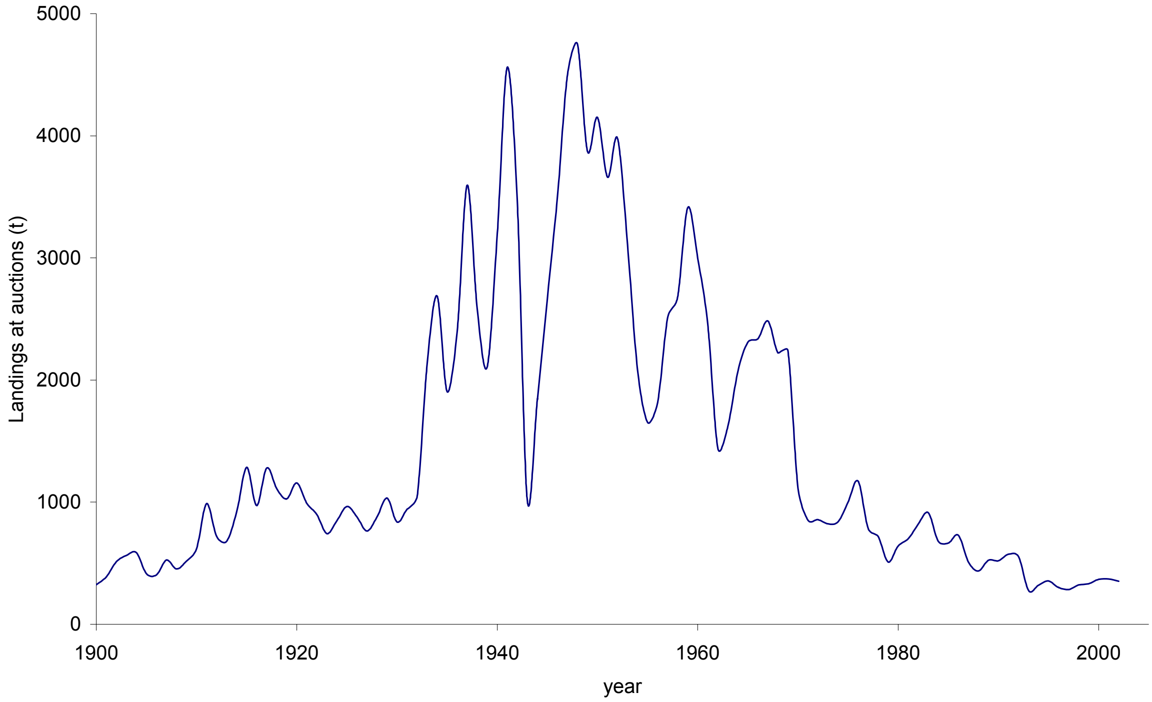

Figure 6.4–4. Landings of yellow and silver eel (combined) from the Zuiderzee/IJsselmeer area. In 1932, the estuarine area was closed off from the Waddensea by a dike. Recent data are confounded by landings from other areas.

Table 6.4–D. Landings in tonnes per year, from the auctions around Lake IJsselmeer. Only landings recorded at the auctions are included; other landings are assumed to represent a minor and constant fraction. Recently, the data become more and more corrupted by landings from other areas, traded via the IJsselmeer auctions.

YEAR	1900	1910	1920	1930	1940	1950	1960	1970	1980	1990	2000
0	324	620	1157	838	3205	4152	2999	1112	641	472	*368*
1	387	988	989	941	4563	3661	2460	853	701	573	*381*
2	514	720	900	1048	3464	3979	1443	857	820	548	*353*
3	564	679	742	2125	1021	3107	1618	823	914	293	*279*
4	586	921	846	2688	1845	2085	2068	841	681	330	
5	415	1285	965	1907	2668	1651	2309	1000	666	*354*	
6	406	973	879	2405	3492	1817	2339	1172	729	*301*	
7	526	1280	763	3595	4502	2510	2484	783	512	*285*	
8	453	1111	877	2588	4750	2677	2222	719	437	*323*	
9	516	1026	1033	2108	3873	3412	2241	510	525	*332*	

Fish traded via the auctions around Lake IJsselmeer is assumed to originate from the lake. It has recently become evident, that this is now a false assumption. Fishermen in the surrounding provinces transport their catch by road to the same auction. The auction bookkeeping records the name of the selling fishermen, but the registering agency (Productschap Vis, Fish Board) lumps all data, regardless of the origin. A preliminary analysis of discontinuities in spatial and temporal patterns in the landings indicates that at least 20% of the recorded total yield since

2000 is due to misallocation, but presumably a lot more. Misallocation in the period before 1990 seems rather unlikely.

Personal communication during summer 2003 indicates a fall in yield during early summer. In past years, prices were good, but this year that does not compensate for the decline in catch volume.

- *Impact of fisheries on the stock*

Instantaneous fishing mortality F of the fully recruited length classes is in the order of 1.0 (Dekker 2000). Although F values have been calculated on an annual basis, the extreme over-exploitation in combination with the lowering quality of the market statistics, have made an up-to-date calculation rather superfluous. All information indicates the extreme overexploitation is continued. Major efforts to reduce the fishing intensity have indeed reduced mortality somewhat, but reductions have not been adequate to derive a sustainable F-level.

Waddensea and coastal areas

Fisheries on the North Sea are obliged to report catch and effort, including eel, since 1995. Total marine catches landed in the Netherlands are listed in Table 6.4–E, by country of origin of the vessel.

Inland waters, exclusive Lake IJsselmeer

Fisheries in inland waters are regulated by governmental licenses, but are not obliged to report their effort or landings. Their yield is estimated at the order of magnitude of 600 tonnes. Circumstantial evidence suggests a stable or slightly increasing yield from the rivers Rhine (and Meuse), but a rather severe decline elsewhere.

Table 6.4–E. Landings of eel in the Netherlands from marine areas, listed by country of origin of the landing vessel. Unit = kg.

YEAR	BE	DE	DK	FR	UK	NL	N/A	TOTAL
1995	6,925	2	-	2	-	38,163	-	45,092
1996	3,184	-	-	-	309	30,719	-	34,212
1997	1,622	24	-	38	41	25,679	-	27,404
1998	1,566	4	-	2	23	20,256	-	21,851
1999	1,690	-	-	3	7	24,307	-	26,007
2000	,783	25	-	-	18	20,055	16	21,897
2001	791	-	461	-	-	34,342	729	36,323
2002	902	-	-	-	-	26,961	1,320	29,183
2003	-	-	-	-	-	16,620	2,165	18,785

NL.1.4 Trend in the stock

The IJsselmeer eel stock is surveyed, independent of the commercial fisheries. Since about 1950, 8-m beam trawl surveys have been operated, targeting either eel (2 mm mesh), or coarse fish (16–20 mm mesh) with a by-catch of eel. The dedicated eel trawling has been replaced in about 1980 by a 3-m beam trawl, with a 300 V DC electric field between the sledges of the beam (only 2 mm mesh). Additionally, market sampling provides information on the stock status too. A combined analysis of all information available has yielded a detailed picture of the composition and abundance of the stock; see Dekker (2004). Overall, a declining trend is in abundance is observed, for small and legally sized eel, declining since early 1960s. Most recent information indicates no substantial deviation from this trend.

NL.1.5 Trend in aquaculture

Different sources reported slightly diverging results for the Dutch aquaculture industry:

Aquaculture production (tons/year)	Data source			
	FEAP	wgeel2003	FAO Fish-stat	Nevevi
1985		20	20	
1986		100	100	
1987		200	200	100
1988		200	200	300
1989		350	350	200
1990		550	500	600
1991		520	550	900
1992		1250	520	1100
1993		1487	1250	1300
1994		1535	1487	1450
1995		2800	1535	1540
1996	1800	2443	2800	2800
1997	1800	3250	2443	2450
1998	3250	3800	2634	3250
1999	3800	4000	3228	3500
2000	4000	3800	3700	3800
2001	4000	3228	4000	4000
2002	4000		3868	4000
2003				4200
2004				4500

Nevevi is the national organisation of fish farmers; one would expect their own estimates to be the best.

NL.2 Management

The Ministry of Agriculture, Nature Conservation and Fisheries (now: A, N and Food Safety) has published a report in 2002, describing the decline of the stock and a long list of potential causes; suggestions for remedies are given. Neither the existing situation nor the remedies have been quantified. Major emphasis is placed on international coordination, by the European Union. Major focus in impacts is on hydropower and habitat loss, with fisheries in a double role: as existing impact and as ultimate beneficiary.

This report was intended as Fact Sheet, with options for a subsequent approach. Given the political prerequisite to safeguard a Level Playing Field between EU member countries, priority has been given to reach international agreement first, i.e. the EU Ministers conference of July 2004 (see http://ue.eu.int/ueDocs/cms_Data/docs/pressData/en/agricult/81505.pdf). It is to be expected that, once this international agreement is now reached, the national process may speed up.

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BE – Report on eel stock and fishery in Flanders (Belgium), 2004

Country: Belgium

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Reporting date and last reported year: September 2004

BE.1 Data

BE.1.1 Trend in recruitment (as an index of the stock, be it exploited or not)

- *What is monitored? Life stage, information source, exploited or not, gear type*

Monitoring of glass eel, immigrating through the sluices at Nieuwpoort on the River Yser, sampling by means of handnet, scientific effort. See Dekker 2002 for details.

- *Tabular data and graph, one record per year, for all years for which information is available (that repeats most information of last years report, but we want to be sure all is correct and updated)*

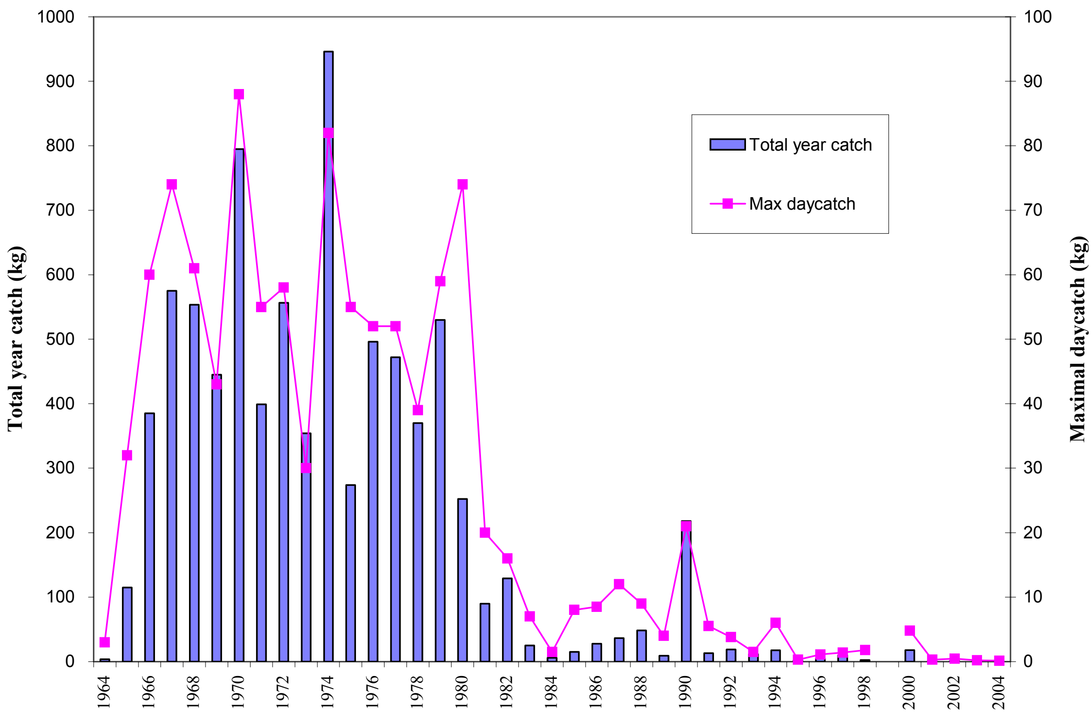

Figure 1. Maximal day catch and total biomass of glass eel caught per year at Nieuwpoort (1964–2004).

Decade Year	1930	1940	1950	1960	1970	1980	1990	2000
0					795	252	218,2	17,85
1					399	90	13	0,7
2					556,5	129	18,9	1,4
3					354	25	11,8	0,539
4				3,7	946	6	17,5	0,381
5				115	274	15	1,5	
6				385	496	27,5	4,5	
7				575	472	36,5	9,8	
8				553,5	370	48,2	2,255	
9				445	530	9,1		

- *If possible/necessary, comment or present information on last season, within year*

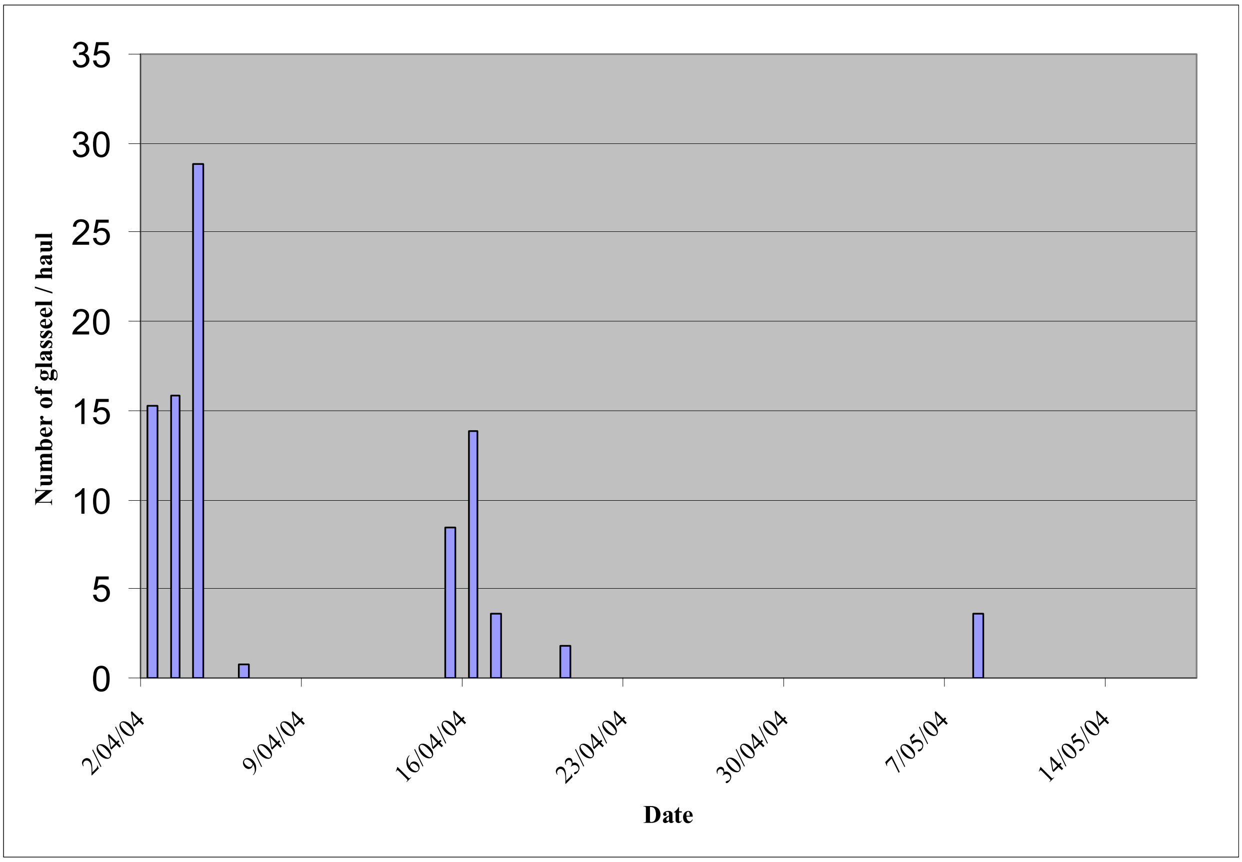

Figure 2. Day catch (mean number per haul) of glass eel caught at Nieuwpoort in 2004.

During 2004, fishing was organised on 11 nights between 2 April and 17 May. Total yield was 1528 glass eel for a total weight of 381 gram. This is the lowest yield ever reported. Maximal day catch was 144 gram, also this is the lowest day catch ever reported for the Belgian glass eel series from 1964 to 2004. Best catches were performed first week of April. Very first glass eel caught in Nieuwpoort on 2 April 2004. Results are biased as a result of the late start of the fishing campaign, due tot the fact that the monitoring is now organised by volunteers.

BE.1.2 Trend in fishery

Status of the stock and trends

In Flemish water bodies (rivers, canals, polder water courses, ponds) fish stocks are assessed by the Institute for Forestry and Game Management using standardised procedures. A dataset of 1332 locations fished during the period 1996–2002 showed very low eel occurrences especially in riverine systems (rivers and brooks 18% of eel presence, canals 50%, closed water bodies (ponds old river arms) 91%). Where eels are present abundance is usually low (rivers, brooks and canals 1–5 ind/100m, closed water bodies > 15 ind/100m) (Belpaire *et al*., 2003).

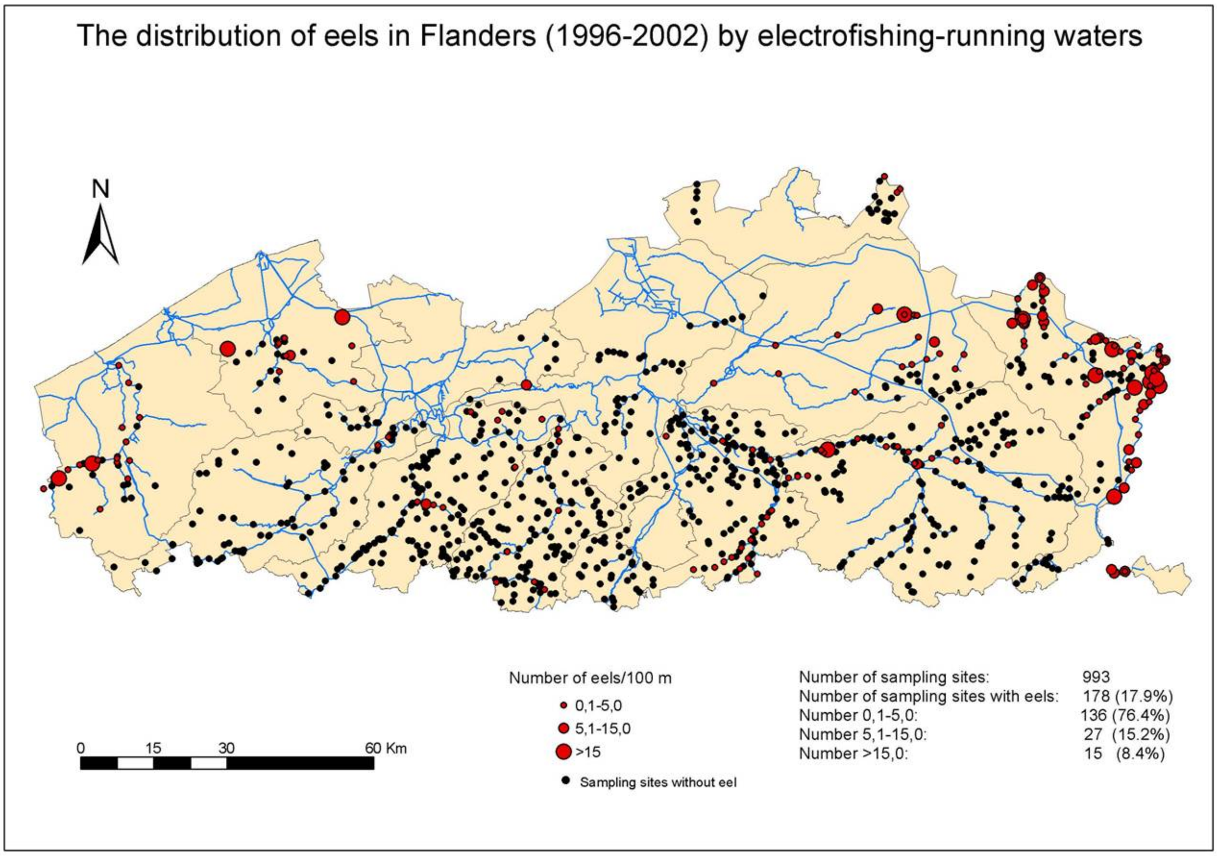

Figure 3. Catches of eels in running waters by electrofishing (1996–2003) (Belpaire *et al*., 2003).

A trend is also available from studies by the University of Louvain on the River Scheldt. Eel densities in the Scheldt estuary were recorded during the period 1991–2002 by analysing eels in the cooling water intake of the Doel power station and by a follow up of the fyke net fisheries. The numbers of adult eel (50–70 cm) per fyke net per day decrease from 1998 to 2002 and the numbers of pre adult eel (20 cm) per 10^3 m^3 cooling water showed a declining trend. Overfishing is a possibility to explain declining catches of eel in the estuary but overfishing does not explain decreasing eel numbers in the cooling water as predominantly small eel are entrapped by the intake.

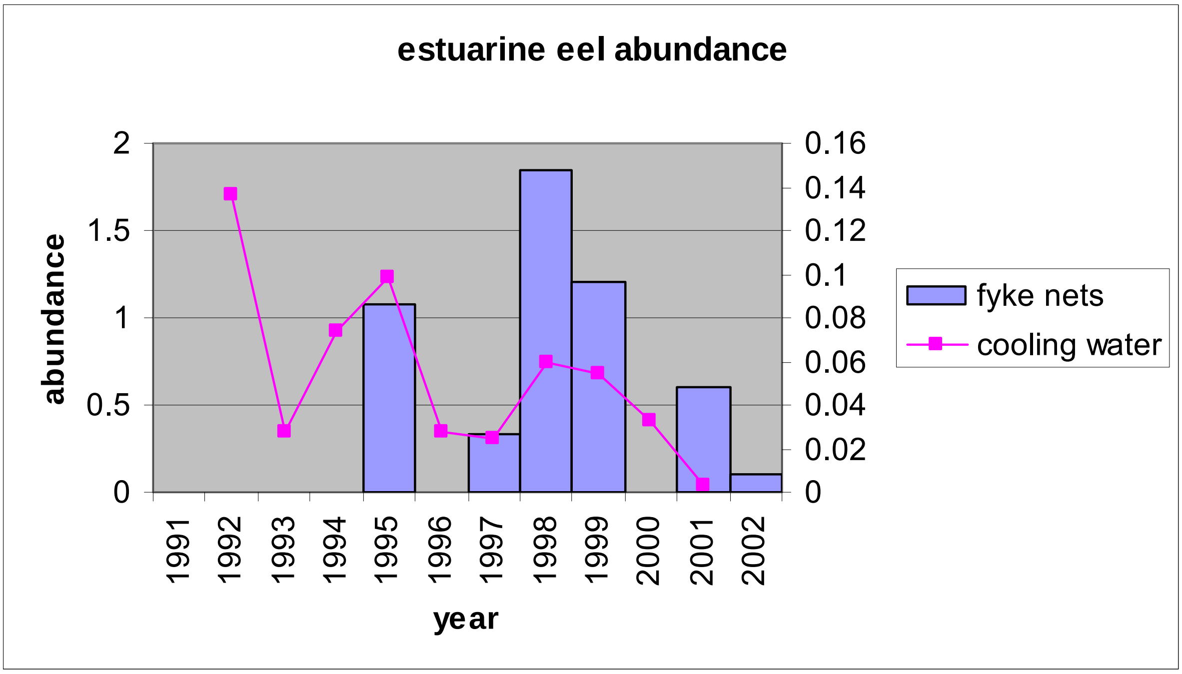

Figure 4. Trends in abundance of estuarine eels in River Scheldt (1991–2002). Data from University Louvain , Belpaire *et al.*(2003).

BE.1.3 Restocking

Since 2000 restocking is carried out only with glass eel. The origin of the glass eel is U.K. 108 kg glass eel was restocked in 2003. In 2004 due to the high market prices no glass eel has been restocked Time series with quantities of glass eel restocked is presented in Figure 5.

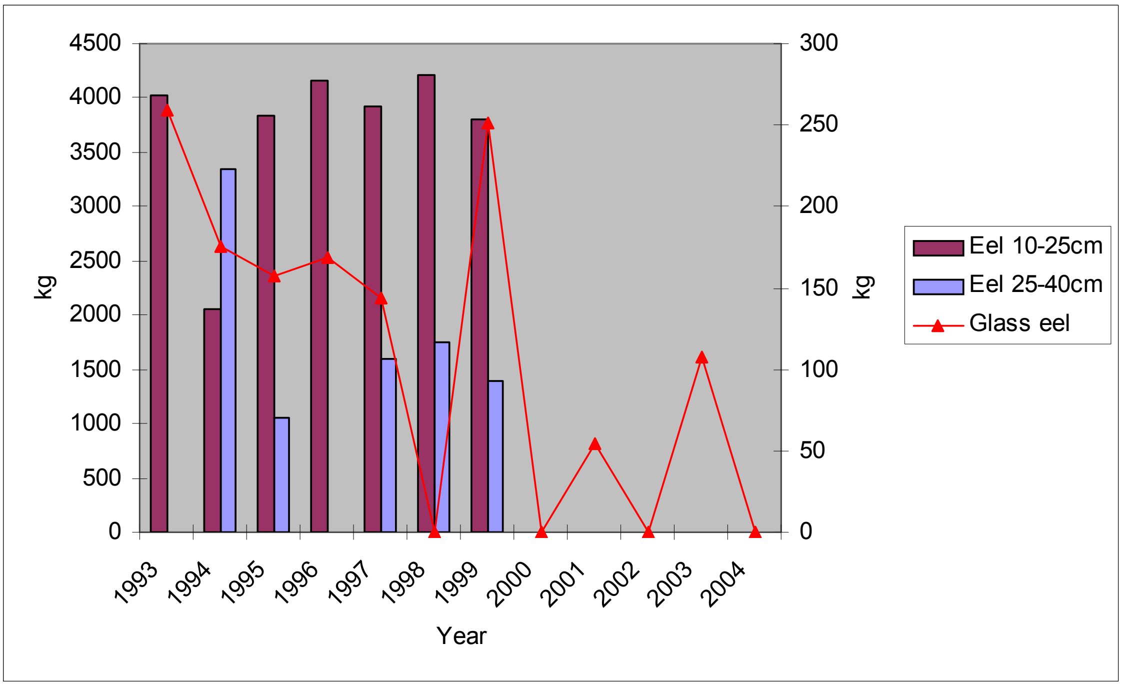

Figure. 5 Trends in stocking of yellow eel and glass eel in Flanders (1993–2004).

FR – Report on eel stock and fishery in France, 2004

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	Laurent Beaulaton	CEMAGREF
	Thomas Changeux	CSP
	Aurore Baisez	Tableau de bord Loire
	Marie Noëlle De Casamajor	IFREMER
	Patrick Prouzet	IFREMER

FR.1 Data

FR.1.1 Trend in recruitment (as an index of the stock, be it exploited or not)

- *What is monitored? Life stage, information source, exploited or not, gear type*
- *Tabular data and graph, one record per year, for all years for which information is available (that repeats most information of last years report, but we want to be sure all is correct and updated)*

The glass eel time series in France are collected from (north to south) the Vilaine, the Loire, the Gironde and the Adour.

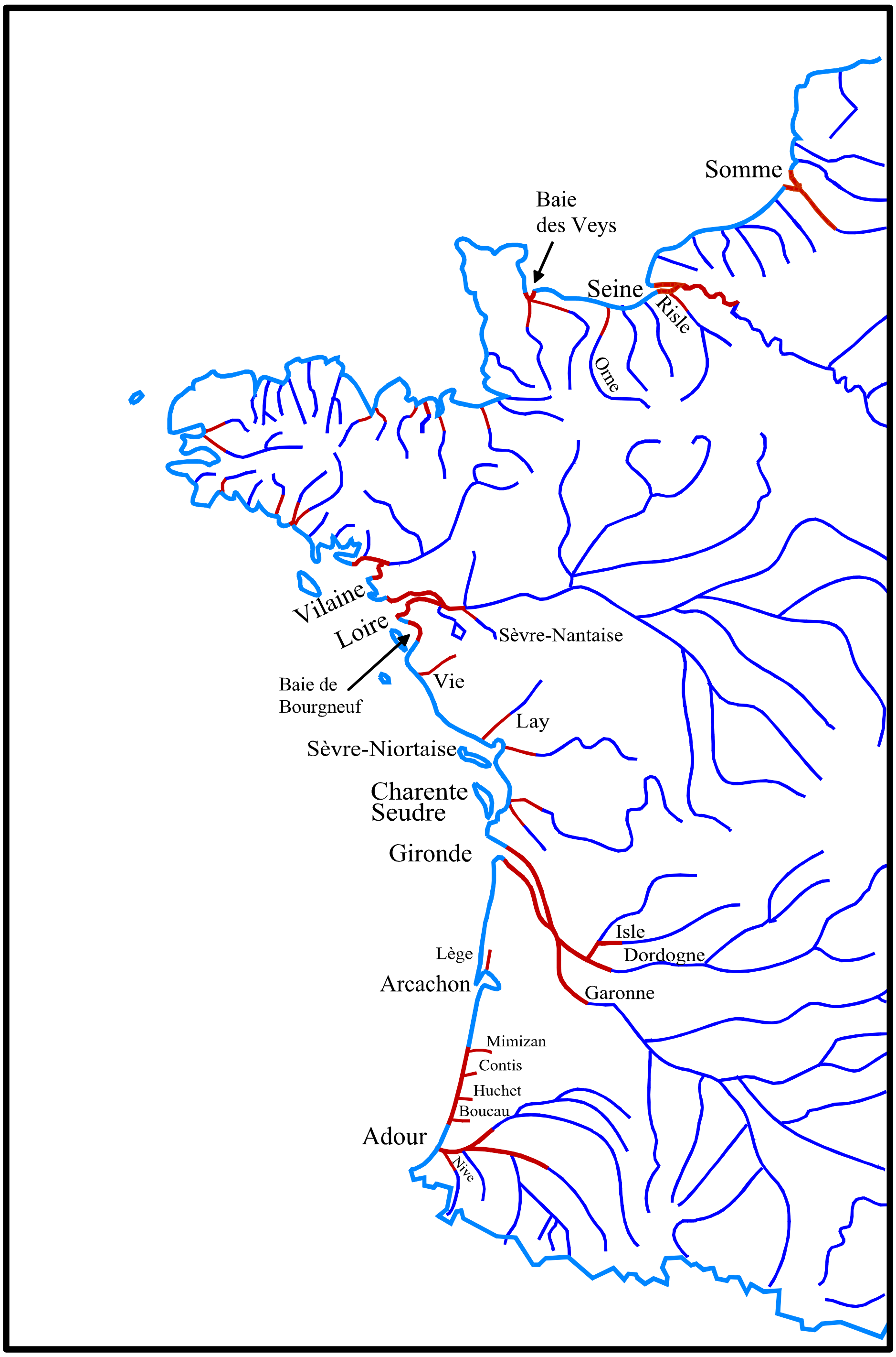

Figure Fr. 1. The glass eel fishery areas in France.

Vilaine

The Vilaine time series is collected from total catches of the fishery. The total catch of the fishery was 7 T. Management measures reducing the duration of the fishing season allowed an escapement of 0.8 T. Corrected from the management measures, total estimated recruitment to the Vilaine estuary was calculated as 7,8 tons (BRIAND et FATIN, 2004).

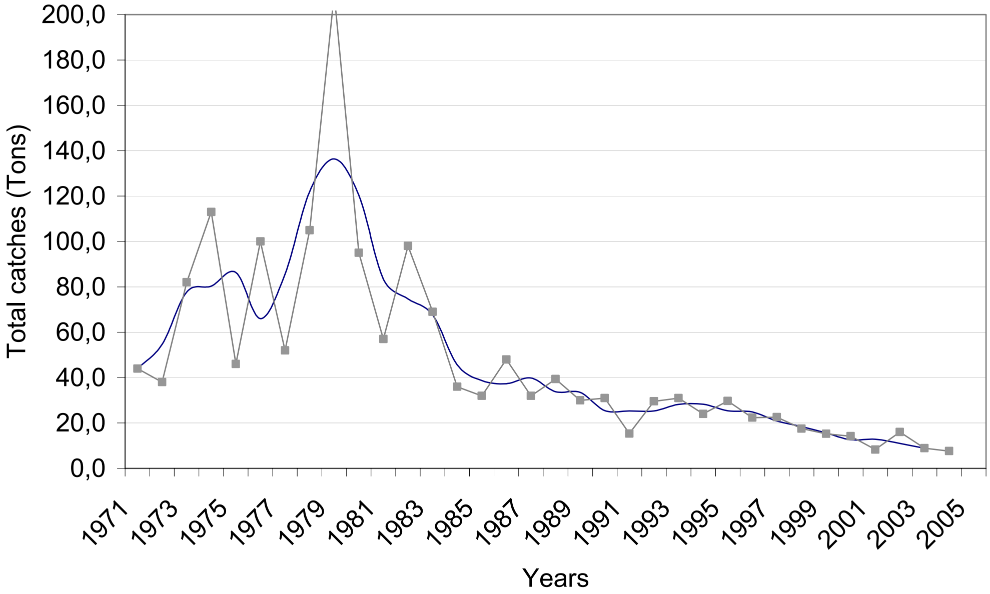

Figure Fr. 2. Trend in catches of the Vilaine fishery, line = smoothed data.

Table Fr. 1. Time series for the Vilaine fishery.

DECADE Season (n-1,n)	1970	1980	1990	2000
0		125	15.3	14.2
1	44	130	29.6	8.1
2	38	140	31	16
3	78	129	24	8.9
4	107	116	29.7	7.8
5	44	100	22.4	
6	106	91	22.6	
7	52	105	17.5	
8	106	106	15.3	
9	209	110	14.2	

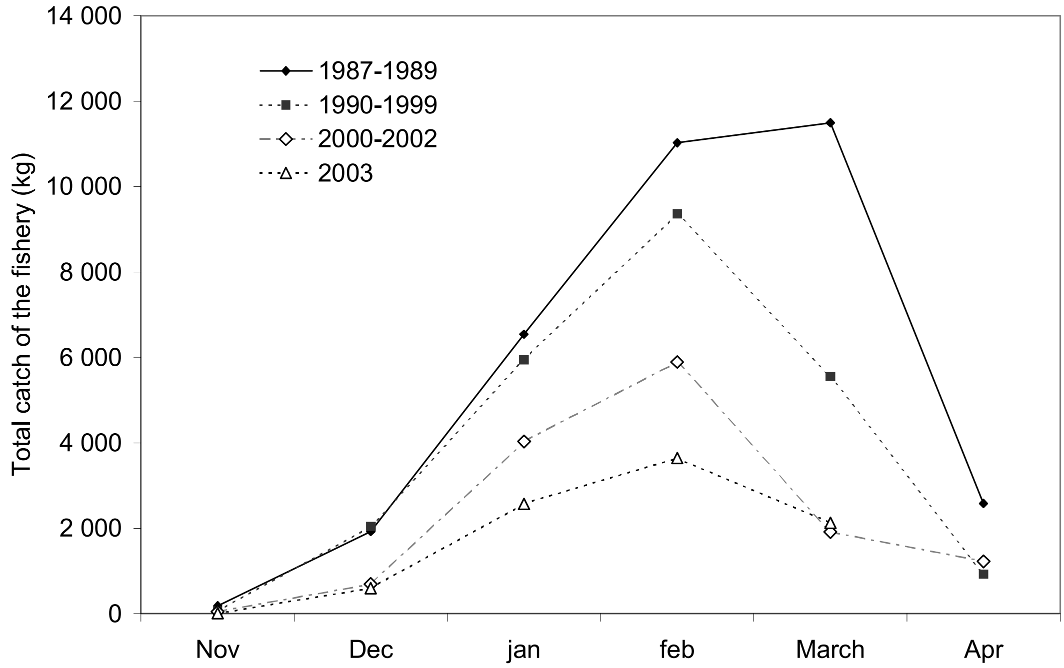

Figure Fr. 3. Intra-seasonal catches of the Vilaine fishery.

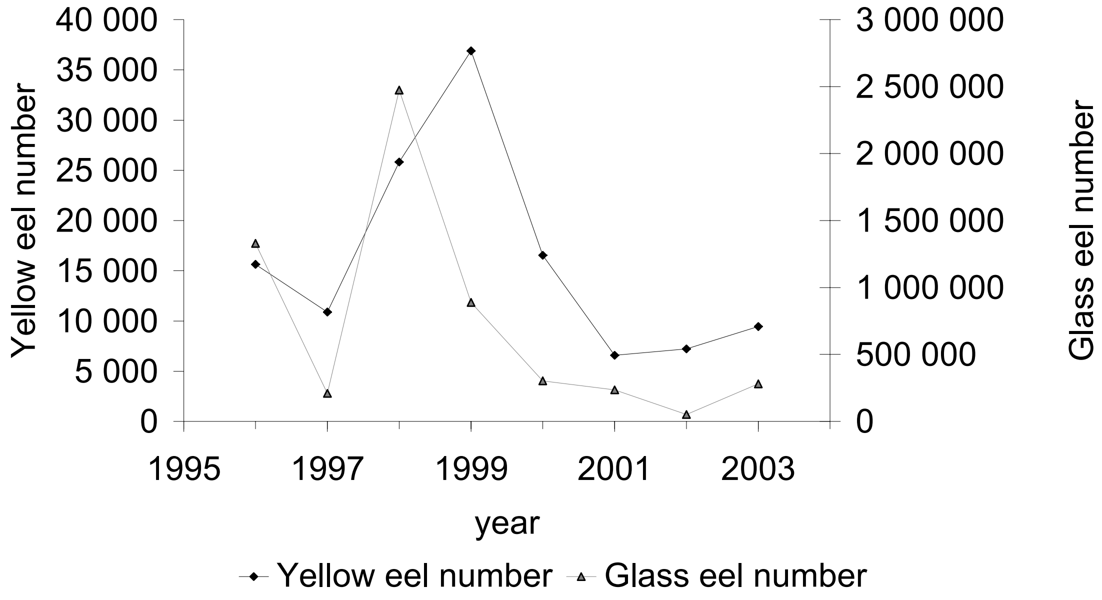

Figure Fr. 4. Number of glass eel and yellow eel collected and counted at the Vilaine trapping ladder.

Loire

The Loire provides one of the longest series starting at the beginning of the 1920th. The historical trend was provided by IFREMER. Most recent data from logbooks analysis 2001, but also phone survey of glass eel buying.

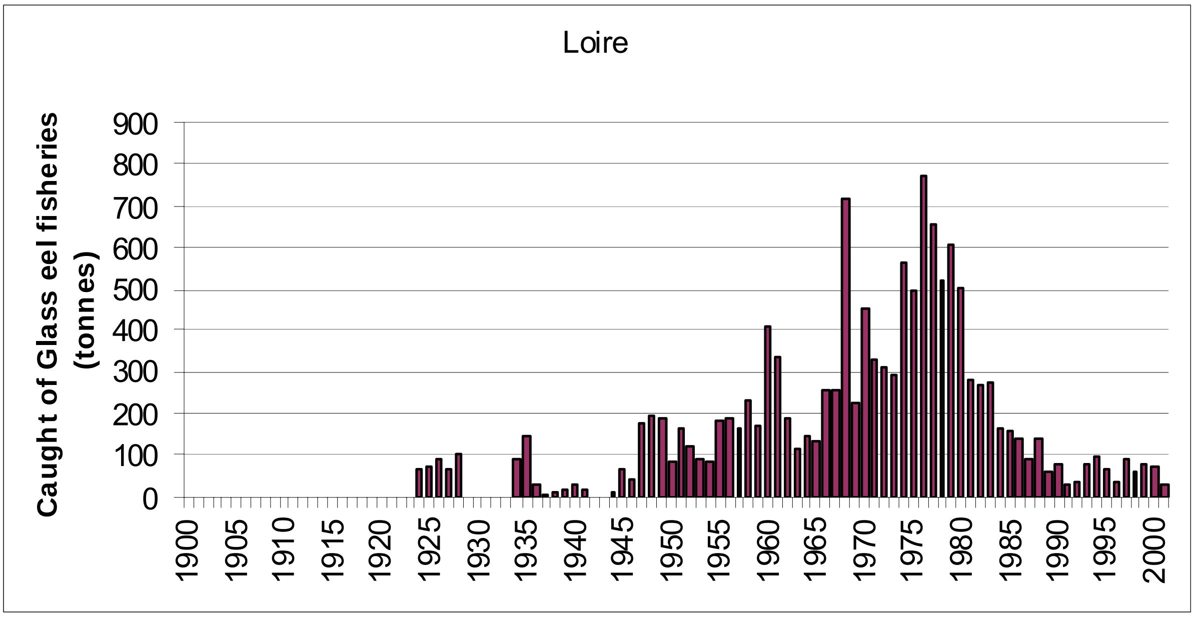

Figure Fr. 5. Time series for the Loire fishery (Source : (GUÉRAULT *et al.*, 1987)).

Table Fr. 2. Time series for the Loire fishery (* an assumption was made for catches of fluvial fishermen, not available at the moment).

DECADE	1950	1960	1970	1980	1990	2000
Season (n-1,n)						
	86	411	453	526	96	80
1	166	334	330	303	36	33
2	121	185	311	274	39	50
3	91	116	292	260	91	*60**
4	86	142	557	183	*105**	*27**
5	181	134	497	154	133	
6	187	253	770	123	81	
7	168	258	677	145	71	
8	230	712	526	177	66	
9	174	225	642	87	88	

Gironde

The following data (capture and effort) are collected by the CEMAGREF from a sample of cooperative fishermen. After a fall of the abundance of glass eel between 1981 and 1985 (considering the two most important fishing metiers) in the Gironde basin, a slight decreasing tendency appears until 2002, with an important variability between years.

Table Fr. 3. Capture of glass eel by type of gears and by category of fishermen, CPUE for the Gironde basin between 1978 and 2002.

	capture (t)					CPUE (kg/day)
	pibalour PRO	tamis PRO	tamis NON PRO	drossage PRO	Total	pibalour PRO
1977-1978	26.7	83.3	107.8		217.8	12.8
1978-1979	28.0	89.7	116.2		234.0	14.0
1979-1980	45.8	167.3	217.1		430.2	25.4
1980-1981	45.5	78.3	150.6		274.4	14.9
1981-1982	49.6	36.6	36.5		122.8	10.9
1982-1983	49.5	25.8	26.9		102.2	12.7
1983-1984	30.5	26.0	26.0		82.6	17.6
1984-1985	16.3	11.7	11.8		39.8	8.1
1985-1986	26.3	13.6	14.4		54.3	8.8
1986-1987	31.9	25.0	28.6		85.5	13.5
1987-1988	25.4	6.7	6.7		38.9	9.3
1988-1989	37.5	15.6	17.3		70.5	7.1
1989-1990	28.6	8.6	9.0		46.2	5.6
1990-1991	36.0	9.6	14.5		60.0	8.5
1991-1992	17.0	8.0	12.8		37.8	4.5
1992-1993	29.6	11.6	21.7		62.9	8.9
1993-1994	34.6	6.5	12.4		53.5	9.2
1994-1995	47.5	9.6	18.9		75.9	7.9
1995-1996	21.4	1.5	4.2	2.2	29.4	4.7
1996-1997	33.0	3.6	6.4	7.9	50.9	6.3
1997-1998	14.1	0.4	1.0	1.7	17.2	3.8
1998-1999	40.6	0.8	2.7	7.5	51.6	8.9
1999-2000	21.2	0.1	0.3	3.4	25.1	6.6
2000-2001	8.8	0.0	0.1	0.2	9.1	1.9
2001-2002	28.3	3.8	6.2	4.7	43.0	4.9

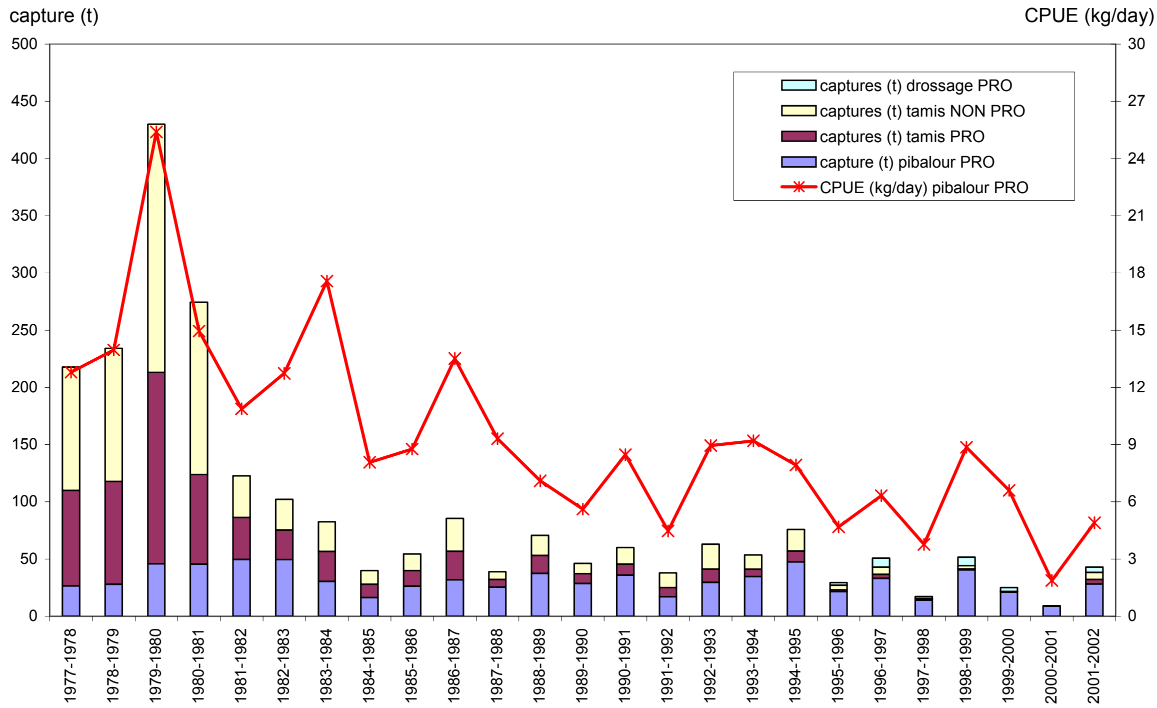

Figure Fr. 6. Capture of glass eel by type of gears and by category of fishermen, CPUE for the Gironde basin between 1978 and 2002.

The CPUE per month for the three métiers (large push net, scoop net and small push net) increased in 2002, when compared to 2001 (figure 2). The highest values are observed as usual in February for the three metiers in 2002.

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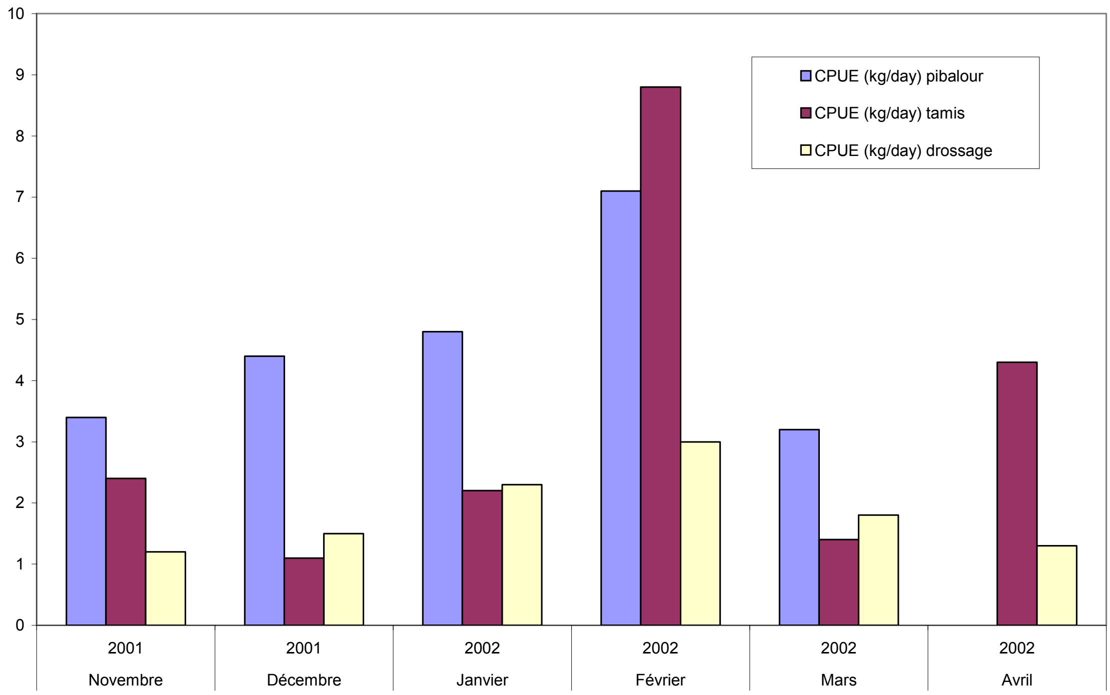

Figure Fr. 7. CPUE per month by métiers for the season 2001–2002 (year 2002) in the Gironde basin.

Adour

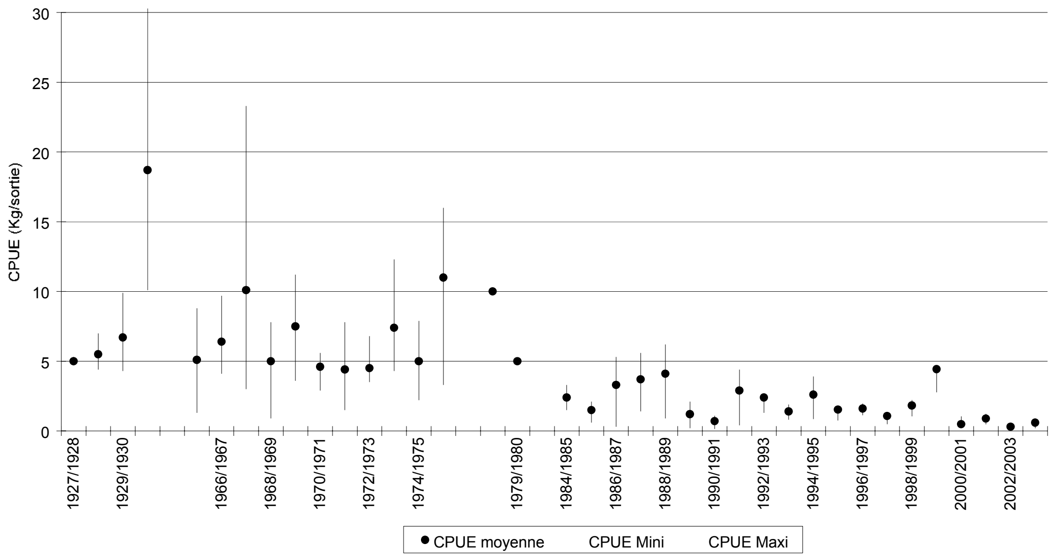

Figure Fr. 8. Variations of the glass eels CPUE from 1927 to 2004 on the Adour estuary.

The variability of the glass eel captures over the recent period (1985–2002) seems especially related to the fluctuations of hydro-climatic conditions.

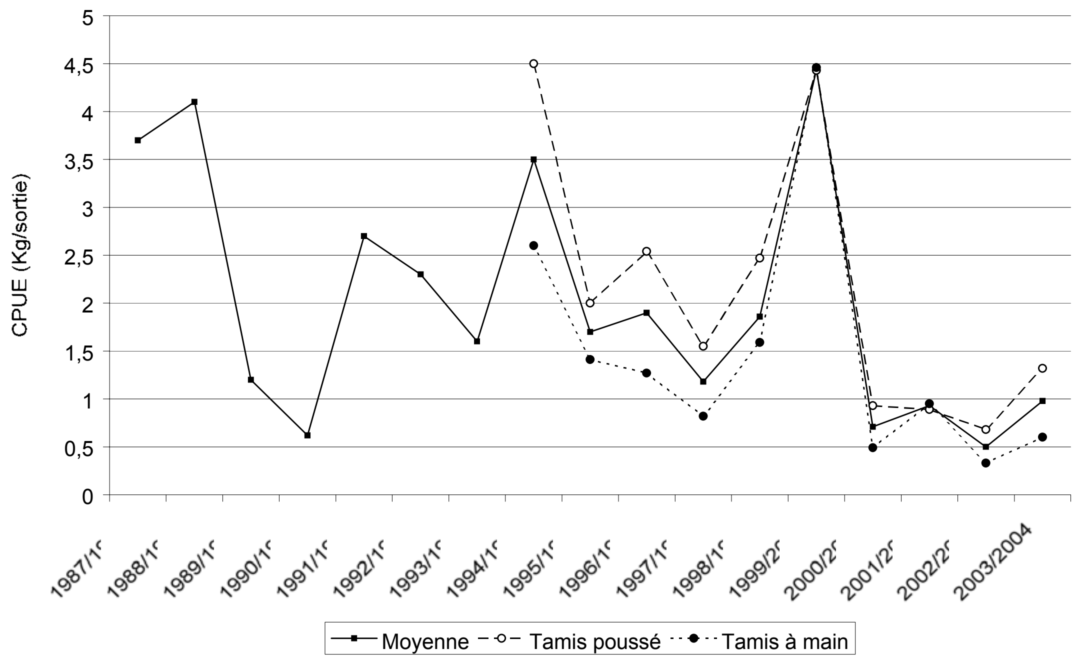

Figure Fr. 9. Variations of glass eels captures per type of fishing gears in the Adour estuary.

Table Fr. 4. Total catches for the glass eel fishery (combining pushed nets and hand nets) in the Adour estuary.

Decade / Season (n-1,n)	1970	1980	1990	2000
0			3.2	10
1			1.5	4
2			8	6
3			5.5	
4			3	
5			7.5	
6		8	4.1	
7		9.5	4.6	
8		12	1.5	
9		9	4.3	

Table Fr. 5. Mean, maximum minimum annual CPUE (Kg/trip) for the glass eel fishery (hand nets) in the Adour estuary.

Year	CPUE mean	CPUE Min	CPUE Max	Year	CPUE mean	CPUE Min	CPUE Max
1927/1928	5	4.7	5.3	1984/1985	2.4	1.5	3.3
1928/1929	5.5	4.4	7	1985/1986	1.5	0.6	2.1
1929/1930	6.7	4.3	9.9	1986/1987	3.3	0.3	5.3
1930–1931	18.7	10.1	35.2	1987/1988	3.7	1.4	5.6
				1988/1989	4.1	0.9	6.2
1965/1966	5.1	1.3	8.8	1989/1990	1.2	0.2	2.1
1966/1967	6.4	4.1	9.7	1990/1991	0.7	0.15	1.1
1967/1968	10.1	3	23.3	1991/1992	2.9	0.4	4.4
1968/1969	5	0.9	7.8	1992/1993	2.4	1.3	2.3
1969/1970	7.5	3.6	11.2	1993/1994	1.4	0.8	1.9
1970/1971	4.6	2.9	5.6	1994/1995	2.6	0.85	3.9
1971/1972	4.4	1.5	7.8	1995/1996	1.53	0.75	1.8
1972/1973	4.5	3.5	6.8	1996/1997	1.6	1.13	1.97
1973/1974	7.4	4.3	12.3	1997/1998	1.07	0.49	1.31
1974/1975	5	2.2	7.9	1998/1999	1.82	1.05	2.21
1975/1976	11	3.3	16	1999/2000	4.43	2.77	4.34
				2000/2001	0.49	0.53	1.05
1978/1979	10			2001/2002	0.89	0.48	1.23
1979/1980	5			2002/2003	0.31	0.09	0.45
				2003/2004	0.6	0.9	0.2

FR.1.2 Trend in fishery

Fisheries Information Source

The marine professional fishermen in Atlantic coastal areas, estuaries and tidal part of rivers in France are monitored from1993 by the Centre Régional de Traitement Statistiques CRTS depending from the Direction des Pêches Maritimes et de l'Aquaculture (DPMA).

No similar system exists for the marine professional fishermen fishing eel in the Mediterranean lagoons.

The river professional and amateur fishermen in rivers above marine estuaries (and in lakes) are monitored from 1999 by the CSP in the frame of the "Suivi National de la Pêche aux Engins et aux filets" (SNPE).

These two monitoring system are based on compulsory declarations of captures and effort using similar fishing forms collected monthly (Table FR 5).

Beside these obligatory systems, local scientific monitoring has been developed in the Gironde basin and the Adour basin. Data on annual captures are provided for some sectors by the local fishery administrations (Affaires Maritimes, Ddaf…).

Table Fr. 5. monitoring of eel fisheries in France.

SEA	INLAND WATERS	
Salt water	**Brackish water**	**Freshwater**
Public domain: Sea Coast	**Public domain: Estuaries**	**Public domain: part of rivers above estuaries and lakes**
Professionnal fishermen	Professionnal fishermen	Professionnal fishermen
no specific licence	Nb licenses by estuary (specific for glass eel since 1993, and for eel in 2005)	Nb licenses by river section and by lake (specific for glass eel since 1988)
logbook for sea fishing	Logbook compulsory (by day, by gear) 1993-2001 treated by CRTS	Logbook compulsory (by day, by gear) 1999-2002 treated by CSP
few oriented fishery on eel, few data available	Total landings for glass eel for the period 1993-2001, very few data for yellow eel	Local monitoring of landings and effort for the period 1978-2002, Cemagref, DDAF
Non professionnal fishermen, amateurs and anglers	Local monitoring of landings and effort for the period 1978-2002, Ifremer, Cemagref, IAV, Affaires Maritimes	Total landing and effort assessment for the period 1999-2002 (CSP, Cemagref,, CRTS)
No licence, no logbook	Ponctual estimates for glass eel, yellow eel and silver eel, France, 1986, 1989, 1999	Non professionnal fishermen, amateurs and anglers
	Total landing and effort assessment for the period 1999-2002 (CRTS, Ifremer, Cemagref, IAV, Affaires Maritimes)	Nb licenses by river section and by lake (specific for glass eel since 1988)
	Non professionnal fishermen, amateurs and anglers	Logbook compulsory (by day, by gear) 1999-2002 treated by CSP
	No licence, no logbook	Total landing and effort assessment using logbooks, 1999-2002 (CSP)
	Public domain: Mediterranean lagoons	Anglers
	Professionnal fishermen	Nb permit per departement
	Nb licenses by lagoon	No logbook
	No logbook	No precise total landing, ponctual estimates (CSP)
	No precise total landing, ponctual estimates (1983, 1998)	**Private domain: part of rivers above estuaries and lakes**
	Non professionnal fishermen, amateurs and anglers	Professionnal fishermen
	No licence, no logbook	No licence, no logbook, ponctual estimate of effort (CSP)
		Non professionnal fishermen, amateurs and anglers
		Nb permit per departement
		No logbook
		No precise total landing, ponctual estimate of effort (CSP)

Eel Fishing In Freshwater

The administration distinguishes two categories of fishermen, (1) professional (commercial) and (2) recreational (called also amateur or non-professional fishermen) who are not admitted to sell their catches. To be allowed to fish in rivers and lakes connected to the network (called free waters), each fisherman have (1) to be member of one of the registered associations for his sub-category (2) to pay a tax in relation with his sub-category.

The number of taxes since 1987, given Table Fr.6, shows a decrease of the number of fishermen for all categories and sub-categories. The professionals are really few against amateurs. Most of the amateurs are anglers even if some of them are allowed to use other fishing gears such as traps, lift-net or deep line, in limited number. When these other fishing gear users fish on the public domain, they pay a specific tax which defines them as a peculiar sub-category.

Table Fr. 6. Number of taxes paid by fishermen in freshwaters since 1987 following the category (Amateur/Professional) and the sub category (Anglers' associations, other fishing gear users on public domain). Source: CSP * in year 2000 the number of anglers with no tax is estimated to 730 000 to add at the taxpayers and the 776 professionals comprise 196 marine fishermen.

Category	Amateur			Professionnal
Sub-category /Year	Tax of Member of Anglers' associations	Tax of Member of Other fising gear users on public domain association	Total Amateur	Tax of Professionnals and Compagnon
1987	2 045 210	9 431	2 054 641	1 445
1988	1 984 024	9 573	1 993 597	1 320
1989	1 949 113	10 644	1 959 757	1 198
1990	1 875 031	11 609	1 886 640	1 125
1991	1 887 385	8 496	1 895 881	1 009
1992	1 797 179	8 121	1 805 300	910
1993	1 765 562	8 263	1 773 825	859
1994	1 694 100	7 975	1 702 075	817
1995	1 569 670	8 056	1 577 726	815
1996	1 483 147	7 859	1 491 006	815
1997	1 403 174	7 604	1 410 778	819
1998	1 366 941	7 368	1 374 309	792
1999	1 337 264	7 291	1 344 555	770
2000*	1 262 735	6 855	1 269 590	776
2001	1 228 190	6 807	1 234 997	750
2002	1 212 523	6 565	1 219 088	710
2003	1 205 394	6 753	1 212 147	708

The fishing methods have not change since last report. No new assessment of the number of fishermen targeting eel since year 2000, but it is surely decreasing.

It is possible to follow the recent decrease in the number of fishermen targeting glass eel by counting the specific tax they have to pay (Tables Fr 7 and Fr 8).

Table Fr. 7. Number of specific taxes paid for glass eel by amateur using small hand scoop nets in freshwaters since 1987. (Source: CSP)

DECADE Season (n-1,n)	1980	1990	2000
0		716	425
1		589	390
2		499	355
3		606	334
4		550	
5		646	
6		648	
7	605	657	
8	764	674	
9	696	541	

Table Fr. 8. Number of specific taxes paid for glass eel by professional using scoop nets in freshwaters since 1987. (Source: CSP)

DECADE Season (n-1,n)	1980	1990	2000
0		611	432
1		637	413
2		438	399
3		273	378
4		422	
5		445	
6		446	
7	547	457	
8	697	448	
9	770	430	

The delivery of the specific authorization to fish silver eel is no longer admitted to private fisheries since 2003[1].

A national logbook database for professionals and amateurs fishing gear users (called SNPE) is managed since 1999 by CSP. It has a mean return rate of 70% for professionals and 50% for amateurs.

EEL FISHING IN MARINE WATERS AND ESTUARIES

Glass eel fishery in France is limited to the estuaries (brackish water) and to the lower part of rivers under tide effect (freshwater). In 1999 the production of glass eels was estimated at 255 tons, with a turnover of 35.2 millions euros in the whole French basins (Table Fr. 9). The historical analysis of the series of captures concerning the principal catchment areas of the Atlantic coast highlights a fall of the glass eel productions starting in the eighties. The geographical

1 Décret 2002-965 du 02/07/02

variation in the number of licences was detailed in last year report. The total number of licences in France is limited to 1137.

Table Fr. 9. Estimation of the total glass eel production and the number of fishermen in France from 1970 to 2000 [2]

ANNEE	1970	1979	1986	1989	1999	2000
Production MP (t)	450	1175		300	225	180
Production PF and river non-pro f(t)	895	675		110	30	16,6
Total Production (t)	1345	1850	500	520 (3)	255	196,6
Mean price /Kg (€)	2,75	5,65		61	138	120
Total value (M€)	2,74	10,44	12,5	30,5		
Number MP(1)	648	964	850	886	936	970 (4)
Number PF and river non-professionals	2424	2588	4000(2)	1512	761	671
Number marine non-pro f				2055	109	
Origin of the data	Popelin (1971)	CIPE (1982)	Desaunay et Aubrun (1988)	Castelnaud *et al* (1989)	Castelnaud (2002) Castelnaud *et al* (2003)	Castelnaud *et al* (2003)

Yellow and silver eel fisheries in France are almost concentrated in estuaries and lagoon (brackish water) and in the lower part of rivers. The production of yellow and silver eels in French rivers including estuaries has been evaluated at 302 t in 1999, with a value of 3 millions euros (Castelnaud, 2000); 220 river professional fishermen and 110 marine fishermen are involved (a large part is also fishing glass eels). Around 500 marine professional fishermen harvest 900 t of yellow eels in the whole Mediterranean coastal lagoon, including Corsica, in 1999, with a value of 5.4 millions euros.

- *Yield data series. If in kg/ha, then add total yield in tons, at least a country total.*

Three institutes (CEMAGREF, CSP and CRTS) have compiled and analysed the statistical data collection for France coming from the different sources for the years 1999, 2000 and 2001. The results for these years are just an addition of the catch reporting, without corrections.

Also, because of the gaps and under-evaluated figures found in the FAO data base for the previous period, a more realistic series for eel was built in France, by biological stages (glass eel, yellow+ silver eel) and sectors. We have used the annual results produced by the punctual scientific investigations (see Table 9 for the years available) and for the others years, we have extrapolated the results obtained in the main basins monitored (the Adour, the Gironde, the Loire and the Vilaine). This work leads to the following data (Table Fr. 10):

- glass eel in inland waters, 1978–2001;
- yellow + silver eel in inland waters, 1986–2001 and in Mediterranean lagoons, 1983–2001.

2 (1) unknown number of marine non-professional fishermen to be added (for 1986, see 2)
(2) marine non-professional fishermen included
(3) comprising 110 t from marine non-professional fishermen
(4) number of licence delivered

The comparison between these corrected data for eel (all stages) in France and the data registered by FAO is given in the following table.

Table Fr. 10. Estimation of capture of glass eel and yellow eel (except rare case, there is no silver eel fishery) in France and comparison with FAO database (Fishstat).

stage	glass eel	yellow eel (+silver)	yellow eel (+silver)	yellow eel (+silver)	all stages	all stages
area	inland water	inland water	mediterranean lagoons	France	France	France - FAO
1978	2 131					
1979	2 547					
1980	2 970					
1981	1 871					
1982	1 135					
1983	969		1 700			
1984	706		1 810			
1985	516		1 501			
1986	518	720	1 224	1 944	2 462	2 687
1987	658	700	1 362	2 062	2 720	1 978
1988	551	700	1 565	2 265	2 816	2 109
1989	520	440	1 306	1 746	2 266	1 672
1990	392	380	1 398	1 778	2 170	1 674
1991	280	380	1 265	1 645	1 925	1 450
1992	264	380	941	1 321	1 585	1 164
1993	456	380	900	1 280	1 736	864
1994	414	380	900	1 280	1 694	607
1995	552	380	900	1 280	1 832	320
1996	282	380	900	1 280	1 562	403
1997	314	323	900	1 223	1 537	1 782
1998	195	250	900	1 150	1 345	449
1999	248	105	900	1 005	1 253	289
2000	214	86	900	986	1 200	399
2001	101	102	900	1 002	1 103	415

A more detailed geographical result is available for the SNPE base (freshwater part). Data for the marine fisheries are not included (Table Fr 11).

Table Fr. 11. Mean annual estimate of landings for eel by freshwater fishermen from 1999 to 2002. (Source: SNPE-CSP).

	Amateur			Professionnel			
Catchement sector\Weigth (kg)	Eel (mostly yellow)	Glass eel	Total Amateur	Siver eel	Eel (yellow and silver)	Glass eel	Total Professional
Rhin	311	-	311	-	2 311	-	2 311
Seine et Somme	-	-	-	-	654	-	654
Vilaine	2 682	2	2 684	-	518	-	518
Loire amont et Allier	159	-	159		12	-	12
Loire moyenne	13 825	48	13 873	3 085	4 620	111	7 816
Loire aval	12 285	44	12 329	11 310	22 189	1 045	34 544
Loire estuaire	3 574	260	3 834	-	1 680	6 720	8 400
Fleuves vendéens	2 304	3	2 307		211	-	211
Charentes	2 076	-	2 076	-	3 049	487	3 536
Garonne amont	761	-	761		1 409	-	1 409
Garonne aval	345	-	345		845	-	845
Estuaires girondins	3 264	229	3 493	-	5 086	4 077	9 163
Dordogne amont	979	-	979	-	1 191	-	1 191
Dordogne aval	727	-	727	-	1 758	-	1 758
Isle amont	98	-	98		-		-
Adour	1 081	375	1 457	-	1 350	9 934	11 283
Rhône amont	195	-	195	-	3	-	3
Rhône aval	179	-	179	-	7 275	-	7 275
Rhône deltaïque	38	-	38	-	9 239	-	9 239
Saône amont	28	-	28	-	14	-	14
Saône aval	67	-	67	-	137	-	137
Doubs	61	-	61	-	23	-	23
Lac du Bourget	317	-	317		8	-	8
Lac Léman	-	-	-		-	-	-
Lac d'Annecy	-	-	-		-	-	-
Total	45 358	962	46 320	14 395	63 580	22 374	100 349

- *Is there information on the impact of this fishery on the stock? Does that provide information by year? If so, report in detail.*

There is only sparse information on the impact of fisheries on glass eel escapement (BRIAND *et al.*, 2003) and (PROUZET, 2002), but a research project is being developed in the Loire and Isle (Gironde) and continued in the Adour, as part of the INDINCANG project. The only significant silver eel fishery is in the Loire and has been evaluated by marking recapture (Boury and Feunteun, unpublished). Several yellow eel fisheries have been studied or are under study and are located in the Gironde (Beaulaton and Castelnaud, unpublished), the Adour (Prouzet unpublished), the Golfe du Morbihan (SAUVAGET *et al.*, 2001), the Loire estuary and the Vilaine estuary (SCHAAN, 1993)). The only full analytical work were conducted on the Grand Lieu lake (ADAM, 1997), and one work is conducted on the Mediterranean Vacaresse Lagoon (Crivelli, unpublished). Work is also conducted within the INDICANG project to provide quantitative information of habitat related mortalities (PROUZET, 2004).

- *If more than one data series is available, present each separately, and country-wise totals.*

Captures, abundance and Seasonality for Yellow eel are recorded on the Yellow fishery of the Gironde basin. The total effort, the total captures and the CPUE have fallen between 1988 and 1989. While the total captures and the total effort have continued to decrease, the CPUE became more or less stable. However, they do not reflect the reality because there was a change in the effort which was not integrated by our effort unit. The number of fishermen has decreased a lot, but those have changed their fishing tactic, moving more on the fishing territory and developing larger real effort.

Table Fr. 12. Captures of yellow eel with pots by category of fishermen and CPUE for the Gironde basin between 1978 and 2002.

	Captures totales (t)			CPUE
	PRO	non PRO	**total**	(kg/pot/month)
1978	**195.5**	204.1	399.6	
1979	**241.3**	229.5	470.8	
1980	**181.4**	155.7	337.1	
1981	**187.8**	148.8	336.6	
1982	**157.9**	133.1	291.0	
1983	**71.8**	76.2	148.1	
1984	**103.8**	164.1	267.9	
1985	**106.0**	170.3	276.3	
1986	**124.5**	160.5	285.0	
1987	**94.8**	134.3	229.1	**1.9**
1988	**102.3**	97.7	200.0	**1.9**
1989	**67.1**	40.2	107.3	**0.9**
1990	**47.1**	28.3	75.4	**0.8**
1991	**26.3**	15.8	42.1	**1.2**
1992	**46.1**	27.7	73.7	**1.1**
1993	**35.7**	21.4	57.1	**0.9**
1994	**35.2**	21.1	56.4	**1.0**
1995	**36.9**	18.4	55.3	**1.3**
1996	**25.7**	7.7	33.4	**1.1**
1997	**32.2**	9.7	41.8	**1.5**
1998	**24.4**	7.3	31.7	**1.5**
1999	**21.8**	1.5	23.3	**1.1**
2000	**20.0**	1.4	21.4	**1.1**
2001	**18.0**	0.6	18.6	**1.2**
2002	**13.1**	1.1	14.1	**1.0**

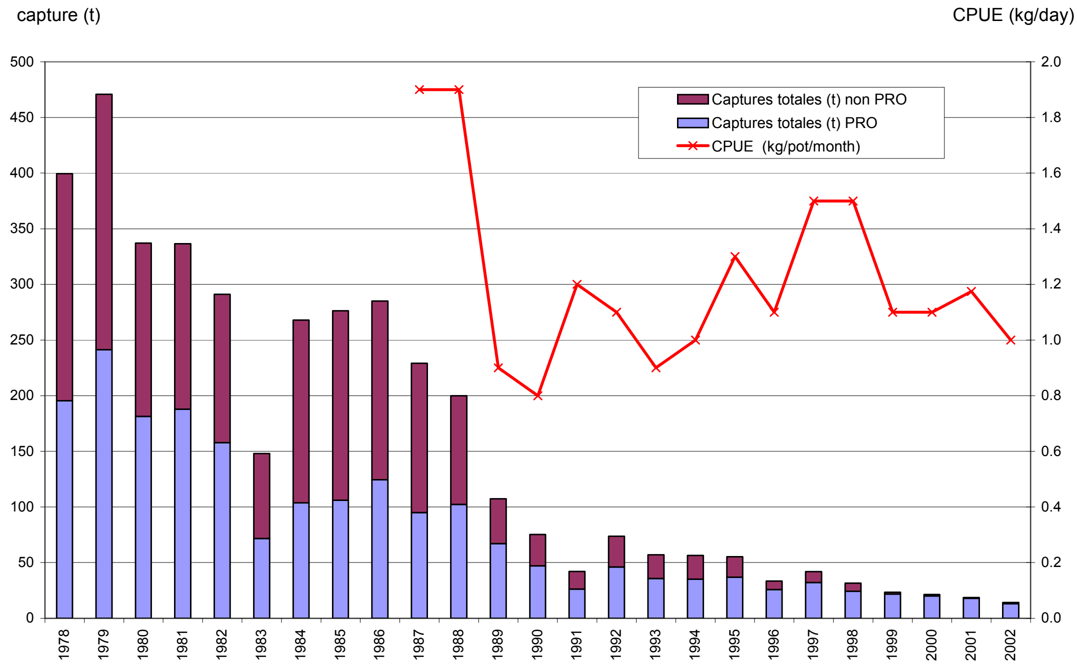

Figure Fr. 10. Captures of yellow eel with pots by category of fishermen and CPUE for the Gironde basin between 1978 and 2002.

In 2002, the highest values of CPUE are observed in the Garonne part, while traditionally, they occur in the estuarine part (Figure Fr 11). The catches peak in May in the estuary, in June and October on the Garonne River and in July on the Dordogne River.

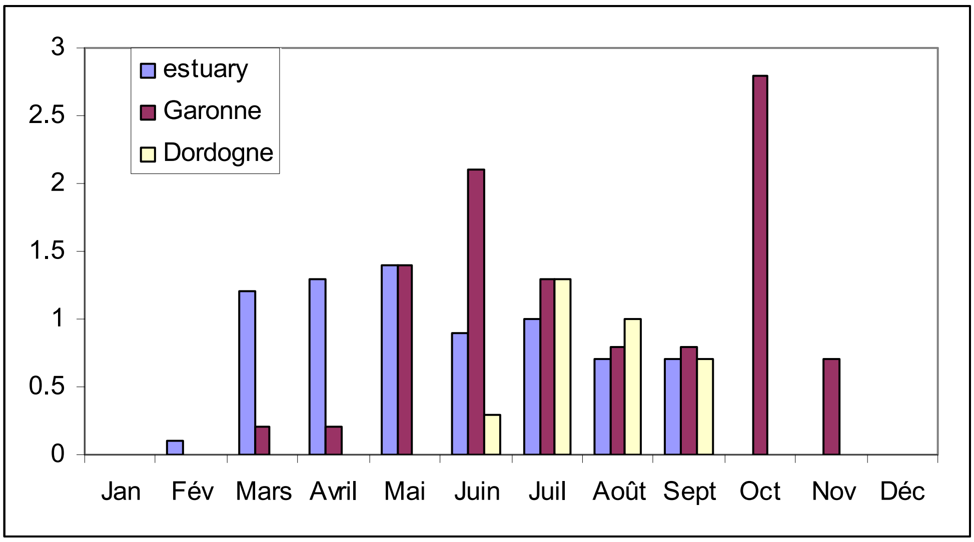

Figure Fr. 11. CPUE (kg/day) per month and by area in the Gironde basin in 2002.

- *If more than one data series is available, present each separately, and country-wise totals.*
- *Describe recent development in fisheries, market, etc.*

FR.1.3 Trend in the stock

- *What is monitored: life stage, what gear, length composition, etc.?*

The only trend concerning the stock is provided by the glass eel recruitment series.

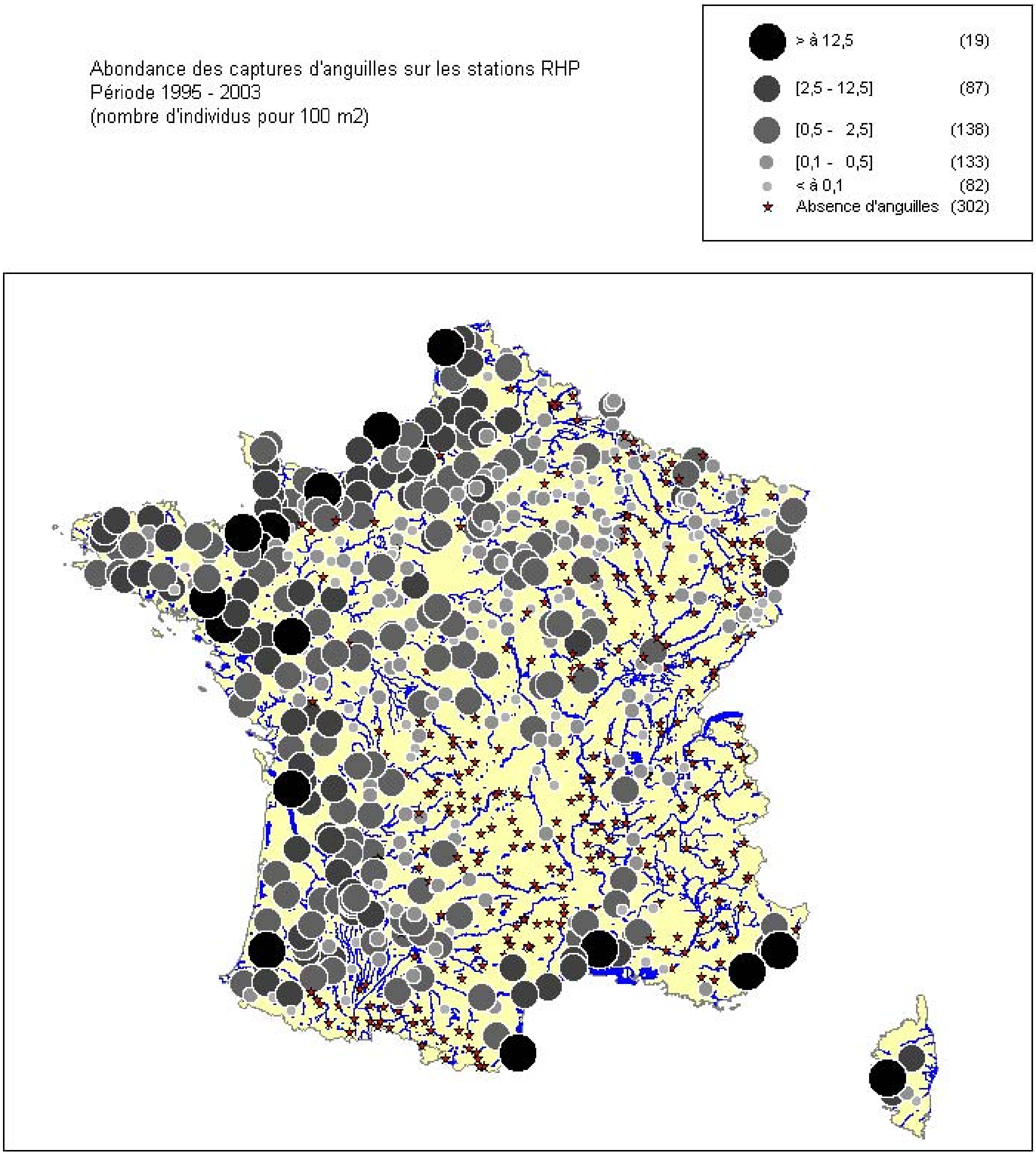

Figure Fr. 12. Trend in standing stock is provided by the yearly electrofishing survey of the of 761 annual RHP electrofishing stations, mean value from 1995 to 2003.

Several trends in standing stock were provided in last year report, figure Fr. 12 provides an overview of annual RHP electrofishing in France.

- *Tabular data and graph, one record per year, for all years (see comment above)*

FR.1.4 Trend in re-stocking

- *What life stage is re-stocked: glass eel, bootlace, larger (specify)?*

No restocking recorded at the central level

- *What is the origin of the re-stocking material (national or international?)*
- *Time series (one record per year) of quantities.*

- *If more than one series (areas) exist, present each, and country-wise totals.*

FR.1.5 Trend in aquaculture

Comment: why do we include aquaculture? It is relevant for the production, the market, but not for the natural population. Include, just for the sake of completeness? If not very much work, that is acceptable.

- *Describe type of aquaculture (indoor, outdoor, local seed stock, international, linked and mixed with fishery?*
- *Number of plants (do you have any information on this?*
- *Total annual production, time series, table and graph. Or broken down in sensible categories, if possible.*

FR.2 Research

To report on the ongoing research, a meeting was held by the French GRISAM group. It resulted in a working paper provided during the Working group

FR.3 Management

- *Is there a national management plan for eel?*

Regional plans at the district scale

- *Major contents.*

See last year report

- *Is it in prep, accepted, implemented, running*

Regional management plans are under revision

- *What is managed: effort, yield, what else?*

Effort and habitat

- *Is a formal target defined?*

No

- *Is compliance and efficacy monitored?*

No, but monitored at the catchment scale

- *Is that target conforming to the required silver eel escapement of at least 30% of unexploited pristine state, the 30% SPR rule?*

No target set for the moment, but it could be included rapidly if it was provided at the EU level in the frame of a restoration plan

- *What is missing in national management plan?*

Central coordination of regional management structure, itself waiting an EU restoration plan, and a clear setting of targets

- *What management measures are currently in effect, inside or outside scope of a formal management plan?*

See last years report.

- *Is there progress in getting a management system up and running?*

Possibly at the regional level, we must await for the management plans under revision

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ES – Report on eel stock and fishery in the Basque Country, in 2004

Country: Spain, Basque Region
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Reporting date and last reported year: August 2004, most data through 2003 / 2004

ES.1 Data

ES.1.1 Trend in recruitment

There is no data in recruitment from last years, due to the inexistence of any managing plan for eels. Nowadays, it is implementing a sampling station which will give an abundance index independent from fisheries. This sampling station will be located in the main glass eel fisheries river in the Basque region, the Oria river, which supports an important fishing effort during the fishing season (October – March). The recruitment will be studied during all over the year to obtain the total recruitment of eel to the Basque rivers in and out the fishing period.

ES.1.2 Trend in fishery

- Life stage concerned: glass eel.
- Describe fisheries, information source, area, gear type, etc.

The glass eel fishery is a very traditional fishery in the Basque Country which affects to zones associated to river mouths, including beaches, estuaries and river banks. Glass eel fishery is located in most of the river basins of Gipuzkoa and Bizkaia and the main river basins for this fishery are Bidasoa, Oiarzun, Urumea, Oria, Urola, Deba, Artibai, Lea, Oka, Butrón and Ibaizabal.

The fishing season is opened from the new moon of October to the new moon of March. It is a night fishing, taking into account that glass eels are more active at night and that they swim in the water column or near the surface. During the day, the glass eels are inside the sediments and they don't move, making the fishing activity more difficult. The local environmental and atmospheric conditions have an important influence in the catchability. That is why several fishermen of some rivers fish during the rainy days in the mouth of the tides, where seawater and fresh water are mixed, whereas in other rivers fishermen fish in new moon nights, from three hours before to three hours after the high tide.

The fishing gears employed by the Basque fishermen are mainly handmade and specific to glass eels, which are fished from the river banks or from small ships. The main fishing gear is the traditional sieve (*cedazo* or *baia*) which can be round or square with a fine wire or plastic mesh and a wooden handle.

The sieve's diameter varies from 60 cm to 140 cm. This fishing gear is very selective even its small mesh size (2 mm) and the only fish captured is the glass eel.

The sieves are used in many different ways to fish glass eels:

- From the boat- This fishery is done from a small boat with 1, 2 or 3 fishermen. Two round or rectangular sieves are put in both sides of the boat and the boat advances by motor power. Regularly, the sieves are removed to take the captured glass eels. The fishing depth varies but normally it is in surface waters, although in Orio River occasionally the use four meters long handles to fish in depth waters. The glass eel catches are limited to the water column, since the sieves will break in contact with the ground.

- From de bank- Round sieves are used in the river mouth areas during glass eel upstream migration moments (mainly in incoming tides). Generally, in intertidal zones there are no many places to fish because the banks ground is too smooth. There are traditional places for this fishing type, where the access is good and the glass eels are next to the edge of the river. Traditionally, the surroundings areas boss is the one who has preference for the fishing place. This is the most traditional fishing type, easily use by occasional fishermen or fishermen with limited economical resources.
- In the waves- A traditional method which is practiced in beaches next to the river mouths. It is not a common fishing method nowadays; since it needs a good training and knowledge of the technique and the glass eels behaviour. The fishing activity takes place at night and the fishermen go to the beaches searching zones where waves converge regularly and accumulate glass eels before they go into continental water courses. The catch is done by a circular or rectangular sieve hold by hand.
- Wall trawling- This fishing type is used from walls next to canalized rivers to which the access is easy and where the fishing can be done walking along the wall and holding a sieve provided by ropes and lines trawling it in the water surface generally in the opposite direction of the current.

There are another different fishing gear employed for glass eel fishing in the Basque Country:

- *Hoe (Azada or Atxus)*- The fishing with hoe takes place during the day, catching the glass eels in the ground, digging up the sand and mud by a hoe. The effectiveness is very low and normally the glass eels captured are used for bait in sea bass fishing.
- *Fyke nets (Butrones)*- Funnel shaped fixed nets positioned on the river bed where glass eel migration occur. The nets are fixed and they spend the day in the river bed leaving an opened side the cod-end to avoid possible fish catches. During the nights, with incoming tide the cod-end is closed catching all the fishes passing though the net. Depending on its size, the fyke nets can take smaller or larger part of the river bed, arriving, in the worst case to block the all river bed. This fishing gear is banned by the Glass Eel Fishery Regulation issued in March 2003.
- *Effort and Yield*

Glass eel fishermen

The number of fishermen has decline during the last three decades, following the decline of the recruitment. As there is no any fishermen list since this year, there is no way to determine this decline in fishermen population but the oldest ones comment that since 70ies the decline is important. Nevertheless, there are some catches data from a boat fisherman which show the turning down between 1996 and 2004 (Figure 1).

It seems that this decline has conditioned fishermen activity, giving up their activity in some cases, or reducing the fishing nights in those who still keep fishing since the catches are lower.

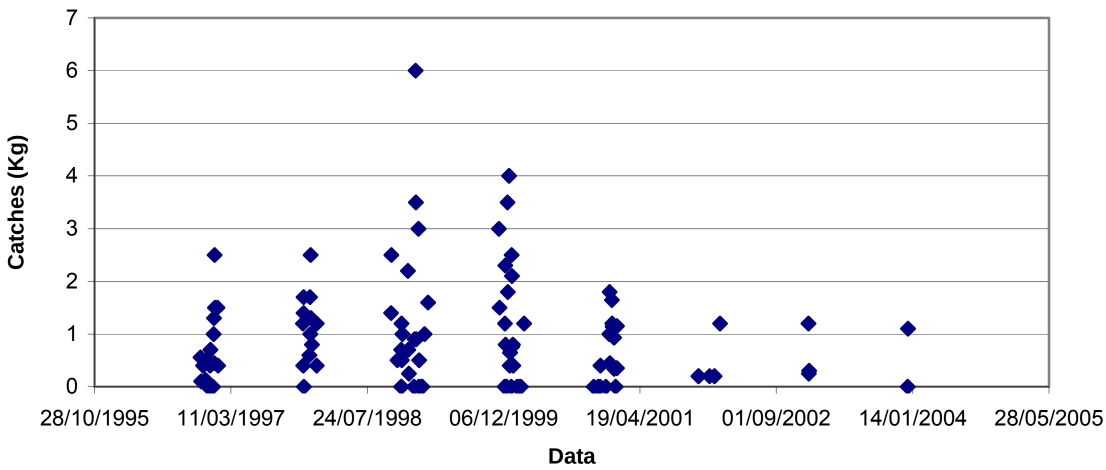

Figure 1: Glass eel diary catches of a boat fisherman from 1996 to 2004.

Nowadays, the fishermen spend some time of their work fishing but as a secondary or occasionally activity. Due to the seasonality of catches (November – March), the important environmental influence and the recent catches decline, it seems that there are few people who are full time for glass eel fishing or this is their principal economical source (if they are not temporally unemployed). There are fishermen that fish only once or twice per year, whereas others fish every suitable night during the fishing season (depending on the moon phase, pluviosity, tides, etc.).

Glass eel sale can be an important complementary income for the fishermen, as the high prices showed in the market. The price paid to a fisherman last season varied from 100 to 300 €/Kg. The sale is directly done to glass eel enterprise located in Aguinaga or to restaurants, wholesalers or particular clients by phone. This hidden market might be the reason why many fishermen keep on fishing

The traditional classification of fishermen as “non-professional” and “professional” is not useful for the Basque Country glass eel fishery. First, most of the fishermen sell their catches. In a second place, professional fishermen at sea, fish glass eel as a supplementary activity, during the winter nights at harbour and using a small “recreational” boat. Besides, the catches are commercialized out of the fish market, so as the other fishermen that blend this nocturnal activity with their principal job. For this reason, is necessary to admit the presence of glass eel fishermen who carry this secondary activity to their job, usually in order to obtain complementary incomes selling their catches.

Nowadays there is an amount of 573 fishermen collaborating in the new licences system. Last fishing season 2003/2004, 1187 fishing licences were issued and 564 have been received in the local fisheries administration (Table 1). This is a good result taking into account that this is the first time this traditional fishery has been touched by a licences system and a fishing law. Most of the fishermen associations were taking part of the legislation process and this year, after the season there have been several meetings to propose changes to the new system in order to adequate it to fishermen requirements.

Table 1. Number of glass eel fishing licences in 2003 / 2004. season.

River basin	Licences to fish from land		Licences to fish from boat	
	Issued	Received	Issued	Received
Artibai	14	7	0	0
Barbadun	49	13	0	0
Bidasoa	1	1	0	0
Butrón	387	138	18	2
Deba	211	118	0	0
Ibaizabal	211	88	4	0
Lea	73	18	2	1
Oka	33	11	0	0
Oria	188	99	45	43
Urola	20	14	41	20
Total	1187	507	110	66

Figure 2 shows the amount of fishermen in each river basin using one fishing type for glass eels. The sieve used for land is the most used fishing gear in mostly all the river basins, The Urola is the one who doesn't have any important fishery from land. The land trawling is one of the most important types in Deba, and the Butron River is the one who has wave fishing type and land trawling together with the sieve one.

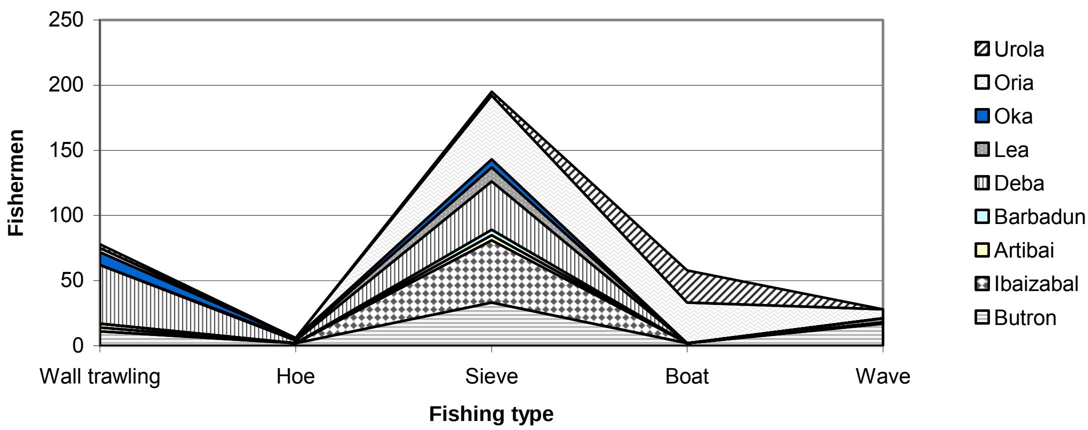

Figure 2: Glass eel fishermen per river basin and fishing type during the 2003/2004 fishing season.

The total glass eel catch for last season is 830 kg from more than the 50% is caught by boat fishery, since the Oria and the Urola are the rivers with an important boat fishery they are the most important from catches point of view taking 56 boats activity (Table 1). On the other side, land fishermen are more important in number and their catches are in a 75% from sieve type and in a 16% from land trawling type, being the hoe and wave fishing less important from the point of view of fishermen and of catches (Table 2; Figure 3).

Table 2. Glass eel catches in each river basin using different fishing types. 2003/2004.

2003 / 2004		Fishing type					
Catches (kg)		Land trawling	Hoe	Sieve	Boat	Wave	Total
River Basin	Butron	2,162	0,097	32,556	6,520	28,027	69,362
	Ibaizabal	1,860	0,000	92,392	0,000	0,200	94,452
	Artibai	2,540	0,000	1,985	0,000	0,000	4,525
	Barbadun	0,000	0,000	2,196	0,000	0,000	2,196
	Deba	54,885	1,710	102,344	0,000	0,000	158,939
	Lea	0,000	0,355	5,992	0,000	3,530	9,877
	Oka	0,000	0,900	4,690	0,000	0,000	5,590
	Oria	2,083	0,000	62,128	321,050	6,127	391,388
	Urola	2,29	0,000	2,3	88,995	0,000	93,585
	Total	65,820	3,062	306,583	416,565	37,884	829,914

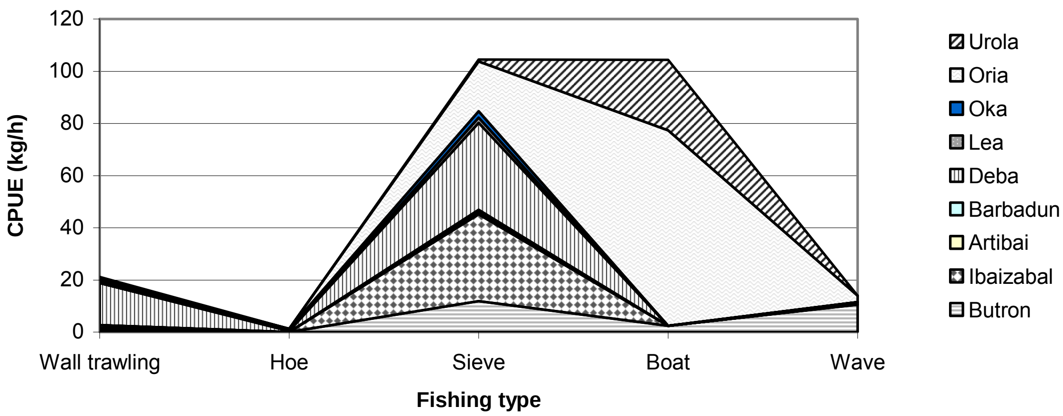

Figure 3: Glass eel CPUEs per river basin and fishing type during the 2003/2004 fishing season.

The affluence of fishermen to the river basins is increasing from October to January with 277 fishermen, and decreasing till the end of the fishing season (Figure 2). The land fishing types, from a river edge point, wall trawling or wave fishing involve most of the fishermen, being the first one the most important in number of fishermen and the others very residuals. More than 50 boats are involved in the fishery during the three central months of the season.

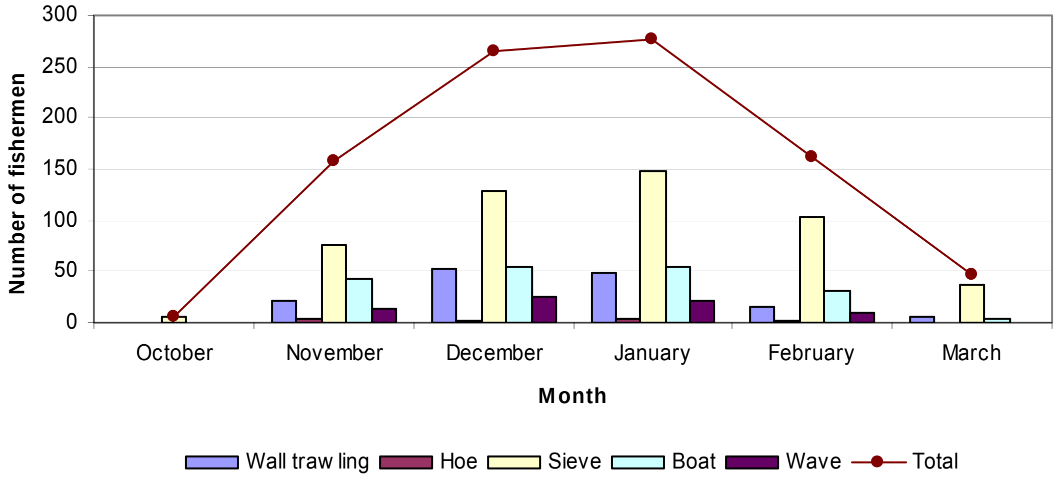

Figure 2: Number of fishermen for fishing type during the 2003 /2004 fishing season.

The time employed by a fisherman in glass eels fishing activity has a different development in each fishing type (Figure 3). For example, the wall trawling takes more than 4 hours per month in November, January and February, more than 3 hours in December and less than 1 hour in March. The fishing by hoe is the most variable among months, being 1 hour in December and 5 hours in January.

In this way, the wall trawling fish takes less than 5 hours per month during the season whereas the wave fishing are only distributed between November and January, with a very variable fishing time during these months, from 1 hour to 5 hours per month. The sieve fishing appears every month with such an important fishing time with an increasing development till February, not being upper than 5 hours in all the season. Boat fishing time is above all continuous from November to March, with about 4 hours per month. The wave fishing takes generally less than 3 hours per month except in January when the activity is longer.

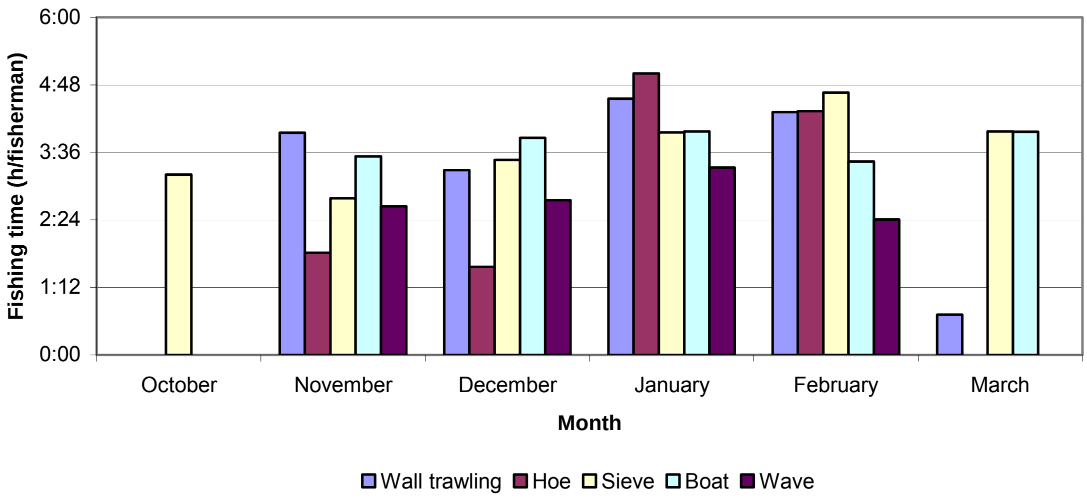

Figure 3: Fishing time employed per fisherman of each fishing type during the 2003 / 2004 Fishing season.

Looking at the catches obtained per fisherman it is clearly seen that boat fishermen are the ones who get the largest catches, arriving to 3.5 kg in December (Figure 4). There is a large difference among fishing types and months. The boat fishery is the most important in catches and the most variable among months. The other fishing types are considerably lower in catches, from 100 grs to 600 grs per month. The principal catches are the one from December, and they decrease along the final months of the fishing season.

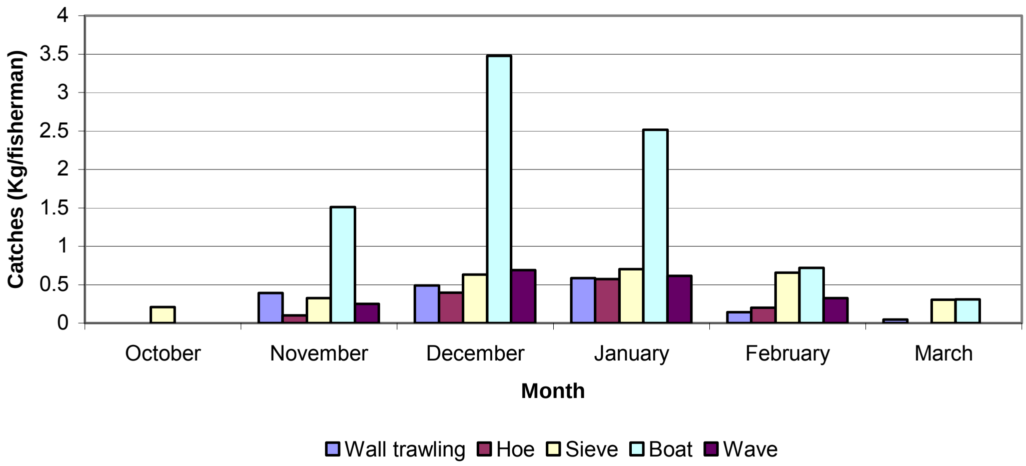

Figure 4: Catches per fisherman of each fishing type during the 2003/2004 Fishing season.

The efficiency of different fishing types, the obtained catches per fishing hour have a different development from the catches per month (Figure 4). In this case, the most efficient month for boat fishery is November, with 170 grs per hour per boat fisherman, and this value slides along the season. The other fishing modalities are less efficient and their main value is the one got in December as showed in catches data series above.

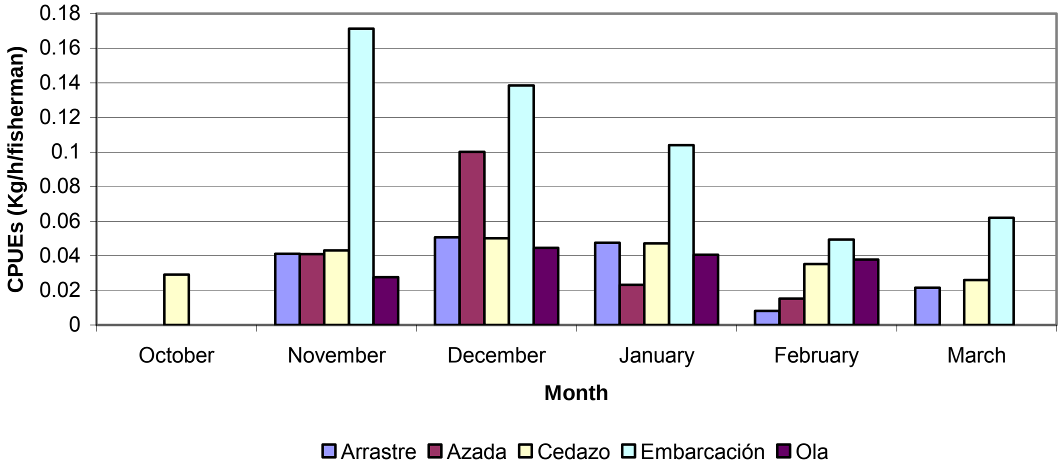

Figure 5: Catches per hour per fisherman of each fishing type during the 2003 / 2004 Fishing season.

ES.1.3 Trend in the stock

European eel stock situation

Recruitment: glass eel.

- *Fishery*

Data from the glass eel fishery are used to know the recruitment per river basin or in total. Figure 6 shows the total catch per month during last fishing season with a main point in December catching more than 40% of the total glass eel of the season. Nevertheless, there is in the central months where most of the recruitment occurs, whereas during October and March there are residual catches.

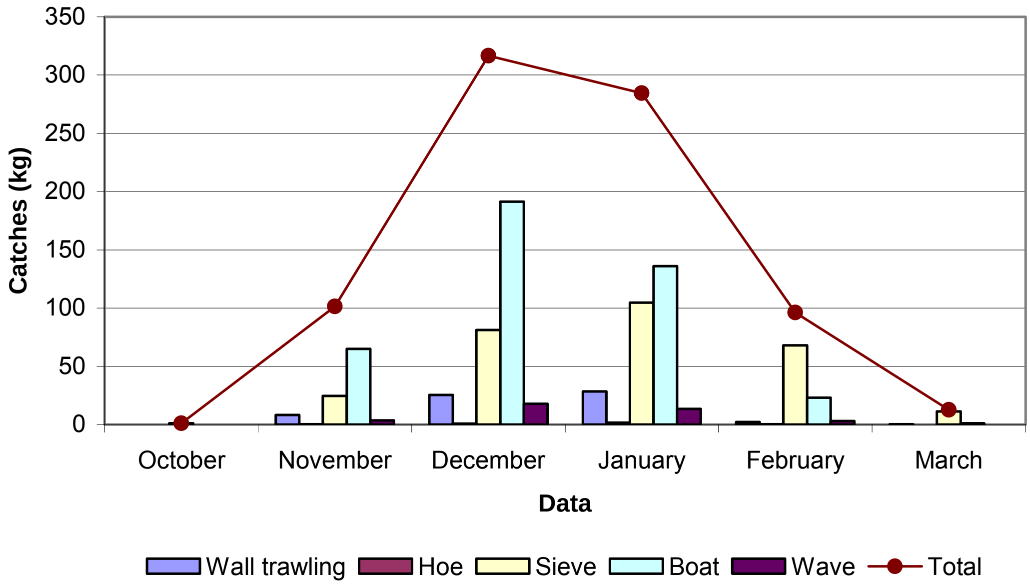

Figure 6: Glass eel catches per month in the Basque river basins during the 2003 / 2004 fishing season.

The diary recruitment shows there is a possible relation-ship between the recruitment and glass eels' photophobic behaviour described above (Figure 7). It seems that the new moon nights with poor visibility correspond to the main recruitment nights in the season.

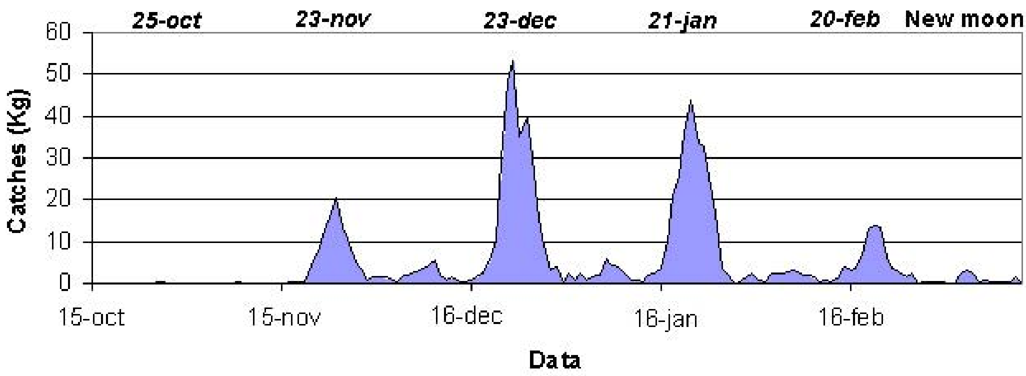

Figure 7: Capturas de angula / día en la cuenca del Oria durante la temporada 2003/2004.

- *The glass eel monitoring: sampling station in the Oria River basin.*

The glass eel sampling station will be located 11 km from the Oria River mouth, 2 km up-stream the tide border where there is already a station for Salmonids monitoring (Figure 7).

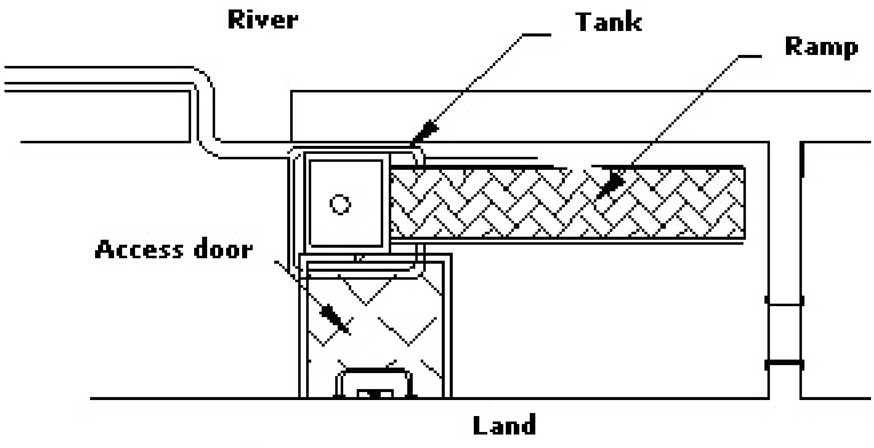

Figure 7: Glass eel sampling station diagram.

The Oria River basin has a length of about 77 km. The area of the basin is 888 km^2. The mean river flow is 26 $m^3\ s^{-1}$. This basin was selected mainly because of its large glass eel fishing tradition, the presence of some infrastructures for sampling of fish populations and the extensive information available on environmental parameters.

The fishery is quite important in the Oria River basin; most of the catches are fished by boats which are allowed to fish from the river mouth to 9 km upstream (the Aguinaga Bridge).

The yellow and silver eels monitoring: sampling by electro-fishing in the Oria River basin.

There is an annual electrofishing sampling among all river basins and particularly in the Oria river the samplings will be specific for eels. This is the first year these sampling are carrying on and the data is still in preparation. Nervertheless, we can see that,...... EKOLUR

- *What is monitored: life stage, what gear, length composition, etc.*
- *Tabular data and graph, one record per year, for all years (see comment above)*

ES.2 Management

In 2001 the Basque Government started to develop the glass eel fishery monitoring plan. First of all, the Basque Government and the fishermen associations in collaboration with fisheries technicians studied the problem of glass eel fishery in the region and decide to elaborate a Fishery Regulation to solve these social problems. From this regulation issued in March 2003, a new licence system started within a mandatory catch report for each fisherman. Last season an amount of 1297 licences were issued, 1187 land fishing and 110 boats fishing.

In 2004 a European project started to develop a monitoring programme on eels and there is planned to get an abundance index for recruitment, colonisation and escapement and its relationship with environmental factors.

PT – Report on eel stock and fishery in Portugal in 2004

Country: Portugal
Author: Carlos Antunes
Author address: Rua dos Bragas, 289 4050–123 Porto, cantunes@cimar.org
Reporting date and last reported year: September 2004 and *in* Dekker 2002

PT.1 Data

PT.1.1 Trend in recruitment

Recruitment monitoring of glass eels takes place in the international Minho River, since 1974, based in professional fishermen data. Additionally scientific sampling is done since 1981. In rivers other than the Minho the glass eels are captured using illegal nets.

year	P(T)	SP(T)	total(T)
1974	0,05	1,6	1,65
1975	5	5,6	10,6
1976	7,5	12,5	20
1977	15	21,6	36,6
1978	7	17,3	24,3
1979	13	15,4	28,4
1980	3	13	16
1981	32	18	50
1982	6,7	9,7	16,4
1983	16	14	30
1984	14,8	15,3	30,1
1985	7	6	13
1986	9,5	5,5	15
1987	2,6	5,6	8,2
1988	3	5	8
1989	4,5	4	8,5
1990	2,5	3,6	6,1
1991	4,5	2,4	6,9
1992	3,6	9,8	13,4
1993	2,9	2,1	5
1994	5,3	4,7	10
1995	8,7	6,5	15,2
1996	4,4	4,3	8,7
1997	4,5	2,9	7,4
1998	3,6	3,8	7,4
1999		3,8	3,8
2000	1,2		1,2
2001	1,1		1,1

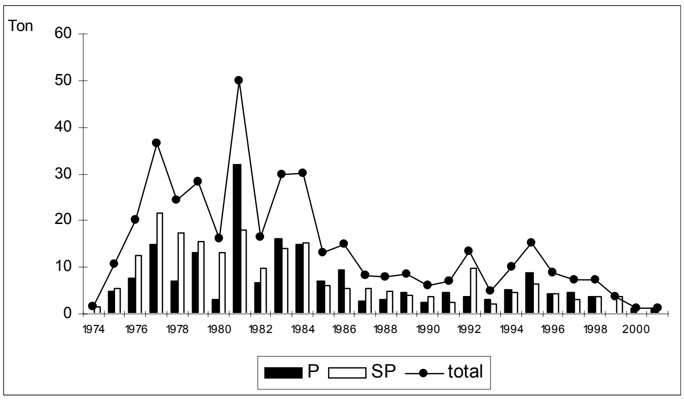

Figure 1. Recruitment data of glass eels (P-Portugal; SP-Spain).

PT.1.2 Trend in fishery

Life stage concerned:

Glass eel and yellow eel

Description of fisheries, information sources, gear types:

An agreement between Portuguese and Spanish authorities allow to fish glass eels in Minho River between November and April, using a stow net ("tela"). In all other Portuguese rivers the glass eel fishery is prohibited for commercial purposes. The professional fishermen catch values are declared annually to the local authorities.

Concerning commercial catches of yellow eels there are two sources of official data: whole sale fish market and local authorities ("Capitania"). Both receive underreporting data. Only a small amount of yellow eels catches pass through the whole sale fish market, as is reflected in Figure 2 where is revealed the national official data between January 1997 and December 2003.

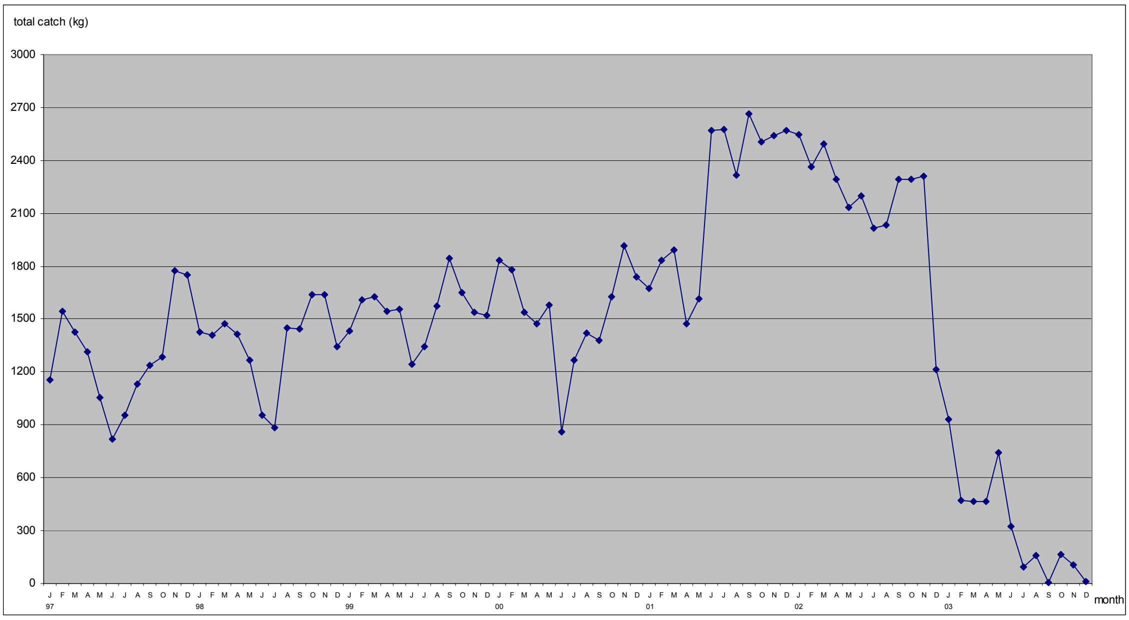

Figure 2. National official data of yellow eels commercialized in whole sale fish market (source: Direcção Geral as Pescas).

Yellow eels are captured using fyke-nets and baited hooks.

There is no idea how many tonnes of yellow eels enter in Portuguese market. Dealer's information reported different countries as source of these eels in Europe, North Africa and North America.

PT.1.3 Trend in the stock

Currently the best indicator of trends in stock is provided by the glass eel indices data in Minho River.

PT.1.4 Trend in re-stocking

There is no re-stocking program.

PT.1.5 Trend in aquaculture

Aquaculture has a week expression in Portugal. In the last years there is no data from intensive aquaculture. In old salines, especially in the center of the country, extensive aquaculture is practised.

	1997	1998	1999	2000	2001	2002
fresh water	12,3	6,6	1,3	-	-	-
sea water	4,3	6,6	1,7	3,8	6,5	4,2

values in tonnes

PT.2 Management

There is no national management plan.

PT.3 Research

The installation of a network of abundance surveys of the most important ecophases of eel (elver, yellow eel and silver eel) constitute one of the principal stakes of the ongoing project INDICANG.

It is based on structures and partners located on 12 basins, located in four countries: France, Spain, United Kingdom and Portugal. They bring into play collaborations between partners belonging to seven areas: English Cornwall; Pays de la Loire; Poitou-Charentes; Aquitaine; País Vasco; Asturias; Northern Portugal. The choice of these basins is related to the localization of scientific teams and technical structures working on estuarine fisheries and on the biology of this species.