Report on the eel stock, fishery, and other impacts, in:

Denmark

2023/2024

Note to the reader - this document accompanies a series of spreadsheet tables that provide the bulk of the data in a format most suitable for the working practices of the WGEEL. Summaries of these data are provided in this document.

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Gudenaacentralen collected and provided recruitment data from Tange Hydropower dam. Hartevaerket collected and provided recruitment data from Harte Hydropower dam.

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1 Summary of national and international stock status indicators

1.1 Escapement, biomass and mortality rates

Year	EMU_code	Assessed Area (ha)	B_0 (kg)	B_{curr} (kg)	B_{best} (kg)	Bcurr/B_0 (%)	∑A	∑F	∑H
2021	Dk_Inla	60,000	1,110,000	203,046	182,746	16	0.105	0.059	0.047
2022	Dk_Inla	60,000	1,110,000	87,118	69,718	6	0.223	0.108	0.115
2023	Dk_Inla	60,000	1,110,000	181,600	165,300	15	0.094	0.054	0.040

Dk_inla. Assessed area (ha) of inland waters. B_0 = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the stock (kg); B_{curr} = the amount of silver eel biomass that currently escapes to the sea to spawn (in the assessment year) (kg); B_{best} = the amount of silver eel biomass that would have existed if no anthropogenic influences had impacted the current stock (kg); ∑F = mortality due to fishing, summed over the age groups in the stock (rate); ∑H = anthropogenic mortality excluding the fishery, summed over the age groups in the stock (rate); ∑A = all anthropogenic mortality summed over the age groups in the stock (rate).

1.2 Recruitment time series

1.2.1 Yellow eel recruitment

The recruitment of young eels, to Danish freshwater, was monitored in pass traps at Harte Hydropower Station in river Kolding Å and at Tange Hydropower Station in river Guden Å. Both rivers empty into Kattegat on the east coast of Jutland. On the west coast of Jutland no passive trapping facilities are available. Here the recruitment is monitored in Vester Vedsted brook a small brook by the Wadden Sea.

In **Vester Vedsted brook** an annual population survey is made by electrofishing four sections of the brook three times a year (further details in Pedersen, 2002). These data are used as a proxy for the yellow eel standing stock.

At **Harte Hydropower Station** the condition for monitoring recruitment at the eel ladder trap has changed. As part of a river restoration project in River Kolding Å, the water supply to Harte Hydropower station has been reduced by 60% since spring/summer 2008. The effect of lower water supply at the trapping site is a decrease in recruitment to the trapping site reflected in the data. This is the second time a major change to the eel monitoring in River Kolding Å has taken place, since monitoring started in 1967. The first change was in 1991 where a trapping facility was terminated at the Stubdrup Weir. At that time a bypass stream was made at the Stubdrup weir allowing eels to bypass the weir without being trapped. This change is also reflected in the recruitment data (Table 1.2.1).

Due to repair work at Harte Hydropower station the water flow was reduced in 2015 during August and September, and a lower catch of ascending elvers was expected in 2015.

At **Tange Hydropower Station**. The local staff at the station is responsible for the daily maintenance of the eel ladder trap and registration of data. The fishery in the reservoir lake Tange has terminated and the trap has not been in operation since 2015 and no data is available during 2015-2018 but the trap was in operation again since 2019.

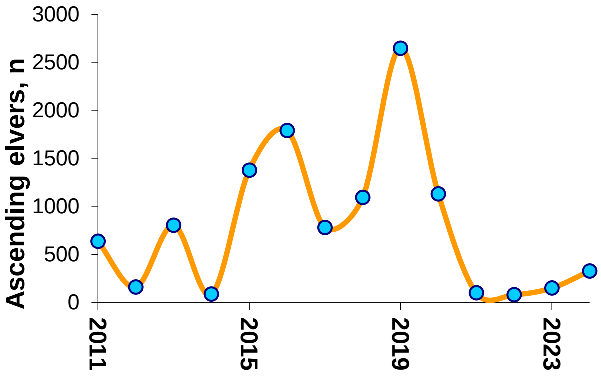
Table 1.2.1. Recruitment data from Tange and Harte Hydropower Stations and Vester Vedsted brook. Mean density during the year and maximum density at any electrofishing occasion.

YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M²		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M²		YEAR	TANGE	HARTE	VESTER VEDSTED BROOK DENSITY EEL/M²	
Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)	Year	Kg	Kg	Mean	Max (season)
1967	-	500	-	-	1987	145	105	-	-	2006	123	7	0.3	0.7
1968	-	200	-	-	1988	252	253	-	-	2007	62	7	0.4	0.5
1969	-	175	-	-	1989	354	145	-	-	2008	131	0.9	0.2	0.2
1970	-	235	-	-	1990	367	101	-	-	2009	20	1.3	0.2	0.2
1971	-	59	-	-	1991	434	44	-	-	2010	14	5	0.2	0.4
1973	-	117	-	-	1992	53	40	-	-	2011	84.6	3.6	0.3	0.3
1974	-	212	-	-	1993	93	26	-	-	2012	Na	4.1	0.1	0.2
1975	-	325	-	-	1994	312	35	-	-	2013	47	1.4	0.1	0.2
1976	-	91	-	-	1995	83	23	2.6	2.6	2014	36	3.0	0.1	0.1
1977	-	386	-	-	1996	56	6	4.6	6.8	2015	NA	1.3	0.2	0.2
1978	-	334	-	-	1997	390	9	0.7	1	2016	NA	2.4	0.3	0.3
1979	-	291	2.8	6.5	1998	29	18	0.3	0.4	2017	NA	0.9	0.14	0.3
1980	93	522	7	13	1999	346	15	0.4	0.5	2018	NA	0.7	0.47	0.59
1981	187	279	7.8	13	2000	88	18	0.6	0.7	2019	97	1.4	0.5	0.6
1982	257	239	-	-	2001	239	11	0.6	0.8	2020	28,8	1,4	0.2	0,3
1983	146	164	-	-	2002	278	17	0.5	0.6	2021	58.7	1.6	0.3	0,5
1984	84	172	-	-	2003	260	9	0.6	0.7	2022	11.3	3,5	0.75	1.3
1985	315	446	-	-	2004	246	9	0.3	0.4	2023	25,52	1,5	0.33	0.47
1986	676	260	-	-	2005	88	7	0.5	0.5	2024	NA	NA	0,08	0,13

Hellebaekken

A new monitoring site since 2011. The site is in Oresund, Denmark (12.55 E; 56.07 N). An eel trap intercept ascending eels from Oresund. There is a reservoir lake above the trap. This trap was established, as it was not possible to make an eel pas connecting the lake with the sea. According to the legislation, it is obligatory to establish a corridor to the lake for migrating eel, so a trap was constructed, and the captured eel is carried to the lake and released in the lake. The National Forest and Nature Agency is handling the eels and reporting the number of captured eels to DTU Aqua.


Picture of the stream Hellebaekken and the house where the eel trap is located. The map shows the location in Oresund.



Year	Number	Year	Number
2011	638	2019	2650
2012	162	2020	1132
2013	804	2021	101
2014	87	2022	82
2015	1380	2023	151
2016	1793	2024	*328
2017	782	2025	
2018	1094	2026	

Figure & Table 1.2.3 Ascending elvers measured in Hellebaekken. *ascending eel until10.08. 2024

1.2.2 Glass eel recruitment

Weirs in streams are being removed as a part of National River restoration projects e.g. to meet the requirements of the EU Water Frame Directive. Monitoring young eel recruitment the traditionally way, using eel pass traps, has become difficult. New methods and locations are urgently needed to monitor the effect of the EU regulation in terms of recruitment of young eel from the ocean.

Since 2008 three small brooks situated on the North Sea coast of Jutland were selected for monitoring. At each brook two or three stations of ca. 20 m length (close to the shoreline <1000 m) are electrofished at three different times from May to August and the population of eels at each station is calculated using the removal method. The brooks have a water depth <50 cm and width of 1–4 m.

The aim is to have this type of monitoring replacing eel pass traps.

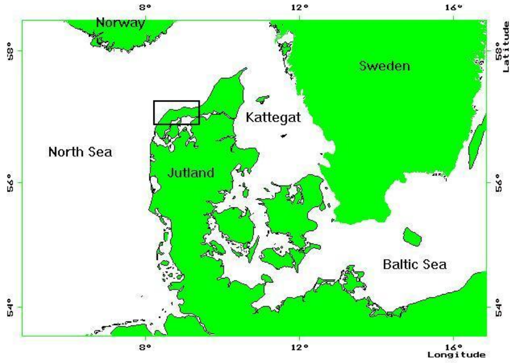


Figure 1.2.2 Map with glass eel monitoring sites (1, 2 and 3) in the North Sea.

Table 1.2.2 Density of newly arrived glass eel or pigmented glass eel (eel/m^2) as a mean of three different electrofishing occasions starting medio May to medio August. The maximum density during the season is given.

	Slette Å (1)		Nors Å (2)		Klitmøller Å (3)	
	Mean	Max.season	Mean	Max.season	Mean	Max.season
2008	1.2	1.2	11.8	11.8	2.8	2.8
2009	0.6	1.0	3.9	6.3	1.3	2.2
2010	1.0	1.4	0.3	0.8	0.2	0.2
2011	4.2	5.7	1.0	2.3	0.8	1.2
2012	1.1	1.8	0.8	2.1	0.2	0.2
2013	1.9	2.9	0.9	2.4	0.8	1.8
2014	19.0	29.6	36.8	75.5	13.0	21.4
2015	11.8	27.5	2.8	5.1	0.3	0.3
2016	4.9	6.9	6.9	11.8	1	1.2
2017	1.3	1.9	0.4	0.6	0.9	5.0
2018	35.9	72.9	11.3	17.4	8.3	11.3
2019	6.0	7.4	12.7	27.2	2.1	3.0
2020	1.7	2.1	3.2	3.8	0.1	0.3
2021	7.5	9.7	0.2	0.5	0.1	0.1
2022	2.3	3.1	3.9	4.8	1.5	3.1
2023	1.0	1.2	3.7	4.6	0.4	0.8
2024	1.8	2.6	12,9	19.1	0.2	0.6

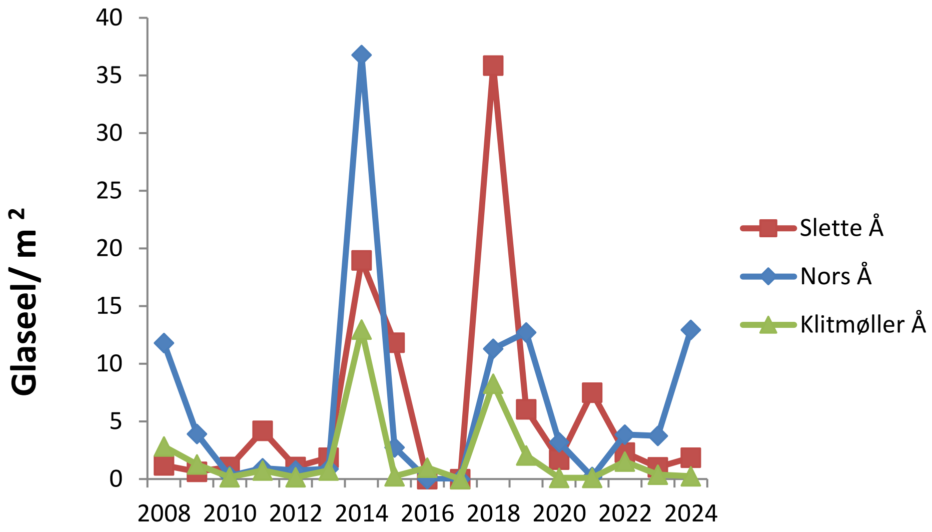


Figure 1.2.3 Monitoring data. Density of newly arrived glass eel pigmented glass eel (eel/m2) as a mean of three different electrofishing occasions starting medio May to medio August.

Slette Å. Monitoring glass eel recruitment by electrofishing. Photo by Jan Skriver.

2 Overview of the stock and its management

2.1 Describe the eel stock and its management

From 1st July 2009 the eel is managed according to the EU regulation, aiming at 40% (relative to the pristine) silver eel escapement in freshwater and 50% effort reduction in the marine waters. The Danish territory is managed as one freshwater EMU excluding two small transboundary river basins named Kruså and Vidå shared with Germany. Intermediate and coastal waters together with community waters constitute the entire marine area.

From 1st July 2009, professional fishing operations are based on licences. The professional fishermen in saline areas are given a licence permitting the use of a limited number of gear in order to meet the 50% effort reduction following the EU eel regulation. Recreational fishermen operating in the marine are permitted to use six fyke nets or six hook lines but in a reduced period of the year. Fishing is closed from the 10th of May to 31. of July in order to reduce effort by 50%. For 2023 and 2024 no recreational fishing in the marine has been allowed.

In freshwater a few professional fishermen have a licence permitting the use of a limited number of gears. For landowners and recreational fishermen, the open fishing season has been limited to a period of 2.5 month (1.aug and fishing is closed from 16 October–31 July.

The escapement target of 40% in freshwater has been calculated to be achieved after ca. 85 years if a total ban on freshwater fisheries will commence. Licences are provisionally issued every year and have to be renewed. The Ministry of Food, Agriculture and Fisheries may implement further reductions pending the development in the eel stock.

The EU commission has enforced a 6-month closing period for commercial eel fisheries in marine waters. In ICES subarea 3, commercial fishing of eels in salt water is not permitted from 15 September 2024 to 15 March 2025 inclusive. In ICES subarea 4, commercial fishing of eels in salt water is not permitted from 1 October 2024 to 31 March 2025 inclusive

Recreational eel fishing using fyke nets have been closed until 31 December 2024.

2.2 Significant changes since last report

There are no significant changes in eel management since the last country report. The expanded closing period in coastal marine fisheries has reduced fishing activity.

3 Impacts on the stock.

3.1 Fisheries

3.1.1 Glass eel fisheries

No data; glass eel fishery is forbidden.

3.1.2 Yellow eel fisheries

The commercial time-series on Silver eel landing are shown below see 3.3.1.1 (Freshwater) and 3.3.1.2 (Marine) and recreational see 3.3.2.1

3.1.3 Silver eel fisheries

The commercial time-series on Yellow eel landing are shown below see 3.3.1.1 (Freshwater) and 3.3.1.2 (Marine)

3.3 Silver eel landings

3.3.1 Commercial

Data on separate landings of yellow and silver eel in fresh and salt water are given below. Data origin is landing reports by commercial fishers reported to the ministry. From medio 2009 landings was only reported from those having a licence to fish for eel.

Table 3.3.1.1. Freshwater landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	-	-	214	**1982**	-	-	163	**2004**	4	12	15
1961	-	-	235	**1983**	-	-	116	**2005**	3	10	14
1962	-	-	215	**1984**	-	-	126	**2006**	7	8	14
1963	-	-	238	**1985**	-	-	111	**2007**	5	6	11
1964	-	-	223	**1986**	-	-	120	**2008**	5	4	9
1965	-	-	205	**1987**	-	-	90	**2009**	8	5	13
1966	-	-	211	**1988**	-	-	119	**2010**	10	3	13
1967	-	-	243	**1989**	-	-	114	**2011**	11	4	15
1968	-	-	258	**1990**	-	-	107	**2012**	9	4	13
1969	-	-	254	**1991**	-	-	99	**2013**	10	3	13
1970	-	-	249	**1992**	-	-	109	**2014**	12	3	15
1971	-	-	183	**1993**	-	-	57	**2015**	9	6	15
1972	-	-	200	**1994**	-	-	60	**2016**	10	3	13
1973	-	-	201	**1995**	-	-	52	**2017**	12	5	16
1974	-	-	163	**1996**	-	-	34	**2018**	6.5	5	11.5
1975	-	-	260	**1997**	-	-	39	**2019**	5.9	4.0	9.9
1976	-	-	178	**1998**	-	-	40	**2020**	3.6	1.6	5.4
1977	-	-	179	**1999**	-	-	30	**2021**	7.7	0.9	8.6
1978	-	-	157	**2000**	4	24	28	**2022**	3.8	0.6	4.4
1979	-	-	78	**2001**	2	34	36	**2023**	4.0	1.2	5.2
1980	-	-	147	**2002**	5	27	27	**2024**	Na	Na	Na
1981	-	-	140	**2003**	2	21	24	**2025**			

Table 3.3.1.2. Marine landings (ton) of yellow and silver eels.

Year	Silver	Yellow	Total	Year	Silver	Yellow	Total	Year	Silver	Yellow	Total
1960	2756	1967	4509	**1982**	1003	1375	2215	**2004**	343	187	516
1961	2098	1777	3640	**1983**	884	1119	1887	**2005**	372	149	506
1962	2132	1775	3692	**1984**	830	915	1619	**2006**	427	154	567
1963	1837	2091	3690	**1985**	793	726	1408	**2007**	411	115	515
1964	1417	1865	3059	**1986**	818	734	1432	**2008**	364	93	448
1965	1498	1699	2992	**1987**	538	651	1099	**2009**	367	87	454
1966	1829	1861	3479	**1988**	799	960	1640	**2010**	304	105	409
1967	1673	1763	3193	**1989**	785	797	1468	**2011**	271	84	355
1968	2063	2155	3960	**1990**	834	734	1461	**2012**	226	78	304
1969	1552	2072	3370	**1991**	724	642	1267	**2013**	243	100	343
1970	1470	1839	3060	**1992**	687	655	1233	**2014**	251	80	331
1971	1490	1705	3012	**1993**	523	500	966	**2015**	202	65	267
1972	1662	1567	3029	**1994**	509	631	1080	**2016**	178	74	251
1973	1697	1758	3254	**1995**	408	432	788	**2017**	170	70	240
1974	1378	1436	2651	**1996**	381	336.5	684	**2018**	88	82	170
1975	1534	1691	2965	**1997**	375	383	719	**2019**	95	79	173
1976	1477	1399	2698	**1998**	306	251	517	**2020**	101	76	177
1977	1141	1182	2144	**1999**	380	307	657	**2021**	130	94	224
1978	1187	1148	2178	**2000**	382	218	572	**2022**	72	87	159
1979	887	939	1748	**2001**	446	225	635	**2023**	24	96	120
1980	911	1230	1994	**2002**	365	217	555	**2024**	Na	Na	NA
1981	897	1190	1947	**2003**	437	188	601	**2025**			

3.3.2 Recreational

Freshwater

Recreational fishermen in freshwater are landowners and do not need a licence to fish. The fishing season are open from 1. August until 15. October and closed from 16. October until 31. July.

Marine

Recreational fishermen in the marine area are allowed to use a maximum of six fykenets. However in 2023 and 2024 a complete closure has been established.

The survey of landing data (Table 3.3.2.1) is based on interviews from recreational fishers from both the marine and fresh water (Sparrevohn og Storr-Paulsen 2010). The data should be treated with care. There is no known explanation why the landings has increased so much in 2022.

Tabel 3.3.2.1 Recreational landings in ton (yellow eel), based on interview from people holding a recreational licence (marine) or landowners (freshwater).

Year	Fresh	Marine	Total
2004-6	16	138	154
2009	NA	100	100
2010	NA	117.5	117.5
2011	4.3	75.2	79.5
2012	0.4	51.9	52.3
2013	0.4	49.5	49,9
2014	2.0	55.0	57.0
2015	23.3	95.0	118.3
2016	10.2	154.1	164.3
2017	8.3	109	117,3
2018	3.5	101.5	105.0
2019	8.5	101.5	110.0
2020	8.0	90.9	98.9
2021	2.7	79.0	81.7
2022	4.0	156.0	160.0
2023	4.1	0	4.1

3.2 Restocking

In 2024 a total of **1.412.500** eels 2-5 gram were stocked. In freshwater 1,274,500 eel and in marine waters 138,000 were stocked (Table 3.5.1 below). The stocked eels are foreign source glass eel imported from France. Imported glass eels are grown to a weight of 2–5 gram in heated culture before they are stocked.

Table 3.5.1. Restocking of elvers (2–5 g) in marine and fresh waters from 1987–2021. Numbers of eels stocked (in millions).

Year	Marine	Lake	River	Total	Year	Marine	Lake	River	Total
1987	0.07	0.26	1.26	1.58	**2006**	1.15	0.35	0.1	1.6
1988	0.11	0.24	0.4	0.75	**2007**	0.59	0.21	0.02	0.83
1989	0	0.24	0.17	0.42	**2008**	0.52	0.19	0.04	0.75
1990	2.46	0.49	0.51	3.47	**2009**	0.55	0.20	0.05	0.81
1991	2.3	0.44	0.32	3.06	**2010**	0.30	0.57	0.67	1.55
1992	2.94	0.81	0.11	3.86	**2011**	0.20	0.77	0.59	1.56
1993	2.97	0.76	0.23	3.96	**2012**	0.25	0.64	0.64	1.53
1994	6.12	0.61	0.67	7.4	**2013**	0.25	0.66	0.61	1.52
1995	6.83	0.72	0.9	8.44	**2014**	0.26	0.71	0.63	1.60
1996	3.58	0.58	0.44	4.6	**2015**	0.13	0.79	0.61	1.53
1997	2.02	0.29	0.22	2.53	**2016**	0.13	0.69	0.71	1.53
1998	2.35	0.53	0.1	2.98	**2017**	0.13	0.69	0.71	1.52
1999	3.38	0.56	0.18	4.12	**2018**	0.13	0.67	0.31	1.11
2000	3.02	0.55	0.25	3.83	**2019**	0.18	0.88	0.75	1.81
2001	1.2	0.38	0.12	1.7	**2020**	0.15	0.56	0.64	1.34
2002	1.66	0.47	0.3	2.43	**2021**	0.33	0.52	0.38	1.23
2003	1.54	0.49	0.22	2.24	**2022**	0.14	1.05	0.60	1.79
2004	0.52	0.18	0.06	0.75	**2023**	0.13	1.04	0.51	1.68
2005	0.24	0.06	0	0.3	**2024**	0.14	0.86	0.42	1.42

3.3 Aquaculture

Aquaculture production of eel in Denmark started in 1984. The production takes currently place at three indoor, heated aquaculture systems, Table. 3.3.1.

Glass eels to Danish aquaculture may be imported from France, Portugal or England. The eel farmers report to the Danish AgriFish Agency what amount of glass eel is imported but not from where it is imported.

Table. 3.3.1. Annual aquaculture eel production.

	Production Units	Production [ton]	Year	Production units	Production [ton]
1984	NA	18	2002	16	1880
1985	30	40	2003	13	2050
1986	30	200	2004	9	1500
1987	30	240	2007	9	1617
1988	32	195	2008	9	1740
1989	40	430	2009	9	1707
1990	47	586	2010	9	1537
1991	43	866	2011	8	1156
1992	41	748	2012	8	1093
1993	35	782	2013	8	824
1994	30	1034	2014	6	842
1995	29	1324	2015	5	1234
1996	28	1568	2016	5	1072
1997	30	1913	2017	3	561
1998	28	2483	2018	3	455
1999	27	2718	2019	3	490
2000	25	2674	2020	3	659
2005	9	1700	2021	3	1179
2006	9	1900	2022	3	463
2001	17	2000	2023	2	173

Table 3.2.1 Usage of aquaculture production (Source: Danish AgriFish Agency).

2023	kg
Imported glass eel	430
Stocking in Dk	5425
Stocking abroad	10538
Eel moved to another eel farm in dk	33158
Large eel for consumption	103396
Large eel for export	18000
Dead biomass	2190
Total production	**172707**

The import and export data **table 3.2.1** are reported by the eel farmers to the Danish AgriFish Agency. The different categories (import, stocking) are reported in kg. The categories stocking export, consumption and dead biomass is reported in kg. Life mortality from the glass eel stage to the stocked eel stage or the consumption stage is about the same level, approximately 5-15 %. It should be noted that the number of glass eel imported to the farm is not necessarily comparable to the number of eels from the farm the same year. The retention time of eel in the farm differs by eel stage, e.g. eel for stocking is 3-8 month and eel for consumption is 18 month or more.

3.4 Entrainment

Hydropower

In 2006 there were possibly between 43 and 61 hydroelectric power units in operation in Denmark. Since then, several hydropower units have been closed down (e.g. Vilholdt, Karlsgårdeværket, Harteværket, Holstebro vandkraft etc). There are no exact data on the number and the capacity of hydroelectric power units at present.

We have measured, using telemetry, a loss of silver eel between 0 and 58 % at two particular hydro power plants. At Tange Hydropower plant there is a significant bypass problem for eels, we have measured a loss of at least 58 % and possibly 77 % (including turbine damaged eel) (Pedersen et al. 2011). At Vestbirk hydropower the fish bypass (1/4 of the water discharge) in combination with 10 mm screens work well and the loss is close to zero. (Pedersen and Jepsen 2012).

We have no data for other hydropower plants.

Trout farms (aquaculture)

Research in relation to weirs of trout farms have been conducted in connection with three trout farms in River Kongeåen and River Mattrup Å. The conclusion from these studies was that delay of eel migration due to low discharge was observed in some yaers and the eels by pass the screens that were supposed to prevent eels and other species to nenter the the trout farm.

Danish trout farms are often located on the banks of rivers depending on water intake from the rivers. To guide the river water into the trout farm, a weir is built in the river. Less than 250 trout farms use “flow through” river water and approximately 10 have systems for recirculation of water. To prevent fish from entering the trout farms a screen with max. 6 mm bar distance is obligatory at the point of the water inflow and a max. 10 mm bar distance at the point of outflow.

Two studies have been conducted. The first study was at Brejnholt trout farm in River Mattrup Å. Here no mortality was observed but migration delay of silver eels at the weir varied with water discharge. The second study was in River Kongeå, here two trout farms are situated on the bank of the river at Vejen and Jedsted. Both trout farms have 6 mm bar distance at the water intake. At Vejen fish farm several fish entered the fish farm despite the 6mm bar screen which seems not correctly installed or damaged. At Jedsted no fish entered the fish farm and the screen was working well. If the screen at Vejen fish farm is fixed properly, eels would not be able to enter the fish farm. However, it is quite difficult to see by eye if there is any such problem at other comparable fish farms unless the place where the screen is mounted is dried out.

The conclusion from these studies is that migrating silver eels is likely to have migration delay at weirs, which may depend on the hydrological conditions (water discharge) at some weirs and at other the screens may be incorrect mounted, causing eels to be trapped at the trout farm. No mortality was observed but delay at weirs is likely to cause higher mortality from predators (Pedersen and Jepsen 2012).

3.5 Habitat Quantity and Quality

The spatial distribution of weirs in relation to hydropower and “flow through trout farms” are geographical limited to Jutland. No updated data on quantity and quality is available since 2006.

It was assumed that 7 ton of eel would die in connection with these weirs (Hydropower 4 ton, Flow through fish farms 3 ton) throughout the Danish inland waters!

3.6 Other impacts

No other impacts to report.

4 National stock assessment

4.1 Description of Method

4.1.1 Data collection

1) Commercial fishermen are obliged to report through logbooks to the ministry of fisheries Landings in weight are separated in yellow and silver eel landings.

2) Recreational fisheries catch are collected through yearly interview surveys.

3) Recruitment data are monitored in freshwater using eel pass traps and electrofishing surveys.

4) Silver eel escapements from all 887 Danish River systems are surveyed using two index river systems. One river systems with a silver eel trap (Klitmøller Å) and one river system with a commercial fisherman (Ribe Å).

Analysis

At River Ribe Å we use tag recapture to estimate escapement (Petersen estimate, Ricker 1981). The depletion method was used (Bohlin et al. 1989) when river population estimates are made by electrofishing.

4.1.2 Reporting

Collected data are published in national reports or international journals, WGEEL CR reports or Eel management progress reports to the EU- commission.

4.2 Trends in Assessment results

Stock indicators

Data from index river systems are used to calculate the total silver eel escapement from the Danish freshwater territory. The count was repeated every third year. The National Institute of Aquatic Resources (DTU Aqua) has succeeded in estimating and counting escaping silver eels from River Ribe Å, upper part of River GudenÅ (terminated in 2020) and Lake Vester Vandet (Klitmøller Å) .

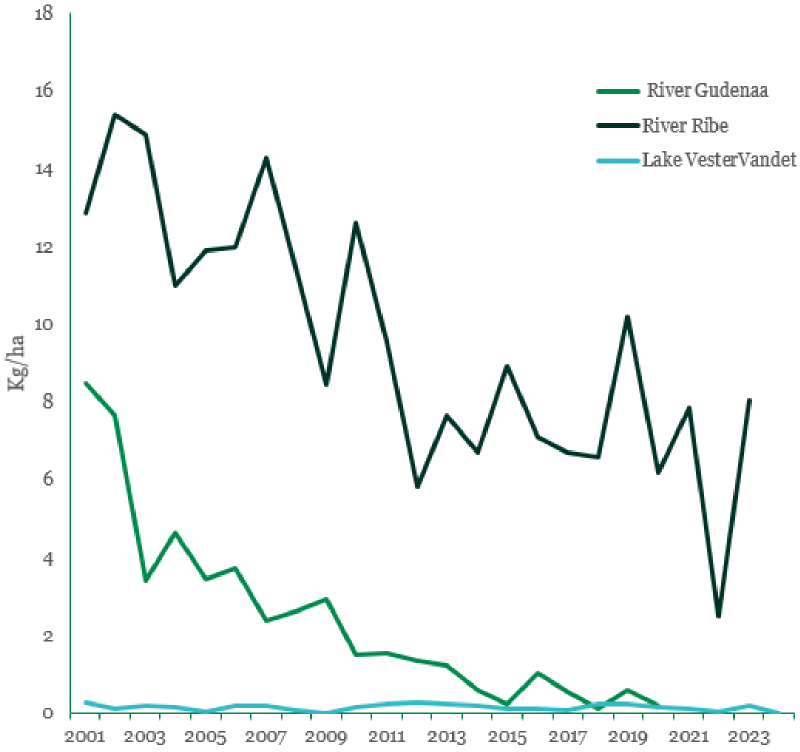


Figure 4.2: The production of silver eel (kg/ha) from three index systems from 2001-2023.

5 Other data collection

5.1 Recruitment time series

Glass eel surveys are described in section 1. of this country report.

5.2 Yellow eel abundance surveys

The monitoring in Vester Vedsted may be recognized both as a yellow eel abundance survey as well as recruitment survey. No other surveys are available! Table

5.3 Silver eel escapement surveys

Described in section 4. of this country report.

5.4 Parasites & Pathogens

Parasites and pathogens

The swimbladder parasite *Anguillicola crassus* is widely distributed throughout both brackish and freshwaters in Denmark. Monitoring of Anguillicola parasites has taken place on a yearly basis at three locations since 1987. However, the fishery in Lake Arresø has now stopped since 2020. The number of Anguillicola infected eels (prevalence) is relatively constant during 1987–2018 at all three locations.

Table 11.2. Anguillicola monitoring data.

Location	Salinity ppt	Coordinates	Year	Total	Infected	Prevalence	Intensity
				N	N	%	n
Isefjord	18	55.50N;11.50E	2018	95	24	25.3	1.2
Ringk. Fjord	5–10	55.55N;08.20E	2018	92	68	73.9	6.4
Arresø	0	55.59N;11.57E	2018	106	51	48.1	2.3
River Ribe	0	56.07N;8.66E	2020	65	45	69	2.7

5.5 Contaminants

No new data available.

5.6 Predators

Cormorants

Cormorants are possibly the only important predator of eel due to the large number of nesting birds; predation is expected to be largest in the vicinity of the colonies, but birds migrating through Denmark may have significant impact during the fall.

The number of cormorants nesting in Denmark during the last 10–15 years can be regarded as stable, but with some fluctuation. The number of nests is now in an upward trend since 2010 - 2013. In the year 2000 the highest number of nests 42.481 was counted in colonies throughout Denmark. In 2017 a total of 33.171nests were counted.

In the Danish EMP (2008) it was suggested that in the period 2004–2006 approximately 80 tonne of yellow eel was eaten by cormorants. However recent work from Hirsholmene (57.29’N; 10.37’E) a cormorant colony in Kattegat analyzing 350 regurgitated pellets showed that eel otoliths occurred with a frequency of 0.3% (Poul Hald, 2007). The frequency of occurrence of eel otoliths found in cormorant pellets in 2005 was 0.12% and Sonnesen (2007) suggesting that wild eels are not important as food in Ringkøbing Fjord (55.55'N;08.20'E). However despite this low occurrence, the estimated number of eels eaten in Ringkøbing Fjord by cormorants in 2004 was 38 000, more individuals than was caught in the fishery, and recovery of cw-tags from 20 000 tagged stocked eels showed a 40% predation from cormorants during the first season (Jepsen *et al*., 2010). Thus cormorant predation can be a very significant factor in areas with a high cormorant density. The number of cormorants in Ringkøbing Fjord is not higher than most coastal areas in Denmark.

Recent analyses of data from ongoing studies of silver eel migration, using PIT tagging, showed that even relative large silver eels can be eaten by cormorants as PIT tags were recovered from nearby colonies and roosting sites. The recoveries may provide a basis for quantification of the predation in future studies.

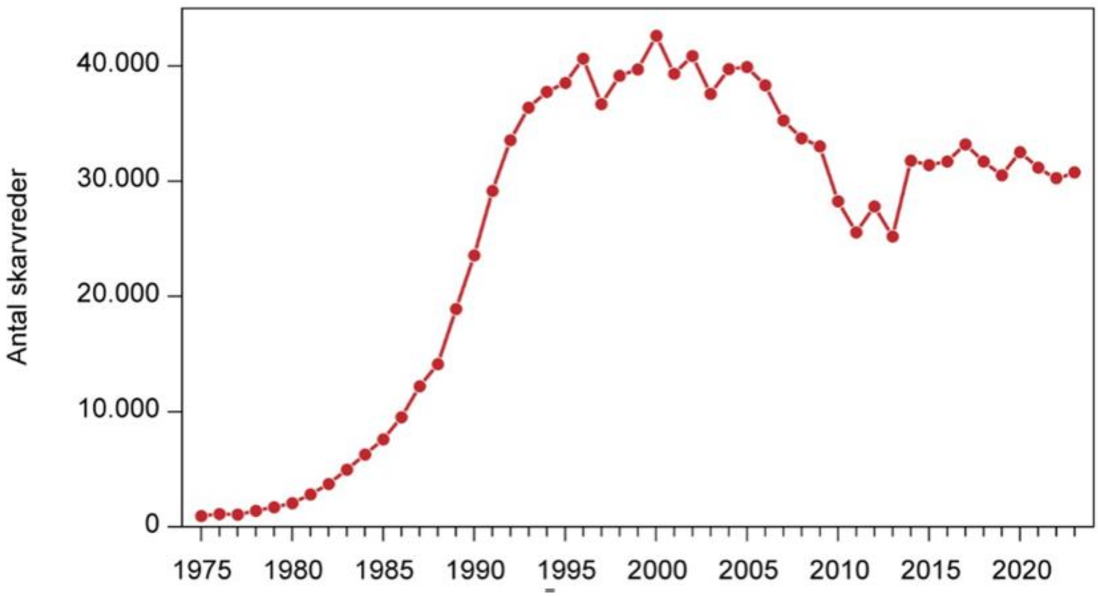


Figure 5.6. Number of cormorant nests in Denmark 1971–2023. Data from NERI. University of Århus.

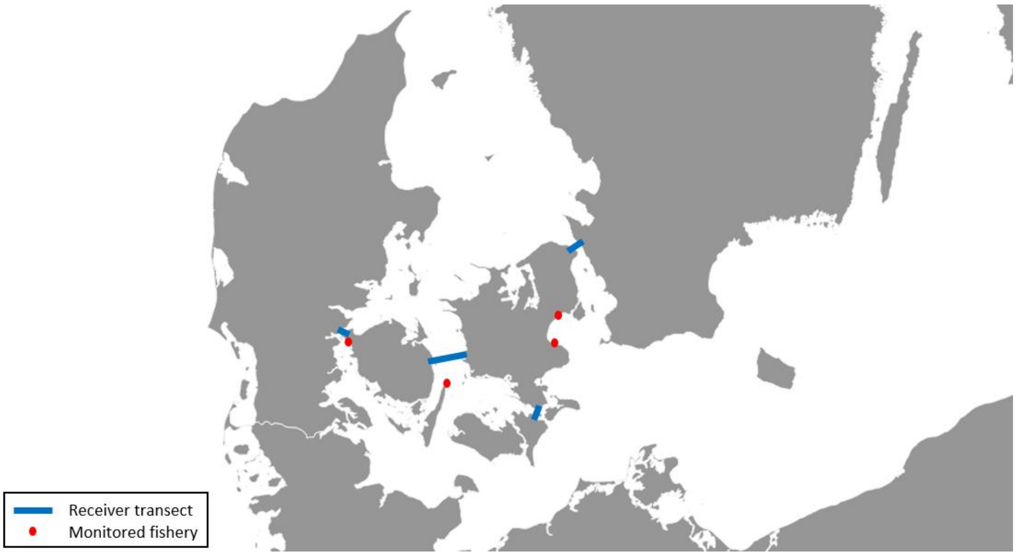
6 New Information

On going Baltic study - DK

In August 2019, DTU Aqua initiated a study with acoustic telemetry that will

1. Investigate silver eel migration behaviour and determine when and where out migrating eels leave the Baltic Sea.
2. Estimate the efficiency of coastal based commercial silver eel fisheries in Denmark.

For the study, silver eels were tagged with an acoustic tag that emits a unique ID. The study attempts to have full acoustic receiver coverage at transects across the exits from the Baltic Sea (Fig. X) to see when and where each individual eel leaves the Baltic Sea. To investigate the efficiency of commercial fisheries, receivers have also been mounted at four commercial fisheries located close to the receiver transects. This enables the study to estimate the proportion of acoustically tagged eels caught by the fishermen versus the proportion that are detected at the receiver transects and considered to have escaped the Baltic Sea.



The study has been joined by research institutions from Sweden (SLU Aqua), Estonia (Estonian University of Life Sciences), Germany (Thünen-Institute), Belgium (Ghent University), Lithuania (Lithuanian Nature Research Centre), Finland (Luke Natural Resources Institute) and Latvia (Institute of Food Safety, Animal Health and Environment). The research institutes contribute to the study with tags, eels and/or receivers. A total of 860 silver eels have been planned to be tagged throughout the Baltic region during 2019-2021, and the majority of these eels are expected to be included in the study. The different research institutes will also use the generated data from the tagged eels to assess a number of other hypotheses.

DTU Aqua is working on making the receiver transects in the belts and sounds permanent, which will allow future research on eel migration behaviour with this infrastructure.

Figure X. Location of receiver transects (blue lines) and monitored fisheries (red dots) in the Danish belts and sounds.

7 Recent papers on eels

Casper W. Berg 2024. Trends in fyke net catches of eel in Dansih waters estimated from citizen science. Draft paper pp 1-15.

Abstract: The report describes a model for the observed amount of European eel *Anguilla anguilla* caught in fyke nets from the Danish "keyfisher" citizen science program. Only eels in the "yellow eel" stage are observed in the fykes. The model is a Delta-Lognormal generalized additive model (GAM). The overall trend in biomass is positive and statistically significant (confidence bounds in final year excludes the overall mean of 1). However, positive trends are only found in the Eastern part of Denmark, whereas the trends in other places are flat or slightly negative. Eel catches are significantly affected by the moon phase, with highest catch rates around new moon and lowest around full moon.

Rasmussen G., B. Therkildsen and MI Pedersen (2024). Growth and production of yellow eel (Anguilla anguilla) and the number of glass eel to fulfill the Danish EMP. Afr.Res.J.Bio.Sc. 1(2) (2024) 89-104 https://doi.org/10.62587/AFRJBS.1.2.2024.89-104

Abstract: Silver eel were sampled in 1981 and 1983 in River Brede, Denmark, with outlet to the North Sea. Yellow eel in River Køge-Lellinge, Denmark, with outlet to the Baltic Sea, were sampled 1965-1968. Silver eel were aged by burning the otoliths. Silver male ages varied from 4 to 25 years, lengths 30.8 to 45.3 cm, and female silver eel varied from 7 to 25 years, lengths 42.3 to 77.3 cm. Assuming linear growth of silver eel at yellow eel stage, von Bertalanffy trajectories of length-atage of male and female yellow eel were calculated in both rivers. Younger yellow eel had significantly higher annual growth rate compared to older age groups, and females grew significantly faster than males. Two models for annual natural mortality M were used to estimate number of glass eel needed to produce the number of silver eel for each sex and silver age group. Annual silver eel production from River Brede Å was 49.2 kg ha-1, demanding 2,894 glass eel ha-1. In River Køge-Lellinge, the silver eel production was 48.5 kg ha-1, demanding 5,570 glass eel ha-1. It was calculated, that one thousand glass eel (0.29 g) contributed to 8.8 kg silver eel in River Køge-Lellinge, and 17.0 kg silver eel in River Brede. To fulfill the Danish EMP in rivers requires annual stocking of 33 tons or 9.4 million reared on-grown eel (3.5 g) to compensate for 183 tons lost silver eel.

Pedersen, M. I., Rasmussen, G. & Jepsen, N., 2023. Density-dependent growth, survival, and biomass production of stocked glass eels (*Anguilla anguilla*) in seminatural ponds. Fisheries Management and Ecology. https://doi.org/10.1111/fme.12641

Abstract: We sought to demonstrate how eel mortality, growth, and biomass production were related to initial stocking density of glass eels, 18 months after stocking. Glass eels with a mean body mass of 0.29 g were caught in three coastal streams of Denmark, and subsequently stocked at four densities (0.5, 1, 1.5, and 2 individuals m^{-2}) in eight shallow, 200 m^2, open ponds. Recapture after 18 months ranged from 13% to 84% and was negatively correlated with stocking density. Likewise, growth (length and body mass) and body condition were negatively correlated with stocking density. The theoretical maximum biomass per stocked glass eel was 7.3 g at a density of 0.005 eels per m^{-2} (one glass eel per pond), and the minimum was at a density of 3 glass eel m^{-2} (600 glass eels per pond). The optimum eel biomass was 3.9 g m^{-2} at a stocking density of ≈1 glass eel m^{-2}, which probably represented the present production capacity (food) of these ponds.

Niels Jepsen,Luise Richter, Michael Ingemann Pedersen, Zhiqun (Daniel) Deng, 2022. Survival, growth, and tag retention of juvenile European eel (*Anguilla anguilla* L.) with implanted 12 mm passive integrated transponder tags and acoustic tags. [Journal of Fish Biology](). https://doi.org/10.1111/jfb.15183

Abstract: To evaluate the efficiency of tagging juvenile European eels with implanted 12 mm passive integrated transponder (PIT) tags or Eel/Lamprey acoustic transmitters (ELATs), the authors studied tag retention, survival and growth of eels (7–25 g). Experimental eels were obtained from an eel farm, tagged and then released in a series of shallow dug-out ponds with a surface area of *c*. 200 m^2. Tagged and control eels were distributed evenly, with 50 tagged and 50 control eels in each of four ponds, giving a total of 200 tagged and 200 control eels mixed. After 76 days, the ponds were drained, and eels were sampled and measured. A total of 344 eels (86%) were recaptured, indicating high survival. Tag retention was 99% as only one of the recaptured PIT-tagged eels had lost the tag and none of the ELAT tagged. The results demonstrated that tagging juvenile eels >16 cm with these small tags is indeed feasible. The growth of tagged and control fish was differentiated but generally low in length and negative in mass but did not differ between the three groups.

Wright, R.M., Piper, A.T., Aarestrup, K. et al. 2022. First direct evidence of adult European eels migrating to their breeding place in the Sargasso Sea. *Sci Rep* **12**, 15362 (2022). https://doi.org/10.1038/s41598-022-19248-8

Christoffersen, M., Svendsen, J.C., Kuhn, J.A., Nielsen, A., Martjanova, A., Støttrup, J.G., 2018. Benthic habitat selection in juvenile European eel Anguilla anguilla: implications for coastal habitat management and restoration. Journal of Fish Biology, Volume 93, pages 996–999.

<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<<abstract The critically endangered European eel Anguilla anguilla is dependent on suitable habitat qualities over a vast geographic area. Even though a significant proportion of the population never enters fresh water, the preferred benthic habitat is largely unknown in the marine environment. Examining substratum selection in A. anguilla reveals that elvers prefer coarse gravel, suggesting that conservation efforts may benefit from targeting this type of substratum in marine coastal areas.

Pedersen M.I. & G. H. Rasmussen 2018. Fisheries regulation on European eel (*Anguilla anguilla*) for 2018; how big is the effect? Journal of fisheries Research. Vol 2 p 17-18.

The EU Council of Ministers decided in December 2017 to implement a limitation on commercial marine catches on eels exceeding 12 cm in length for 2018. We aimed to evaluate the effect of the fishing limitation using data on actual and potential silver eel escapement (stock indicators). The data suggest that fisheries exploitation of adult eels in the marine areas has relatively little effect on the biomass of silver eel that potentially can escape to the spawning grounds in the Sargasso Sea. The 2018 fishing regulation for the marine commercial fisheries increases migrating of silver eels towards the spawning grounds in the Sargasso Sea, from expected 10,000 t to 10,200 t, equivalent to 2 % increase. Other anthropogenic mortality and predation may be far more important than landings of all life stages and account for 49 % of the total loss.

Pedersen M. I. Jepsen N. Rasmussen G, 2017. Survival and growth compared between wild and farmed eel stocked in freshwater ponds. Fisheries Research, Volume 194, October 2017, pages 112-116.

To evaluate the efficiency of eel stocking, we compared the survival and growth of wild eels (2-5 g) with that of "farmed" eels (3-6 g). Wild eels were caught in a river and farmed eels came from a farm, where wild imported glass eels are cultured. Two experiments of 5-12 month duration were conducted in a series of shallow, open ponds of approximately 200 m^2. Wild and farmed eels were batch tagged, mixed and released in the ponds at an initial density of 0.5 individual /m^2. Survival was rather high (34 – 88%) with variations between ponds. No significant difference in survival was found between wild and farmed during the first 5 month in both experiments. Growth rates were significantly higher for farmed eels compared to wild eels in both experiments. The results show that farmed eels performed better than wild eels. In regions with low recruitment the eel population may be increased by importing glass eels, stocked directly or stocked as on-grown farmed eel. The optimal size for stocking (between glass- and 3 g eels) may be determined through future studies.

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