Ministry of Agriculture, Nature and Food Quality

THE NETHERLANDS EEL MANAGEMENT PLAN

THE MINISTRY OF AGRICULTURE, NATURE AND FOOD QUALITY

15 July, 2009

1. DESCRIPTION OF EEL HABITATS (MANAGEMENT UNITS)

1.1. Eel management units

The management unit for the implementation of the Eel Management Plan is the national territory of the Netherlands, including the coastal waters in the Dutch Exclusive Economic Zone. The scientific justification is provided below. The Minister of Agriculture, Nature and Food Quality (LNV) is the authority that is directly responsible for the eel fisheries management in the entire country.
Ministry of Agriculture, Nature Management and Food Quality
Department of Fisheries
PO Box 20401
2500 EK Den Haag
phone: +31 70 378 4442 (secretariat of directors)
fax: +31 70 378 6153

Surveillance for compliance for the Minister of LNV is carried out on behalf of the minister by the General Inspection Service (Algemene Inspectiedienst = AID) and the national police service (KLPD).

Inventory of individual river basins

The Netherlands is located in the estuaries of a mix of rivers ending in the North Sea. The country recognises four river basins, all extending beyond the national boundaries:

1. The river **Ems** basin in the North-East is shared with Germany. The drainage area is 18,000km^2, 2,400km^2 in the Netherlands.
2. The river **Rhine** basin is shared with Germany, Luxemburg, Switzerland, France, Austria and Liechtenstein. The drainage area is 185,000km^2, of which 25,000km^2 is in the Netherlands.
3. The river **Meuse** basin covers Belgium, Luxemburg, France and Germany. The drainage area is 35,000km^2, of this 8,000km^2 is in the territory of the Netherlands.
4. The river **Scheldt** basin in the Southwest shared with Belgium and France. The drainage area is 22,000km^2, with 1,860km^2 being in the Netherlands.

Scientific justification for designating the Netherlands as one administrative unit

- Mixing of different water basins

The country of the Netherlands is situated in the joint delta and estuarine area of four major rivers. All rivers are intertwined and confluent. Downstream, the Rhine and Meuse in fact have a complete anastomosis. Outlets of the Meuse have been redirected through former outlets of the Scheldt. The fourth river is the river Ems, the edge of whose basin downstream is in the far northeast of the Netherlands. The mouth of the river Ems in the Waddensea is quite close to the original northern outlets of the Rhine. In view of the above, sharp boundaries between river basins in the Netherlands for managing eel impacts appear neither practical nor appropriate, as long as management cannot yet be dealt with at an international level.

- International dimension of river basins

All four river basins have an international dimension. Despite the long collaboration between range states, the coordination for eel management plans is still rudimentary, since to date the appropriate management bodies have been tailored to water quality rather than managing human impacts on eel.

1.2. Maps

The management unit for the implementation of the Eel Management Plan is the national territory of the Netherlands, including the coastal waters in the Dutch exclusive economic zone. This will be the case until the collaboration with the adjacent nations to establish management by river basin has been completed. Figure 1.2.1. depicts the national territory and the four different river basins that cover the national territory by colours. The Rhine covers the largest area in the central part of the country and is subdivided in the map in four parts: blue, yellow, red and purple. The Meuse (turquoise) is the second largest river and covers a large part of south and southeastern Netherlands. The river Ems (brown) touches the edge of the country in the northeastern part of the country, and the river Scheldt (olive green) coming from Belgium only the Southwestern province of Zeeland.

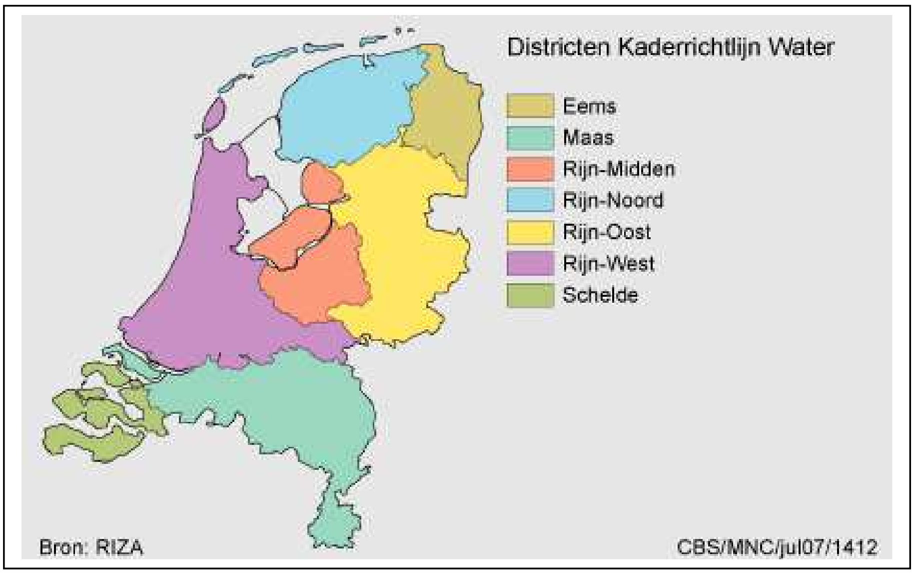

Figure 1.2.1. The geographical extent of the Eel Management Unit, the country of The Netherlands, depicted in the four main river basins.

1. **Ems** in the North East = brown,
2. **Meuse** in the South/Southeast = turquoise
3. **Rhine** in the North, Central & West, = subdivided in blue, yellow, red and purple
4. **Scheldt** in the Southwest = olive green

Maps that illustrate the four river basins covering the EMU in the Netherlands

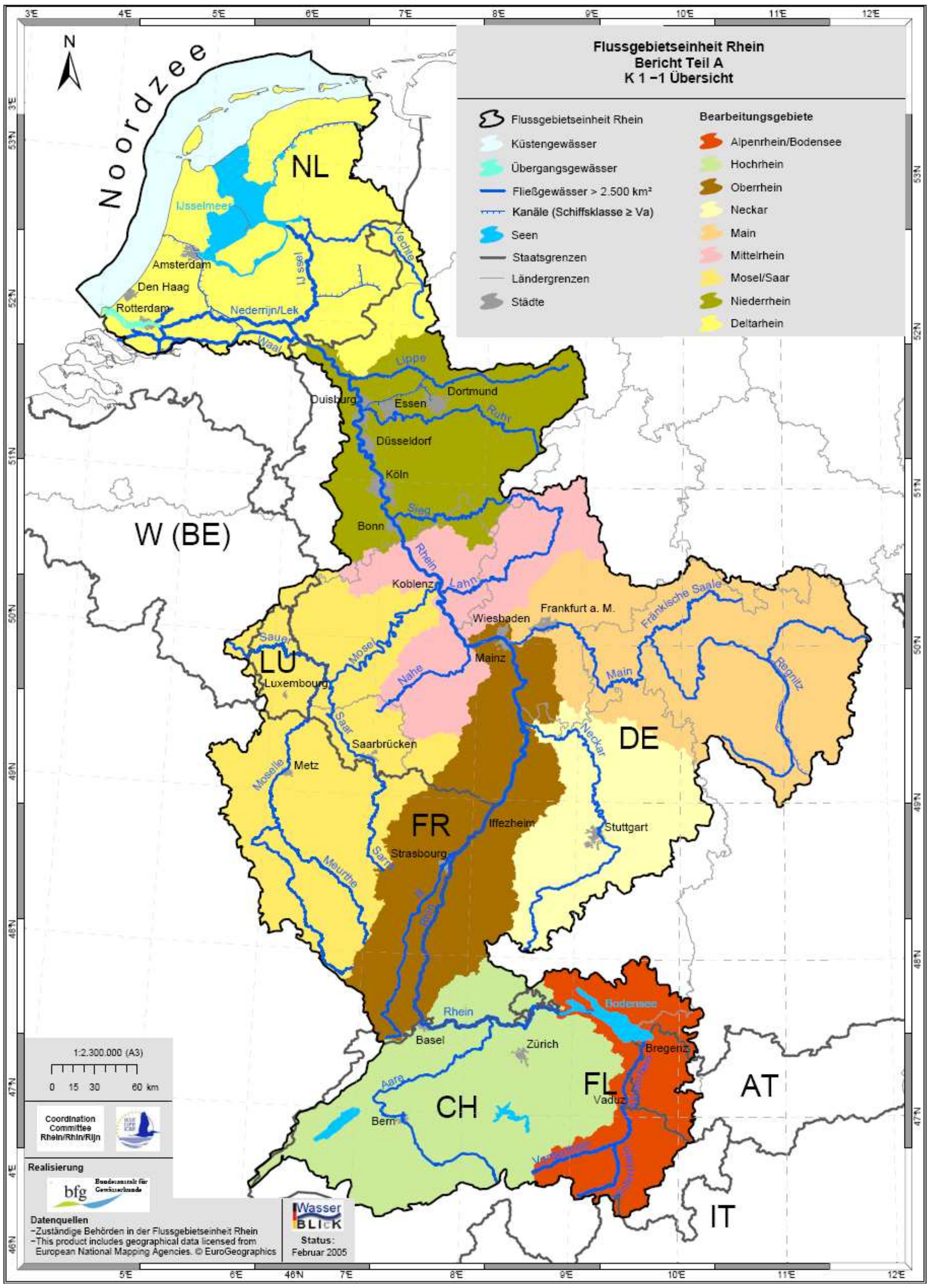

Figure 1.2.2. The Rhine river basin. Source: International Rhine Commission, www.iksr.org

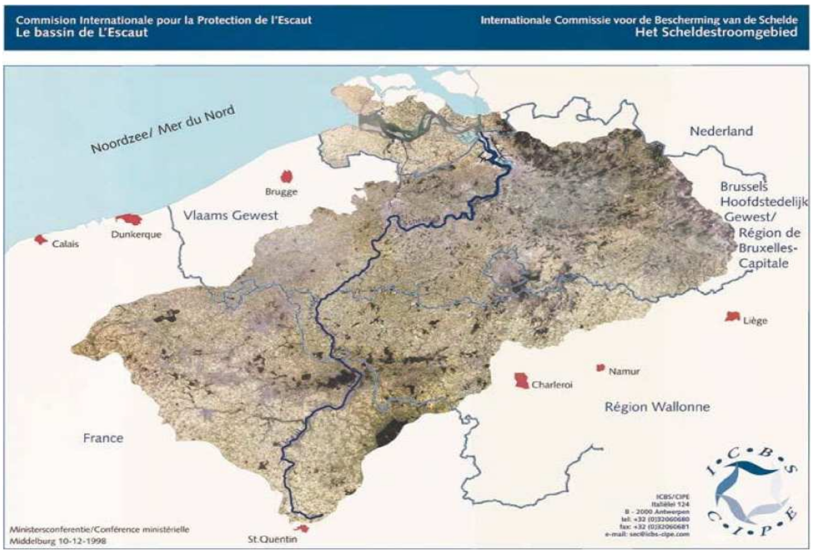

Figure 1.2.3. Scheldt River basin. Source: Scheldt Commission www.isc-cie.com

Figure 1.2.4.: The Meuse river basin. Source: International Meuse Commission, www.meuse-maas.be

Figure 1.2.5. The Ems river basin. Source: International Ems Commission, www.ems-eems.nl

Maps with the surface areas of the various eel habitat types in the Netherlands

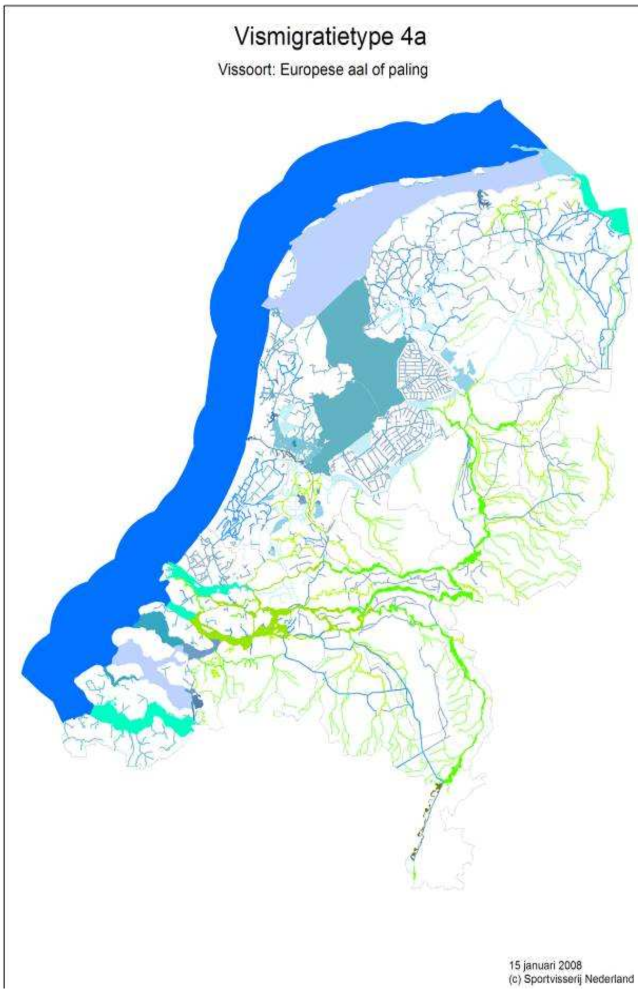

Figure 1.2.6b. Biotope of the eel in the Netherlands, including in blue the type **water-lines** (*i.e.* streams, rivers, canals, etc.). The total length is about 10,000km. The biotope types M3, M30, M6, M10 and M7 (WFD-codes) contribute 88% of the total (Kroese et al., 2008).

The total number of physical obstacles for migrating eel is depicted in figure 1.2.7. This situation, dating from 2001, is used as a reference point in time for indicating the rate of reduction of their numbers over time as a contribution to improved eel habitat.

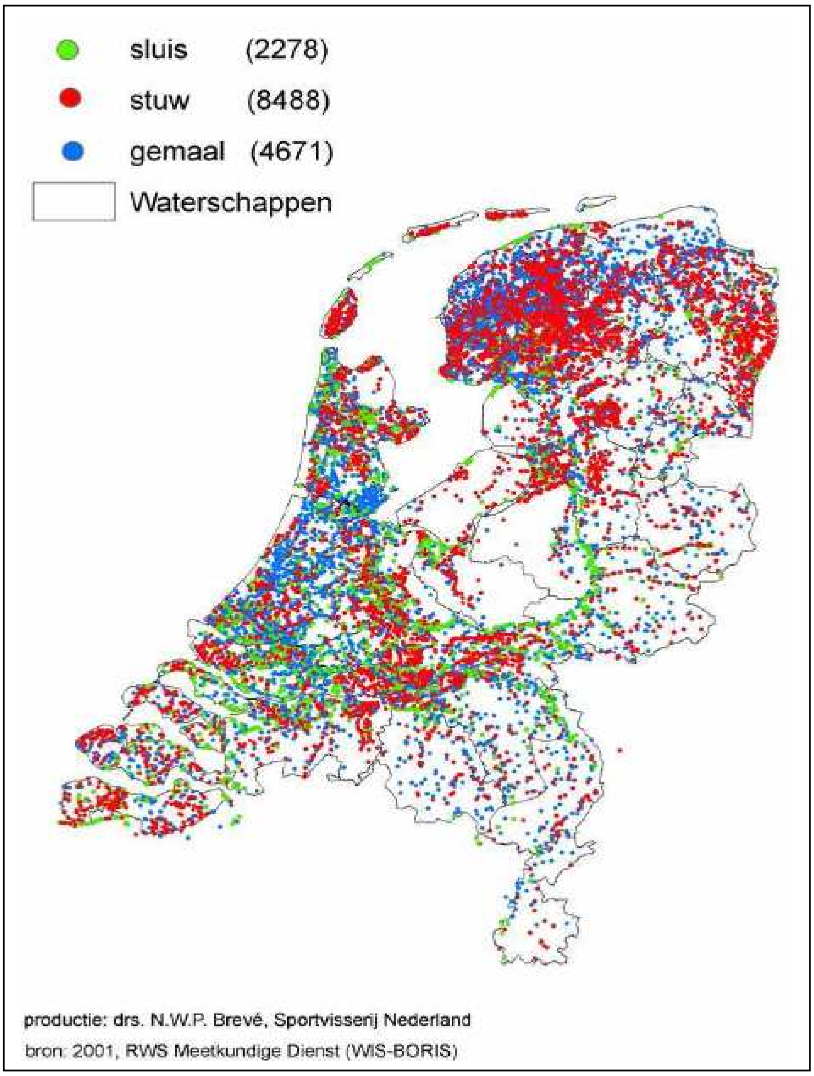

Figure 1.2.7. All identified physical obstacles for moving eel in the Netherlands. More than 13.000 absolute barriers are identified, in the form of 4671 pump stations (blue) and 8488 barriers/dams (red), many situated in small ditches. Green (locks) dots are not completely barring but may still form obstacles for passing eels. (Vriese et al., 2008).

Coastal and transitional waters

Coastal and transitional waters in the Dutch exclusive economic zone will also be managed under the Eel Management Unit. Measures directed at eel fisheries will equally apply to the fresh water zone as well as to the coastal and transitional waters (for example Wadden Sea, Estuaries in the South-West of the Netherlands) were commercial and/or recreational eel fishery is carried out. Direct measures for eel fisheries management in coastal and transitional waters will be managed within the EMU.

2. FOR EACH RIVER BASIN:

2.1. State whether river basins covered by the management plan are entirely in the national territory of the Netherlands

The Netherlands is located in the estuarine area of four different rivers that end in the North Sea. Four river basins are recognised as covering the Netherlands. All of the river basins in the Netherlands extend beyond the national boundaries. For reasons given in section 1), the Netherlands will provide one national eel management plan.

Meanwhile, discussion to integrate national eel managements plans within international river basins management plans has started. The Ministry of LNV actively participates in the respective international committees for each of the four river basins:

International Ems Commission, www.ems-eems.nl

International Rhine Commission, www.iksr.org

International Scheldt Commission, www.isc-cie.com

International Meuse Commission, www.meuse-maas.be

The international river commissions have existed for a long time, the Rhine Commission being the oldest, dating from 1950. The commissions were originally installed by nations to jointly combat pollution levels (phenols, salt level, etc). Work was subsequently extended to water quality in generic terms, but it remained directed at the abiotic rather than biotic components of the river. Although this is of great relevance to the habitat quality of *inter alia* eel, the commissions have therefore never been directed at accommodating associated issues like fisheries management. This justifies this EMP to cover the Dutch national territories of each of the four river basins (see section 1).

The most advanced on this subject is the International Rhine Commission, where coordination of eel management plans has started in the form of information exchange and workplans. A joint historical distribution map by all Rhine range states for eel is currently in preparation, and an overview of all priority barriers for the entire Rhine river basin. Parties to the Rhine Commission will screen the EC Water Framework Directive on relevance for the EC Eel Directive in terms of restoration of habitats and improvement of water quality. The Rhine Commission will also produce a strategy for the coordination of its member states in terms of eel management plans, aiming at further integrating the respective eel management plans. The other three commissions are still in an early phase of coordinating their work on management to support eels or other fish.

2.2. The status quo of the eel population in the Dutch EMU

The present situation of the eel population in the Dutch territorial eel management unit is provided here in trends. Absolute densities have never been reliably estimated, due to the complexity of the eel distribution. New catch per unit effort (CPUE) series for eel were started in 1992, operated under national authority by the national research institute IMARES (formerly the RIVO fisheries institute).

In the Netherlands, eel fishing is concentrated in the following areas:

- The Waddensea (bordering the **river basins of Rhine and Ems**);
- Lake IJsselmeer (**Rhine basin**);

- two main rivers **Rhine and Meuse**;
- Zeeland province in the Southwest, where the rivers Rhine, Meuse and Scheldt flow into the North Sea (**basins of Rhine, Meuse and Scheldt**);
- remaining waters, 1340 km^2 of lakes, smaller rivers and canals (**all basins**).

There are four data series that contribute to the understanding of eel abundance and trends in abundance in The Netherlands:

1. The annual survey for glass eel in Den Oever has taken place since 1939. This location is in the middle of the Rhine estuary, indicator of the eel density in the river Rhine basin. Figure 2.2.1 shows the resulting time trend, both in terms of a moving average (grey area) and an annual index.
2. Surveys in the "IJsselmeer and Markermeer", by far the largest water bodies in the Netherlands, with 100% coverage since 1992.
3. The "big rivers" survey, conducted since 1992, see figure 2.2.2.
4. Coastal waters survey. All coastal waters are sampled annually since the late1960s. The survey is known as the Dutch Young Fish Survey, figure 2.2.3.

The yellow eel surveys are not representative for the whole River Basin Districts or the country, especially since the smaller water bodies (canals, polders, regional lakes) are not surveyed; these waters cover nearly 25 % of the total water surface, but probably constitute the preferred eel habitat. The main Rivers surveys are probably reasonably representative for the rivers. But Lake IJsselmeer and the main Rivers differ substantially, so it is not yet clear how the two should be weighted, and how the uncovered waters relate.

There are no routine surveys for silver eel in the Netherlands. In 2004-2007, the German states Nordrhein–Westfalen and Rheinland–Pfalz, and the Netherlands jointly conducted a silver eel tagging study in the Rhine, in order to (1) quantify the female part of the whole downstream migrating Rhine silver eel population independently from fisheries, and (2) determine the relevance of the different migration routes of these female migrants in the Lower Rhine, the mortalities during downstream migration and the escapement to the sea.

The length and consistency of the combined experimental time-series, which are all independent of fisheries, make them useful indicators of the eel population status. In particular the prolonged low numbers of glass eel indicate that the eel population is at an historic low.

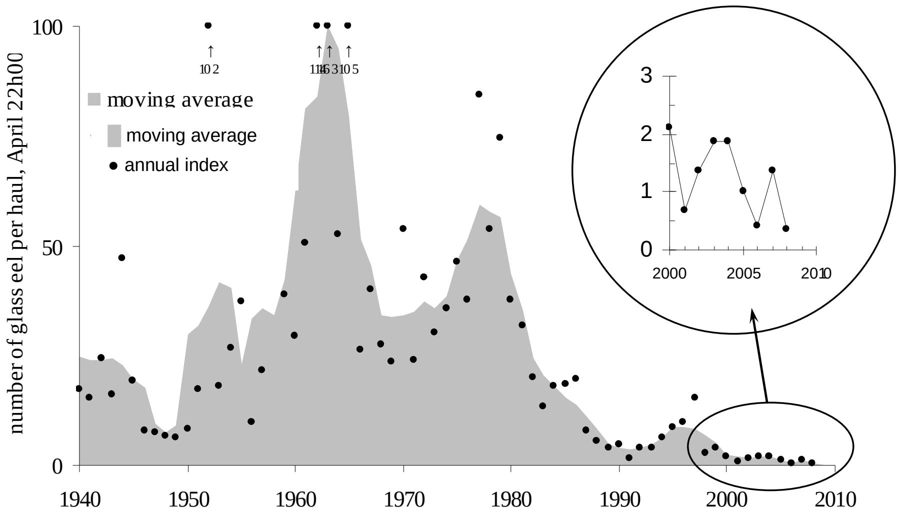

Figure 2.2.1. Time trend in glass eel surveys. The y-axis denotes the number of glass eels per haul at a set location over more than 60 years. Source: Dekker et al., 2008.

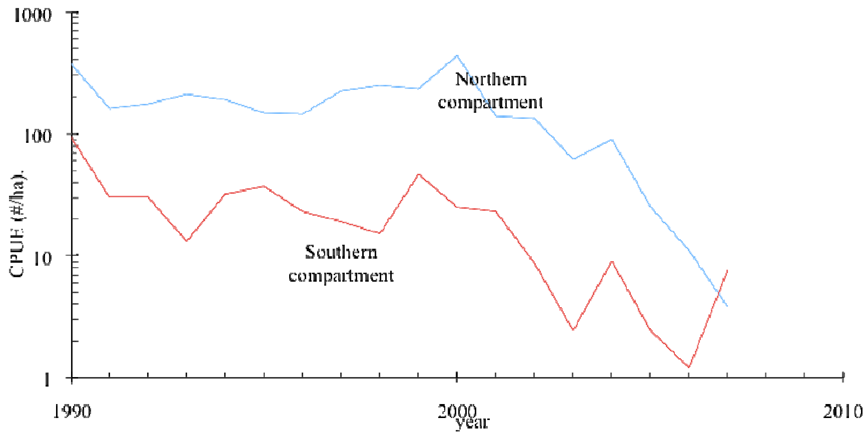

Figure 2.2.2. CPUE in two main water bodies, IJsselmeer and Markermeer, since 1990, presented as raw data per year. The downward trend is marked. All survey information from monitoring is site-specific (Dekker, 2008a).

It is generally acknowledged in the scientific community in the Netherlands that local eel densities are not necessarily representative of the eel abundance. The index of the glass eel survey (figure 2.2.1) should therefore be attributed more value than the other trends as indicator of eel abundance, at least in the Rhine.

Monitoring and registration intensity determines accuracy of population assessments and the impact of management measures. In addition, mark-recapture experiments have contributed to the present understanding of eel abundance in the Netherlands in Meuse and Rhine. Hundreds of silver eels were marked and recaptured down the stream. Enough numbers/recaptures can provide mortality estimates. A more reliable method is telemetry tagging, detecting individuals when passing detection stations.

In summary, while the available information does not allow a reliable estimate of the eel population status, the CPUE-indices and glass eel surveys confirm the existing circumstantial evidence that the current eel status is extremely low. The same conclusion can be drawn from current escapement levels, which are about a factor 10-15 lower than the estimated pre-1980 levels (see section 5.1).

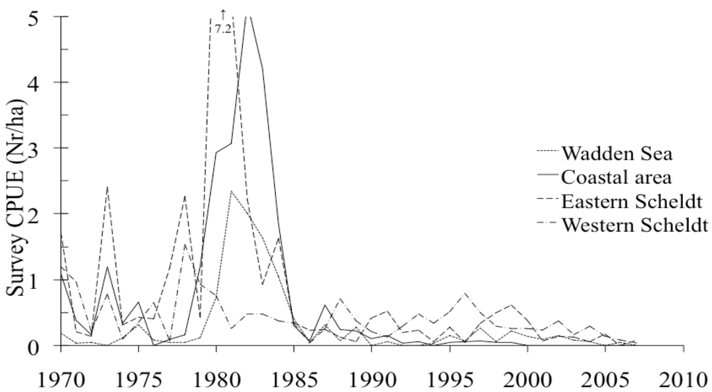

Figure 2.2.3. CPUE-series for eel in the Dutch Young Fish Surveys. Note that this survey is not dedicated to eel alone but to all young fish (Dekker et al. 2008).

2.3. Description of the eel fishery in each river basin

- A quantitative and qualitative description of the eel fishing units

Table 2.3.1 provides annual catches of professional eel fishery in 2004. Estimates are provided by river basin anticipating the collaboration for eel management by river catchment areas. There is no catch of glass eel in The Netherlands because the legal minimum size for eel fishery in the Netherlands is 28 cm.

Yellow eel		Rhine	Meuse	Scheldt	Ems	TOTAL
coastal		37	75		3	115
IJsselmeer		240				240
Large rivers		46	4			50
Other inland waters		222	4		9	235
Total		**545**	**83**		**12**	**640**
Silver eel						
coastal						
IJsselmeer		40				40
Large rivers		91	9			100
Other inland waters		133	2		5	140
Total		**264**	**11**		**5**	**280**
TOTAL EEL	total # of companies					
coastal	70	37	75		3	**115**
IJsselmeer	70 *	280				**280**
Large rivers	23	137	13			**150**
Other inland waters	58	555	6		14	**375**
Total	**237**	**809**	**94**		**17**	**920**

Table 2.3.1. Total estimated landings (tonnes) of professional eel fisheries in The Netherlands, per river catchment. This table is a rearrangement from Dekker, 2008. [* see text below]

Fishing units

Fishery in the water bodies of "IJsselmeer and Markermeer" is operated as an open access fishery, while the other fishing areas are categorised according to individual licence holders, based on spatial distribution of waters (territorial fisheries).
Table 2.3.1 lists the number of fishing companies with an eel fishing license, by fishing area. For marine waters and Lake IJsselmeer, a vessel register is kept, but for the other waters no central vessel registration is required because the vessels are very small. Registration of the number of gears owned or employed is available for Lake IJsselmeer, but lacking for other fishing areas. For Lake IJsselmeer, a maximum number of gears per company is enforced by authentic tags attached to individual gears, but the actual use is often much lower, *inter alia* since restrictions apply to the combinations of types of fishing gears.
Table 2.3.2. presents estimates of the numbers of gear-types and fishing units that are permitted/used in The Netherlands in 2007. Estimates are partly based on information, and partly extrapolated from this information. In the column "other inland waters", there is no information for some 40% of the fishing units. Fishing effort can only be partly quantified, because some of the gear-types are not registered.

Gear	IJsselmeer Markermeer	rivers	coastal waters, professionals	other inland waters	coastal waters, recreational	Total
large fykes	1,579	155	-	+		> 1,734
cage fykes		163	574	+		> 737
shooting fykes	3193	2,433	273	+		> 9,052
small fykes		51		+		> 2,007
pots&traps	7415	551	+	+		> 7,966
longlines	11		+	+		+
electric scooping nets		+	-	+		+
other “eel-gear”				+		+
# of fishing units	70	28	48	around 100	978	around 1228
Area surface (ha)	169,150	20,867	354,959	134,966	354,959	679,942

Table 2.3.2. Gear-types used in the eel fisheries in the Netherlands, with estimates of the numbers used for each gear type.

Fishing effort

Current total fishing effort is not recorded, since in most of the country fishing capacity is not known. In areas where fishing capacity is known, no record has been kept of the actual usage of fishing gears. Consequently, no exact information is available on fishing effort. For Lake IJsselmeer, an estimate of the number of gears actually used is available for the years 1970-1988. In the mid 1980s, the number of fykes was capped, and reduced by 40 % in 1989 (see Dekker, 2008a). In 1992, the number of eel boxes was counted, and capped. Subsequently, the caps have been further reduced in several steps, the latest being a buy-out in 2006. Since the number of companies decreased at the same time, the nominal fishing effort per company has not reduced at the same rate, and underutilisation of the nominal effort probably still exists. The effort in the longline fishery is restricted by the number of licenses.

Quantitative description of the recreational fishing in inland waters

Note: The catch of recreational fishers discussed in this section is defined as the eel catch that is taken home, excluding eels that are returned to the water.

There are two determining factors in estimates of recreational eel fishing: the total number of fishermen and the total number of eel taken. The latter is dependent on the fishing frequency, which greatly varies amongst the fishermen. For mortality estimates from recreational fishermen, a derivative factor of interest would be the survival rate of those eel that are returned. The number of fishermen and the number of eel they take have been estimated in interview surveys in 2002, 2004 and 2006. In addition, an internet survey in 2007 was carried out by the fisheries institute IMARES.

Recreational catches of eel are not systematically recorded, and the order of magnitude is not well known. Surveys amongst fishermen about angler licensing in 2003 indicated that 350,000 out of 913,000 male anglers fish for eels; 57,500 of them take eels back home, in an average annual quantity of 18 specimens, approx. 1 kg per capita per annum. The number of female anglers is much lower, but not exactly reported. Additionally, some 1000 individuals are licensed (by the minister of LNV) for recreational fishing in coastal waters on mixed species, including eel. This fishery makes use of professional gear such as fykes. In coastal communities the issuance of these licenses is considered as an historical right. Assuming 50 fishing days per year, and a daily catch of 0.5 kg per fyke, their catch will be in the order of 25 tonnes.

Sniggling is a form of angling especially targeted at eel. It is usually practiced at night, in the period spring-autumn.

Sea angling is becoming more popular in the Netherlands, and a survey was commissioned in 2006 amongst 30,000 households to investigate the intensity, frequency, participation, catches and expenses of sea angling (Vriese *et al.*, 2008). Less than 10% of the sea anglers lands eels. The data yield an estimate of 50-250 tonnes of landed eels per annum.

	Individual catch kg/year	**# of individuals**	**Total catch tonnes/year**
Recreational (small fykes)	25	1000	25
Sniggler†	2.650	3,773	10
Anglers inland	0.15	47,000-193,000	7.5-29
Anglers at sea	0.1-0.5	505,000	50-252
Totals		557,000-703,000	93-317

† translation: sniggle=peur.

Table 2.3.3. Breakdown of landed eels (eels taken home) by recreational fishing and the type of fisherman. Data from Vriese et al. (2008), Dekker et al. (2008) and guessed "estimates".

A preliminary breakdown of catches by the type of fishers is given in Table 2.3.3. The total quantity of eels taken home has recently been analysed (Vriese et al., 2008), by applying a range of correction factors on the available catch information. The authors arrive at an order of magnitude of 200-400t per annum, stating that circumstantial evidence indicates that the true figure may be rather closer to 200 tonnes.

2.4. Estimates of the potential downstream escapement in the absence of human factors and relationship with recent levels

Potential escapement levels

Human impacts on eels are centuries old, both in form of fisheries and of the human adaptations to waterways. Therefore, actual data on escapement levels in the absence of human factors do not exist.

Based on catch data from Lake IJssel fisheries, and samples of eels collected from the Lake IJssel fish auctions, Dekker et al. (2008) calculated the potential escapement of silver eel from this lake to be 3080 tonnes.

Subsequently, the potential escapement of silver eel from the Netherlands was estimated in a study by Klein Breiteler (2008). This analysis is based on historic fishery data (method Article 2, sub 5a of EC 1100/2007) and based on the potential production area for eel (method Article 2, sub 5b of EC 1100/2007).

The eel catch from fisheries is considered as the minimum estimate of the biological production. By this way the potential production for different water bodies is calculated:

- 10-16 kg/ha for small water bodies and canals

- 19-25 kg/ha for lakes
- 4 kg/ha for coastal waters
- 25 kg/ha for flowing waters.

The production area is given in Dekker (2007). The assessment included some major implications of human impact, namely the building of coastal dams and reclaiming land out of the Zuiderzee (Lake IJsselmeer), which was first closed from the Waddensea in 1932. In the original situation the eel production would have been lower because of the saline water conditions. Given the potential biases in both directions, the estimates for the total escapement without human impact are provided as 10,000-15,000 tonnes of silver eels. These are minimum estimates and the actual volumes may be twice as high (Klein Breiteler, 2008). The aspired escapement of silver eel would then become 40% of this, *i.e.* 4000-6,000 tonnes. In Annex 1 the full analysis of the potential downstream escapement from the Netherlands in the absence of anthropogenic mortalities is given.

However, following the publication of these reports a debate has started on the assumptions and used methods on which the above calculated escapement rate is based. An independent commission has reviewed this, and published a report "streefbeeld aal" (Eijsackers te al, 2009). The commission concludes that the calculated escapement targets done by Dekker and Klein Breteler are based on scientifically acceptable methods, but that these methods are less suitable for the calculation of a reference level without human impact. Furthermore, effects of factors like density-dependent growth and mortality, eutrofication and cormorants, have not been taken into account sufficiently. The commission therefore states that an exact escapement target can not be defined for the Netherlands because of a lack of available data, the high variation in eel numbers, and the large amount of factors that influence the eel numbers. Indicative, the commission argues that the aspired escapement of silver eel lies within the range of 2600-8100 MT, and most probably lower than the previously calculated rate of 4000-6000 tonnes.

Verwijderd: .

Preceding the decision of the European Commission to approve or disapprove of the Dutch eel management plan, ICES evaluated the scientific assumptions on which the measures described in the plan are based.

ICES is of the opinion that the density dependent factors as mentioned by the commission Eijsackers are weaker than indicated and that the carrying capacity is higher than suggested. According to the ICES advice, the estimate for the total escapement without human impact is set at 13,000 tonnes of silver eels. The aspired escapement of silver eel would then become 40% of this, i.e. 5200 tonnes.

Current escapement levels

The current escapement level from Lake IJssel is estimated at 11 ton (Dekker et al. 2008).

The current escapement level for the Netherlands was estimated using a combination of different methods: (1) calculation on the basis of a reference level, estimated trends and human induced mortality factors, (2) mark recapture studies, in recent years complemented in the form of telemetry, and (3) modelling exercises to back-calculate the original population size with estimates of current densities and mortality rate.

The available area for eel production has substantially changed in the 20th century, since with the building of dams and dykes in many places in the Netherlands, the fresh water area, and therefore the area available for eel production, increased dramatically, while at the same time the barriers for eels reaching those areas decreased. The estimation method is a combination of the processes in Article 2.5 of EC Regulation 1100/2007. Descriptions of the method are presented in Klein Breiteler (2008). While the expected precision of the estimates seems limited, the order of magnitude of the actual values is expected to be not entirely out of scale.

While recognising the high levels of uncertainty, the scientific authorities estimate the current escapement levels to be 400 tonnes of silver eel. Of this, about 200 tonnes originates from neighbouring countries, mostly from the Rhine basin, and 200 tonnes is produced in the Dutch national waters (Klein Breiteler, 2008).

Further details are given in Annex 1.

Current potential escapement given a total fishing ban

On average 1120 tonnes is caught in the commercial and recreational fishery. If this fishery is stopped the potential escapement corresponds to at least this amount plus the 200 tonnes already escaping giving an estimate of 1320 tonnes of silver eel escapement. To estimate potential escapement without anthropogenic mortality 61-167 tonnes (Table 2.4.1) must be added to the current potential escapement given no fishing, for mortalities from hydropower and water pump stations, plus an unknown fraction of mortality related to barriers. This will result in a 1381-1487 tonnes plus an unknown fraction due to barriers.

2.5. Conditions of the eel habitats and mortality sources other than fishing

Scale of eel habitat

On the basis of a GIS-analysis, the surface and length of habitat-types for eel have been estimated (Kroese *et al.*, 2008). Eel is found in all water categories (coastal, transitional, river, lakes as well as man-made water bodies). According the Netherlands typology of water bodies developed for the WFD, the most likely river types for eel in the Netherlands are considered to be R5, R6, R7, R8 and R16. Rivers are both important as habitat and as migration corridors. The scale of the habitats can be measured using the M-categories that are the stagnant water bodies. The largest areas of eel-habitats are M21, M14, M27, M32 and M20, comprising 2575km^2 (88%) in total. Of the man-made waterways, types M3, M30, M6, M10 and M7 form 8800km (88%) of the total length which are both important habitats and migration routes.The coastal water types K1, K2 and K3 apply for eel, as does the transitional category O2.

Reduced tidal movements

The intensively regulated water systems in the Netherlands have resulted in major changes in the tidal systems in rivers and estuaries. This particularly took place in the 20th century, but already long before that have the Dutch been reclaiming land and building dams to regulate water, with serious impacts on freshwater fish populations including eel. Tidal effects on the edge of salt/fresh water have disappeared, due to redirected waterways, dams and barriers. The influx of glass eel is dependent on tidal currents in order to migrate up rivers, so this has serious consequences for local accumulations of glass eels in coastal zones (Dekker & van Willigen, 2000).

Barriers

The Netherlands is a densely populated country, with an intensive use of the natural resources. Situated in the joint delta of four different river basins, the country is extremely rich in waterways providing potential habitats for eel. The intensive use of the country has generated enormous numbers of barriers for eel migration, as can be seen in figure 2.5.1, which is both update of figure 1.2.7 and at the same time a selection relevant for eel. It provides an overview of the available eel habitat, migration routes and physical barriers. The study (Buijse et al 2008) concluded that of the 2700 identified barriers, 1800 are of particular importance for the migration of eels. The map shows within which time period certain barriers will be solved (red dots before 2010; purple dots before 2015; orange dots after 2015; black dots still to be planned). The green dots indicate that the barrier has been removed, or that a fish migration device has been installed.

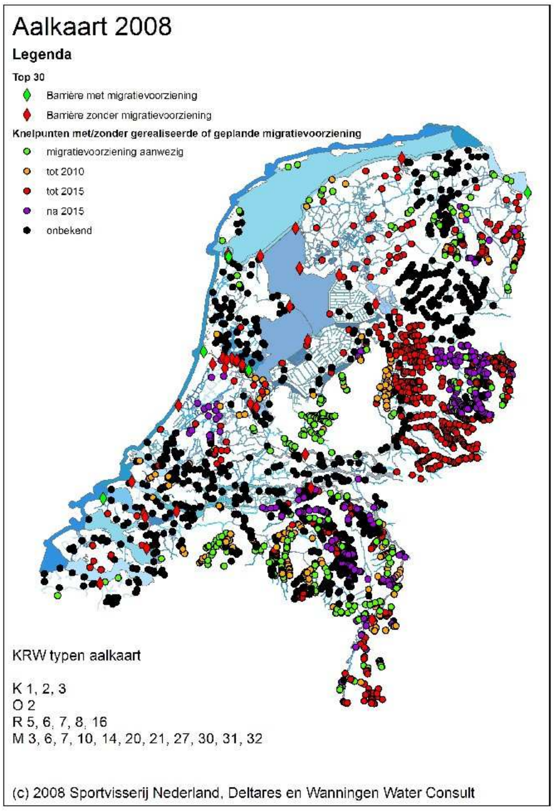

Figure 2.5.1. Barriers for eel migration in the Netherlands, and planned solutions (Buijse et al. 2008). Some 40 locations are considered most important, because they give access to large inland water areas. Near 255 barriers a migration facility is already in place. The planning foresees 136 new facilities by 2010, 538 by 2015, 239 by 2027. For 608 it is yet unclear whether migration needs to be and will be improved.

Hydropower stations

There are six hydropower stations in the Dutch part of the river basins of the Rhine and Meuse, three of which are a factor ten larger than the others, see table 2.5.1. This concerns the stations in Lith, Linne and Amerongen, which are all situated in the main stream of the river. All of these stations have been equipped with fish passes in order to allow for upstream migration.

river	location	company	registered power	annual production	year of first use
Meuse	Lith	Nuon	14.0 MW	44 Gwh	1990
Meuse	Linne	Essent	11.5 MW	35 Gwh	1989
Lower Rhine	Amerongen	Nuon	10.0 MW	24 Gwh	1988
Lower Rhine	Hagestein	Nuon	1.8 MW	3 Gwh	1958
Overijsselse Vecht	de Haandrik	Essent	0.2 MW	0.3 GWh	1988
Roer	Roermond	Nuon	0.25 MW	0.1 GWh	2000

Table 2.5.1. Main hydropower stations in the Netherlands.

The silver eel mortality and injury level due to hydropower stations has been monitored in the river Meuse. A recent telemetry study of migrating silver eel indicated a mortality range of 16-34% in two hydropower stations in the Meuse that are set in series, almost half of the total mortality that was observed in the study (Winter & Jansen, 2006). It is estimated that the mortality caused by each power station located in the Rhine is in the order of 18% (Vriese et al. 2008).

Pumping stations

There is no quantitative information on the effects on other obstacles like pumping stations that are used for water management, but it has recently been recognised as an important mortality factor. They can form effective barriers for any eel entering or leaving certain water bodies. The number of pump stations in The Netherlands (4671) is enormous, with a high density in the western low level part of the country, see figure 1.2.7. Limited information is only available for single site data in different types of stations, but a general feature appears that particularly large eels will have low survival rates. For the smaller pumps, there is little chance that any eel will pass through undamaged. Gathering information of eel survival in pumping stations has been identified as an important short term research subject.

Pollution and the proportion of eel affected by contaminants, pathogens and parasites.

Annually a study is conducted on a large set of contaminants in Dutch yellow eel. The most recent published results (Hoogenboom et al, 2007) show the occurrence of dioxins and dioxin-like Polychlorinated Biphenyls (dlPCBs). The catch locations formed a strong factor in the level of pollution. Particularly samples from downstream locations in the lowland rivers, e.g. Meuse, Rhine and Waal, showed the highest contamination. Hoogenboom measured the level of contamination by length class. It showed a correlation between length and dioxin levels.

Another study indicated that the reproduction capacity of the silver eels can be impaired by swim bladder parasites, EVEX-virus and PCBs, suggesting that contaminated eels contribute less to the recruitment of the species (van den Thillart, 2005).

Little is known about the effect of pathogens and parasites in the eel populations. Non-native parasites, particularly the swim-bladder parasite *Anguillicola crassus*, has become widespread in eels. It is estimated that after the initial outbreak in the late 1980s the rate of infected eels has stabilised, fluctuating between 40 and 60%. It is difficult to estimate quantitative effects to the eel survival rates (Dekker, 2004), but research is leading to an increased understanding.

Cormorants

Cormorants form a natural mortality factor and do not form an anthropogenic mortality factor. Nevertheless the increase in the numbers of cormorants has given rise to concerns amongst fishermen and is sometimes considered to be caused by human impact in the landscape. It was estimated that in the period 1995-2000 the number of eels consumed by cormorants was around 1% of the total catch by fishermen (Van Rijn & van Eerden, 2002).

Other factors

When water levels are low, there is an assumed increase of eel mortality by human induced factors such as propellers of vessels and cooling water from power stations resulting in high water temperatures. There are no quantitative data for these factors, but they are likely to occur in the summer when little migration of silver eel takes place.

Summary of factors

In table 2.4.1 the effect of the different factors on eel mortality is indicated. The factors appearing as major contributors to pre-escapement mortality are professional fisheries and water pumps and hydropower stations (Dekker, 2007).

	mortality silver eel (tonnes)	mortality yellow eel (tonnes)
mortality factor		
Migration barriers	No data available	No data available
Hydropower stations	15.5	3.5
Water pumps/pump stations	15-65*	27-83*
Fisheries – professional	280	640
Fisheries - recreational	0	240-400
Complexity of factors	17	No data available
dioxins and dioxin-like PCBs	No data available	No data available
Cormorants	0	50

* depends on fisheries mortality

Table 2.4.1. Estimated mortality attributed to different factors (Vriese et al., 2008). Estimates are considered to be the best available, despite being recognised as being very rough and requiring more accuracy in the future.

3. RESTOCKING

3.1. Quantitative and qualitative description of restocking carried out in the past, per river basin

Glass eel and young yellow eel have been used for re-stocking inland waters since time immemorial, mostly by local action of stakeholders. Since World War II, the Organisation for the Improvement of Inland Fisheries (OVB) has organised a re-stocking programme, importing glass eels from France and England, and buying yellow eel from commercial fishermen who were fishing in the downstream rivers and in the Waddensea. Domestic supplies declined in the 1970s. In recent years the global availability of glass eel sharply declined. Because of this and the associated price increase, the re-stocking of glass eel has become very small in recent years. Data on re-stocking quantities are listed in table 3.1.1. Average weight of the young yellow eel amounts to approx. 33 grams (Dekker, 2008a).

DECADE	1940		1950		1960		1970		1980		1990		2000	
Year	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	0.1	0
6	7.3		23.1	0.7	8.9	1.1	18.0	0.5	10.5	0.7	1.8	0.2	0.582	0
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	0.216	0
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	0	0.230
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		

Table 3.1.1. Re-stocking of glass eel and young yellow eel in the Netherlands (millions). Columns depict the decades, rows the years in those decades. Conversion from weight into numbers implied the assumption of 3000 glass eels per kg, resp. 30 young yellow eels per kg. As examples: In the year 2003 there were 1,600,000 glass eels released and 100,000 young yellow eels; in 2008 people released 230,000 young yellow eels (Dekker, 2008b).

Location	Water	Year	Supplier	numbers
Friesland	Polderwateren het Grootslag en De Vier Noorderkoggen	2006	Various	10,000 (trianniel)
Utrecht	Wateren rond Nijkerk	2007	AquaFarm	30,000
Gelderland	Veluwemeer	2007	FPZ Harderwijk	20,000 (2,000 tags)

Table 3.1.2. Restocking locations in 2006 and 2007. These eels all originate from aquaculture.

3.2. Quantitative and qualitative description of restocking in the future eel management plan

Restocking will be one of the management measures of the Dutch eel management plan. Restocking has never been applied in a structured approach, nor has evaluation taken place in the past. The effects of restocking will only be noticeable after a considerable number of years.

A group of stakeholders recently established an independent foundation, *Future for Eel*, with the purpose to take the necessary concrete steps towards stabilization and recovery of the eel population in the Netherlands. This foundation is a partnership of eel fishery, eel aquaculture, eel processing and eel traders, under the umbrella of the Dutch Fish Production Board (www.futureforeel.nl).

The basis for restocking of eel in the Netherlands will be the protocol in figure 3.2.1. More than twenty habitat factors have been identified. Of these, a number could be generally applied, while others are specific for certain locations. Most of the location specific measures have insufficient scientific basis to be used, but this does not imply that they are not considered important. The most influential abiotic factors in Dutch waters are acidity (pH=4 – 9) and oxygen content (always > 3mg/l, often > 5mg/l).

It is generally accepted that the current human induced mortality cannot be entirely compensated by restocking. Restocking in the Netherlands would therefore be only one amongst more measures that are intended to contribute to the improved escapement of silver eel or as compensation of human induced mortality.

One can distinguish between measures with effects at a national level and those with effects at a local level. Klein Breiteler (2008) assesses the main factors that are to be considered in the restocking policy in the Netherlands.

The protocol has been recently assessed according to a list of ecological considerations:

- 25 different environmental factors, the majority being pertinent at a local level;
- Inter-specific interactions (the effect of restocking eel on other species);
- Quality of restocking animals and of the restocking procedure;
- Carrying capacity and existing density of the area to be restocked;
- Genetic and pathogenic considerations;
- Effect of restocking on the ecosystem.

In addition, there are considerations related to fisheries and other socio-economic factors, and the limitations to the implementation. For implementation, one needs to take account of:

- The availability of restocking material;
- Transport opportunities and limitations;
- Institutional support;
- Financial support;
- Ownership.

Finally, there are risks and uncertainties associated with many of the aforementioned factors. The restocking protocol addresses all the factors and, with the necessary evaluation processes, aims at the best possible decisions.
To summarize, the Netherlands will use restocking as a management measure. To minimize the ecological risks associated with restocking, the above mentioned protocol will be the basis of all restocking programmes.

Restocking is coordinated by the foundation “future for eel”. This foundation collects financial contributions form private companies. The ministry of LNV intends to co-fund the restocking programmes of the foundation through a yearly subsidiary of €300,000 from the European Fisheries Fund (EFF). Together with private contributions it is estimated that an annual budget of €500,000 - €800,000 will be available for restocking. Given an estimated glass eel price of €500/kg, it will be possible to purchase 1000-1600 kg glass eels. It is expected that the actual figure will be lower since not only glass eel will be restocked, but also pre-grown eel from aquaculture less that 20cm of length. Furthermore, EFF funding for restocking purposes can only be made available after the Dutch eel management plan has been accepted by the European Commission.

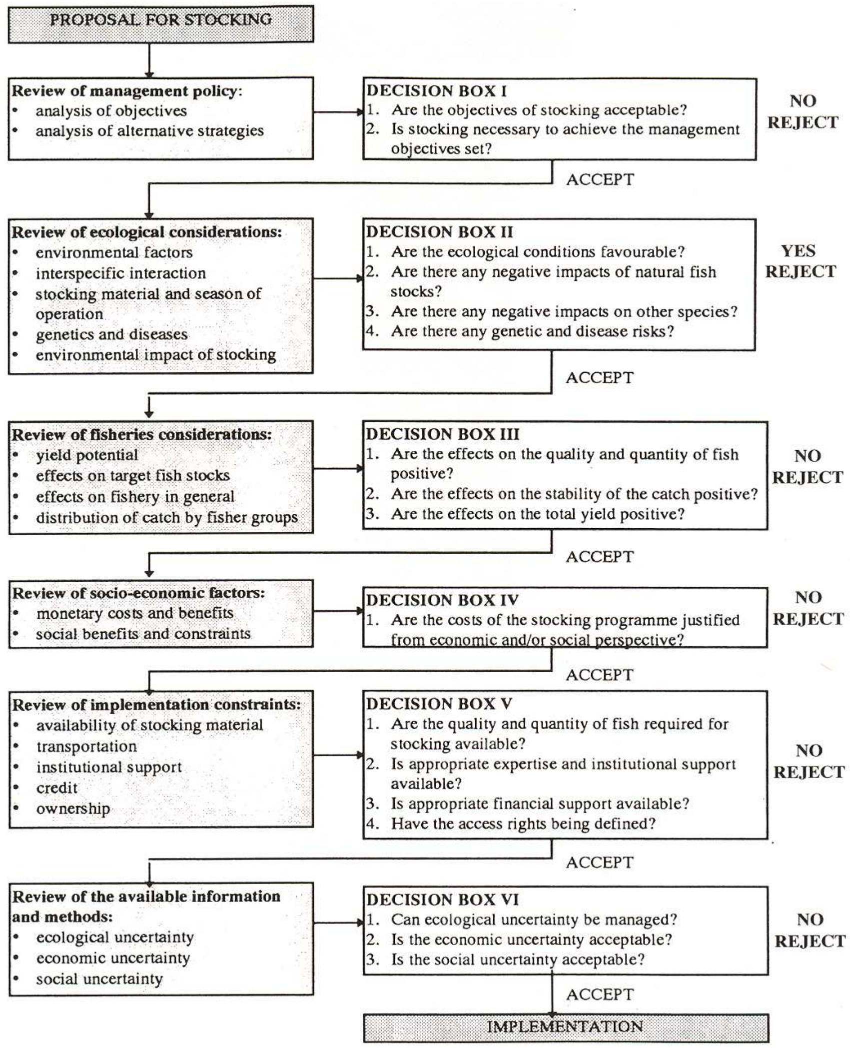

Figure 2. Scheme for planning stocking programmes. The review boxes on the left illustrate the different levels of data collection and processing, and the decision boxes on the right show the respective decision levels with some relevant question. Stocking should be rejected if any answers to the questions are unacceptable (adapted from EIFAC 1994).

Figure 3.2.1. A protocol for restocking by Cowx from 1999, as provided in Klein Breiteler (2008). The author emphasises the importance of evaluation of restocking proposals and of results.

3.3. Identify the geographical areas for restocking and choice of locations

The geographical areas to be restocked will be identified according to the protocol described in 3.2. One of the most important conditions in the protocol is that the eels are to be stocked only in water bodies from where free and safe migration to sea is possible or where provisions have been made at migration obstacles in the migration routes to the sea. Restocking will not be done in closed water bodies from which eels can not migrate to the sea.

- *Explanation of the choice of restocking locations to contribute to 40% escapement target. Quantitative estimate of the contribution of restocking towards the 40% escapement target.*

A quantitative estimate of the contribution of a suite of measures to improve escapement is provided in Klein Breiteler (2008). According to this report restocking with glass eels will result in 100 ton of silver eel escapement in 2027. This figure is based on an available budget of €300,000 per year. If additional funding from private parties (see 3.2) will become available, the figure could double.

- *Quantification of surface area to be restocked*

The assessment according to the protocol that is described in 3.2 should also clarify the surface areas for restocking. It is expected that *Future For Eel* will identify the surface areas from 2009 onwards, once the Eel Management Plan for the Netherlands has been accepted by the European Commission. Given the estimated available budget for purchase of glass eels, and the preferred restocking density of 250 glass eels per hectare (Klein Breiteler, 2008), a potential area of 10,000-16,000 ha can be restocked with glass eels.

3.4. Estimate of eels <20cm needed for restocking

See also sections 3.3 and 3.4. The foundation *Future For Eel* is intended to coordinate the necessary activities for *inter alia* restocking from 2009 onwards, including the estimation of eels <20cm needed for restocking.

3.5. Percentage of caught eels < 12cm to be used for restocking in The Netherlands

There will be no restocking of wild caught eels <12 cm, because no eels <12cm are caught in the Netherlands. The legal minimum size for eel fishery in the Netherlands is 28 cm. Therefore this percentage is zero (0%).

3.6. Description of system to ensure that by 2013, 60% of wild caught eels < 12 cm are used for restocking

Not applicable, since no eels <12cm are caught.

4. MONITORING

4.1. Monitoring the actual and future escapement

Monitoring of actual escapement has started in recent years. Mark recapture experiments and telemetry with radio tags have been the two techniques for estimating downstream mortality, assisting in the estimation of escapement rates of silver eels. Telemetry is considered to be the more reliable and promising technique.

Telemetry studies in recent years have shown causes of human induced mortality of silver eels downstream (Winter and Jansen, 2006). The estimations are expert judgements of attributing the category "unknown" to any of the other categories.

	2002 (n=121)		**2004 (n=105)**	
	Observed (%)	estimated (%)	observed (%)	estimated (%)
Successful passage to sea	37	>37	31	>31
Professional fisheries	15	21-25	13	19-22
Recreational fisheries	1	1	2	3
HPS*	9	16-26	21	25-34
- direct	9	9	21	21
- indirect	-	7-17	-	4-13
"unknown"	38	11-25	35	10-22

* hydropower station

Table 4.1.1. Observed and estimated mortality ratios of silver eels, results from radio telemetry studies. These indicate (see top row) that 30-40% of the marked silver eels were successful in escaping into the sea. Two factors seem major contributors to the pre-escapement mortality: professional fisheries and hydropower stations (Dekker, 2007).

EC Regulation 1100/2007 has the objective that 40% of the escapement in natural conditions is successful. According to Article 2.5.sub a, any most appropriate year pre-dating 1980 may be taken as a reference year. Note that in table 4.1.1 the successful escapement rate (37% and 31%) denotes the escapement of the current level of silver eel. Since the current population size of silver eels is estimated at less than 1% of the natural population or any pre-1980 level, it is generally assumed that accordingly the escapement rate is very low as well.

Unfortunately, telemetry studies are too expensive and require expertise that is currently non-existent to be applied at a large scale in either time or space. Therefore, an individual-based model will be developed and applied that takes account of both temporal and spatial and variations. It is generaaly acknowledged that the distribution of eel differs greatly among waterbodies, as are the eel catches. The model will take account of management that is specific for locations/regions and the appropriate sustainability criteria. This research work has been started in 2008 and will continue into 2009. One of the key activities will be a pilot project on eel monitoring in a selected area. At the end of 2009 the results will be statistically analysed, and a nation wide eel monitoring programme will be established. The Netherlands will inform the European Commission on the proposed eel monitoring programme as soon as the research works have been completed.

Price monitoring and reporting system for eels < 12 cm

It is forbidden to catch eels less than 28 cm, so there is no glass eel fishery in the Netherlands. Therefore, there is no need to establish a system for the monitoring of glass eel prices in the Netherlands.

4.3. Sampling system for catch and effort data

Data of eelcatches and stockassesments of eel are only available within the framework of a stock monitoring programme in State controlled waters. Starting in 1993, the fish assemblage in the main rivers and linked waters has been monitored. This has been done by means of logbook registration of commercial catch and by-catch, in a restricted number of fyke nets (four large fyke nets or two pairs of summer fyke nets per location), mostly on a weekly basis. See section 2.2 of this report for a full description of CPUE-recordings. For eel, the numbers of yellow eels and silver eels caught are recorded. Results show that the quality of the data is not enough to generate a particular trend over the years, and the year-to-year variation is considerable. There is no formal application of these data in eel fisheries management, but the results have frequently been quoted in the debate on the status of the eel stock. This monitoring programme is operated under the governmental responsibility for monitoring state-managed waters, and is executed by the public research institute IMARES.

Eelstock assesments are conducted annually for Lake IJsselmeer and for the main streams of the rivers Rhine, Meuse and IJssel. These assesments are conducted under governmental responsibility. The stock-surveys give representative data of the eel abundance and trends in abundance in the indicated large waterbodies. Information on eel abundance in the remaining (smaller) waterbodies are at this stage not yet available.

In addition it is compulsory for all commercial fisheries within Lake IJsselmeer to land all caughtfish (including eels) at specific designated auctions. Consequently, data on eel landings are available. Such a system is not in place for eel fishery elsewhere.

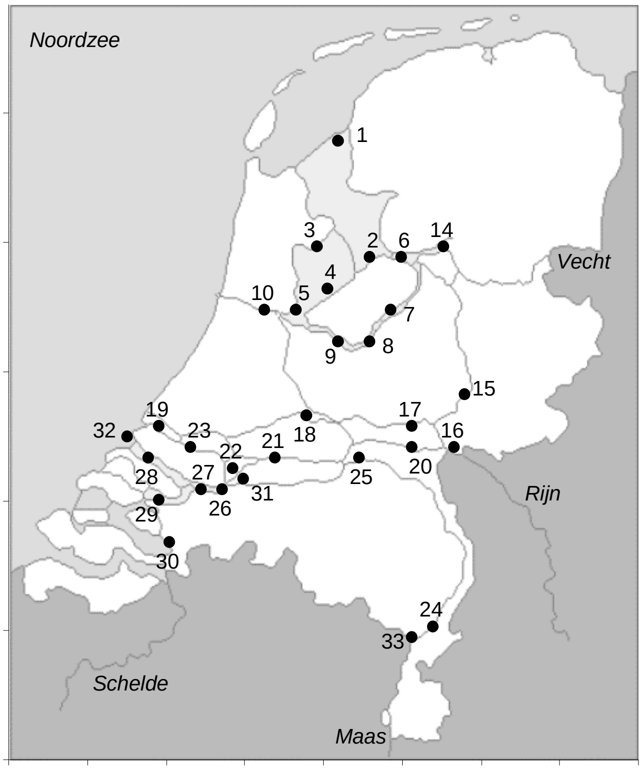

Figure 4.3.1. Sampling sites for the 4-fyke monitor programme of commercial catches and by-catch (Dekker, 2008a).

To summarize, information on eelstocks and eelcatches are at this stage only available from specific waters (mainly the large waterbodies), a centralized sampling system for all eel catches and effort in all waters is currently not yet available. An inventory of the existing experimental projects on monitoring of catches was carried out in 2008, in combination with a future monitoring programme that is intended as an integral component of this eel management plan (see 4.1). It is clear that a paper logbook as is being used in marine fisheries is not practical for the small-scale inland eel fishery. Therefore in 2009 it will be investigated if a PDA-based catch registration system can be developed. The set-up of an overall sampling system of eel catch and eel fishery effort with regard to the requirements of the European Data Collection Regulation (EC 1639/2001) will be tested in a specific pilot in 2009, and will only be available from 2010 onwards. The Netherlands will inform the Commission as soon as the research works have been completed.

4.4. Description of measures to:

b. Identify the origin and traceability of all live eels imported and exported outside the Community area

In the articles 7 and 8 of the national regulation “Uitvoeringsregeling visserij”, which is based on the 1963 Fishery Law, is regulated that an administration of every supply or storage of more than 5kg of eel, and its origin, should be kept by suppliers and professional buyers of eel.

In article 2.1.5 and 2.1.6 of the national regulation “Regeling aquacultuur” it is obliged that aquaculture production businesses and authorised processing establishments keep a record of all movements of aquaculture animals. This in accordance with article 8 of Directive nr. 2006/88/EC.

Also, article 18 of Regulation (EC) nr. 178/2002 (General Food Law) obliges the traceability of food-producing animals at all stages of production, processing and distribution. By virtue of article 113a of the regulation “Regeling preventie, bestrijding en monitoring van besmettelijke dierziekten en zoönosen en TSE's” it is prohibited to violate article 18 of the regulation.

From March 2009 onwards the European eel (A*nguilla anguilla*) will be listed on Appendix II of the CITES Agreement and the Annex B of the basic CITES regulation (EC 338/97). Any exports from the Community will have to be consistent with article 5 of EC 338/97. For all species listed on Annex B, including eel, this means that:

- In and export outside the Community area will only be permitted with a permit
- Trade in eel will only be possible if the legal origin of the eel can be determined.

The Netherlands will adapt the national legislation in order to accommodate these requirements. Accordingly, the Netherlands will comply to the requirements of article 12 of the European Eel Regulation.

c. Determine whether eel harvested and exported outside the Community area were caught in consistency with Community conservation measures.

Under CITES regulation export outside the Community area can only take place if a “non detriment finding' can be made. At this moment the Scientific Review Group of CITES is discussing if, given the present state of the eel stock, such a non detriment finding can be issued. Even if it is decided that such a finding can be issued, EC 1100/2007 requires that all eel fishery takes place according to approved eel management plans, or that the Member State reduces its eel fishing effort or catch with 50%. In that way all eel fishery from 1 July 2009, is consistent with Community conservation measures.

d. Determine whether eel harvested in any relevant RFMO and imported into the Netherlands was caught according to the regulation of that RFMO

In previous years, the Netherlands has imported glass eels from South-Western Europe (France, Spain and Portugal) and the UK. These countries are within the European Community. There are no relevant RFMOs with non-EC member states that export European eel to the Community.

5. MEASURES

5.1. Description of all measures to reach the 40% escapement objective

In section 2.4 the potential and current silver eel escapement levels are indicated. It was argued that no exact escapement level can be calculated.

The Netherlands will implement the following measures:

- Reduction of eel mortality at pumping stations and other water works
- Reduction of eel mortality at hydro-electric stations
- The establishment of fishery-free zones in areas that are important for eel migration
- Release of eel caught at sea and at inland waters by anglers
- Ban on recreational fishery in coastal areas using professional gear
- Closed season from 1 September to 1 December
- Stop the issue of licences for eel sniggIers by the minister of LNV
- Restocking of glass eel and pre-grown eel from aquaculture
- Research into the artificial propagation of eel.

Besides these measures it is expected that other policies related to the improvement of the environment, such as the reduction of negative impact of animal manure and the water Frame Work Directive, will have a beneficial impact on the water quality, and thus on the eel population. Water quality has particular consequences for reducing the mortality of yellow eel. Lack of oxygen and the poisonous ammonia are major potential factors, in combination with the lack of opportunities for eel to migrate to other areas when such local incidences may occur. Due to the long life cycle of the eel, diminishing occurrence of these indices will have a big influence of the number for yellow eel that eventually mature into silver eels (see also paragraph 5.2).

Furthermore, measures that have been taken in the recent past will also contribute to an increased escapement of silver eels. Most important in this respect are:

- The reduction of the total fishery effort in lake IJsselmeer in 2006, resulting in a decrease of eel fishing gear with 55%
- The year round opening of the sluice gate at the Brouwersdam in 2005, resulting in an 80% increase of silver eel escapement

Although the exact effect of above measures can not be quantified, overall there will be a positive effect on the number of silver eel that can escape.

In the following the measures are described more into detail.

<u>1). Reduction of eel mortality at pumping stations and other water works.</u>

In figure 2.5.1 barriers for eel migration in the Netherlands and planned solutions are indicated. The implementation of the Water Framework Directive includes a programme for the improvement of fish migration (including eel). Approximately €200 million has been reserved for this programme. Besides, as part of the regular renovations also a number of barriers will be resolved. It is therefore expected that of the 1800 most important migration barriers, half will be resolved before 2015 and the remaining before 2027. Within the process of drafting of the next generation of river basin management plans (under the Water Framework Directive), it will be decided if planned renovations need to be re-prioritised if new information on eel habitat and migration becomes available.

Figure 5.1.1. Examples of recent measures that improve the habitat conditions for eel.

2). Reduction of eel mortality at hydro-electric stations

The installation of a migration passage is compulsory for new hydropower stations. Existing hydropower plants can be categorized into large (>10 MW) or small (<2 MW), see table 2.5.1. All the six hydropower stations have been equipped with a fish pass for upstream migration. Early 2009 one of the three large hydropower stations will have installed an experimental fish passage device for down stream migration (location Linne). For the other two large hydropower stations (Lith and Amerongen), measures will have to be taken in order to reduce (down stream) eel mortality with at least 35%. One of the management options is to change the turbine management. Adaptation of the turbine management may also include halting the turbines in a certain period. The minister of LNV will sign an agreement with the operators of these two large hydropower stations in order to formalise the measures (early 2009). Of the three small hydropower stations, the one at the Roer has been equipped with a fish passage for downstream migration. The one at the Vecht is situated in a small river with subsequent small catchment area. The one at Hagenstein has a capacity of only 1,8 MW. Therefore the impact on the overall eel population of these two small hydropower stations is considered low.

3). The establishment of fishery-free zones in areas that are important for eel migration

This measure will be particularly effective on those locations that are known as important migration routes/points. Currently, a research project is undertaken in order to identify the most critical areas for eel migration. These include areas along the coast, and inland areas near large barriers that have been equipped with fish passages. From 2010 onwards, a number of these important migration zones will be assigned as no-fishing zones for eel fisheries in the regulation "uitvoeringsregeling Visserij", which is based on the 1963 Fishery Law.

4). Release of eel caught at sea by anglers.

Anglers that catch eel in coastal and marine waters will be obliged to release the eel alive in the same water as from July 1, 2009. This obligation will be regulated in the regulation "Uitvoeringsregeling Visserij".

5). Ban on recreational fishery in coastal areas using professional gear.

By virtue of article 36 of the regulation "Uitvoeringsregeling Visserij" a licence can be obtained from the Minister of LNV to fish with maximum 2 fykes and 100 m of gill nets in the coastal waters of the Wadden Sea, Eems/Dollard, and Ooster/westerschelde. From 2011 these licences will not be issued anymore.

6).Closed season from 1 september to 1 december (3 months).

In the period from 1 September to 1 December circa 90% of the total annual silver eel catch is caught (Hoefnagel and Dekker, 2005). In the same period approximately 26% of the yellow eel is caught. In total, closure of this period will reduce the fishery mortality with 45%. In order to maximise the effect of this measure, the commercial fishery of all eel will be prohibited during this period in marine, coastal and inland waters. This prohibition will be regulated in the regulation "Uitvoeringsregeling Visserij". Since the ban will be effectuated in the form of a ban on the use of all types of eel fishing gear ("aalfuik, aalhoekwant, aalkistje, aaldogger, aalzegen, aalkub, ankerkuil en electrovistuig") also the fishery on yellow eels will be closed. In order to (partially) compensate the financial losses for the fishermen, the Ministry of LNV will provide financial assistance from EFF sources, €700,000 per year, starting in 2009 for a maximum period of 4 years.

This measure is aimed to be temporarily. It is the intention to shift to decentralised, local eel management, carried out within the framework of the Fish Management Committee's (VBC's).In these Committees, fishermen, anglers and water managers define and implement local fisheries management. In order to manage eel stocks on this level, more information is needed on the local eel situation of the stocks, the local catch and effort etc. A research programme has been started in order to collect these data. It is expected that at least 2 to 3 years will be required before local eel management can be established. When that situation arises, the Netherlands will adapt their eel management plan accordingly, for approval by the European Commission.

7). Stop the issue of licences for eel snigglers

The Minister of LNV currently issues approximately 75 licenses for the sniggling of eel at state owned inland water bodies. The annual renewal of these licenses will be discontinued. Although the real effect of this measure in terms of extra silver eel escapement is limited, the public signal is considered to be substantial.

Besides the following additional (voluntary) measures will be taken.

8). Restocking of glass eel and pre-grown eel from aquaculture.

Details of this management measure are given in chapter 3 on restocking.

9). Voluntary ban on eel landing by anglers

In the summer of 2008, the national organisation of anglers (Sportvisserij Nederland) has announced a voluntary ban on eel landing from 2009 onwards for owners of fishing licences, issued by the organisation. According to this decision, no eel should be landed, though catch-and-return remains allowed. The area for which the organisation issues fishing licences covers about 90% of the Dutch inland waters.

Even though the restriction is voluntary, its enforcement will take place in accordance with the 1963 Fishery law. This because by virtue of article 21 of the 1963 Fishery Law, it is prohibited to fish without a fishing right or a licence, issued by the owner of the fishing right. This also includes fishing in violation of a fishing licence, issued by Sportvisserij Nederland.

10). Research into the artificial propagation of eel

Since a number of years the Ministry of LNV subsidizes research at the University of Leiden aimed at the artificial propagation of the eel. If a reliable technique could be developed for the mass production of glass eels, at least the aquaculture of eel would no longer be dependent on wild caught glass eels. This will reduce the pressure on the wild stock. So far the research work has resulted in a better understanding of the biological mechanism of maturation of silver eel. It was found that a continued period of swimming is an essential stimulus for maturation of the gonads. By simulation of the natural migration in “swim tunnels” spawning of male and female eels could be induced. Unfortunately, few of the obtained eggs hatched and the glass eels died within a couple of days. In 2009 the research work will be continued in the form of an European research project.

5.2. Time table of implementation

In the following table the year of implementation of the eel measures is indicated.

No	Measure	Year
1	Pumping stations/barriers	Present-2027
2	Hydroelectric plants	2009
3	Fishery-free zones	2010
4	Sea angling	2009
5	Recreational fishery	2011
6	Closure of eel fishery sept-dec	2009
7	sniggling	2009
8	restocking	2009
9	Angling inland waters	2009
10	Research artificial propagation	On-going

5.3. Time table of effect of the measures

Klein Breteler (2008) analysed the effectiveness of different potential eel measures. Following a request from the Commission and ICES, a supplementary report was prepared by Klein Breteler (2009) explaining further details on the method and assumptions used for the calculation of the effect (silver eel output) of the measures. This report is included as Annex 2, "eel management plan the Netherlands; supplement ICES comments". In this report the effect of the Dutch eel measures were recalculated using a more conservative assumption of a recovery time of 80 years. The time table of effect of measures now reads as follows.

The effect (silver eel escapement in ton/year) on the short term (2012), medium term (2027 en 2050) and long term (2090).

No	Measure	2012	2027	2050	2090
1	Pumping stations/barriers	265	268	606	1476
2	Hydro-electric stations	11	39	40	118
3	Fishery-free zones	110	110	249	634
4,5,9	Angling & recreational	100	100	226	576
6	Closed season sept-dec	320	320	724	1846
7	Sniggling	5	5	11	29
8	Restocking	0	100	100	100

Above effects are based on a number of assumptions (Klein Breteler, 2008 and 2009), creating a great deal of uncertainness as regarded to their effect. In order to satisfy the requirements of the Eel Regulation, an indication of the time needed to attain the 40% escapement objective can be obtained by adding the effect of the individual measures. This results in an escapement of 4779 tonnes in 2090. With the aspired escapement objective of 5200 tonnes silver eel, (see paragraph 2.4 of the Dutch EMP), than the time schedule for attainment of the 40% objective is approximately 6-7 eel generations. This estimation is based on the assumptions that the effect of the measures are independent, that increasing numbers of silver eel become available because of the implementation of eel measures in those countries that share river basins with the Netherlands, and that increasing numbers of glass eels become available because of the overall improvement of the stock.

On the other hand, as mentioned in 5.1 there are also measures already taken, that will directly or indirectly increase the number of silver eel escapement. For example, improvements in water quality are expected to result in additional silver eel escapement. This effect has not been taken into account when preparing the above table.

5.4. Measures in coastal waters

Where relevant the measures indicated in section 5.1 and 5.2 will be applicable in coastal and transitional waters as well. This concerns the Fishery-free zones (no. 3), sea angling (no.4), recreational fishery (no.5), and the closed season (no.6). Fisheries outside these waters within the Dutch EEZ are estimated to have very low eel catches (<1 tonne), because of the large mesh size used and the low eel density at sea.

6. CONTROL AND ENFORCEMENT

To enable control and enforcement of the measures, described in this eel management plan, the following measures will be regulated in the national regulation "Uitvoeringsregeling visserij":

- the establishment of fishery-free zones in areas that are important for eel migration, from 2010 onwards (measure 3);

- the obligation for anglers that catch eel in coastal and marine waters to release the eel alive in the same water as from July 1, 2009 (measure 4);

- a fishing ban in the months September, October and November.

The above measures in the regulation "Uitvoeringsregeling visserij" will be based on article 3a of the 1963 Fishery Law. Violation of article 3a and regulations based on that article is an economic offence by virtue of articles 1 and 2 of the Law on economic offences (Wet op de economische delicten).

Besides this, the Minister of LNV will stop the annual renewal of licences for the sniggling of eel at state owned inland water bodies (measure 7). Also, the national organisation of anglers (Sportvisserij Nederland) has decided that licences issued by owners of fishing rights, associated to this organisation, only allow the fishing of eel by anglers if they immediately return the eel to the water (voluntary measure 9). By virtue of article 21 of the 1963 Fishery Law, it is prohibited to fish without a fishing right or a licence, issued by the owner of the fishing right. This applies to both publicly and privately owned waters. Violation of this article is a crime by virtue of article 56 of the 1963 Fishery Law.

The responsible authority in the national government for enforcement of the 1963 Fishery Law is the Minister of LNV. Control for compliance is carried out by the General Inspection Service of the Ministry of LNV (AID: Algemene Inspectiedienst).

As stated in Chapter 4.4.1, under a, of this Eel Management Plan, an administration of every supply or storage of eel, and its origin, should be kept by suppliers and professional buyers of eel, by virtue of the articles 7 and 8 of the regulation "Uitvoeringsregeling visserij". In article 2.1.5 and 2.1.6 of the regulation "Regeling aquacultuur" it is obliged that aquaculture production businesses and authorised processing establishments keep a record of all movements of aquaculture animals. Also, article 18 of Regulation (EC) nr. 178/2002 (General Food Law) obliges the traceability of food-producing animals at all stages of production, processing and distribution. By this, the catch of eel can be traced.

7. Modification of Eel Management Plans

Verwijderd: Pagina-einde

A large number of measures that are relevant for this eel management plan are currently being put in place and are envisaged to be further implemented from 2009 onwards. Modification of this Eel Management Plan in the Netherlands is expected to have generated sufficient results to make subsequent adaptations. In particular this can be expected from legal arrangements, re-arrangements of the management responsibilities, and coordination with the adjacent Member States to agree on management plans on the basis of the different river basins that cover the territory of the Netherlands.

A constant stream of new data is expected to become available, since many of the above measures that have been taking or are planned will be closely monitored. For example, future results of the reduction of fishing pressure and other eel mortality factors will feed into options for revising the EMP, irrespective of the procedural matters that will be measures meant for reduction be developed over time.

The work on the recovery of the eel stocks is to be intensified from 2009 onwards. Research projects exist on eel production potential and on intended measures, with associated risks, costs, efficiency and public support. There is ongoing work monitoring and registration. A model is being designed to assess the potential effects of decentralised management. In addition, further research to harmonise the work on reducing the migration barriers is in progress. All this work is expected to further modify the eel management plan as appropriate and desired.

References

Buijse, T., T. v.d. Beld, N. Breve, H. Wanningen (2008). Knelpunten en migratievoorzieningen op de migratieroutes voor aal naar belangrijke leefgebieden in Nederland. Concept rapport.

Dekker, W. and J. van Willigen, 2000. De glasaal heeft het tij niet meer mee! RIVO rapport C055/00. 34 pp.

Dekker, W., 2004. Slipping through our hands. Population dynamics of the European eel. PhD-thesis , 188pp.

Dekker, W., 2007. Report on the eel stock and fishery in the Netherlands, 2007. National annual report to ICES. 22pp.

Dekker, W., C. Deerenberg and H. Jansen (2008). Duurzaam beheer van de aal in Nederland: onderbouwing van een beheersplan. IMARES-report 2008-CO41/08. 99 pp.

Dekker, W., 2008a. Report on the eel stock and fishery in the Netherlands, 2008. National annual report to ICES. Draft 18 August 2008. 29pp.

Dekker, W., 2008b. Herstel van de aalstand II. Project proposal, IMARES. 22pp.

Hoogenboom, L.A.P., M.J.J.Kotterman, M. Hoek-van Nieuwenhuizen, M.K. van der Lee, W.A. Traag. 2007. Onderzoek naar dioxines, dioxineachige PCB's en indicator-PCBs in paling uit Nederlandse binnenwateren. RIKILT-report 2007-003, 34pp.

International Ems Commission, 2008. www.ems-eems.nl, consulted in spring 2008.

International Meuse Commission, 2008. www.meuse-maas.be, consulted in spring 2008.

International Rhine Commission, 2008. www.iksr.org, consulted in spring 2008.

International Scheldt Commission 2008. www.isc-cie.com, consulted in spring 2008.

Klein Breiteler J.G.P., 2008. Herstel van de Aalstand II. Bouwen aan een beheerplan. Hwet streefbeeld, de huidige uittrek, een nadere verkenning van de mogelijke maatregelen en een protocol voor het uitzetten van aal. VIVION BV, Utrecht. Project number VIVION 08.002a, 118pp.

Kroese, M.J., N. Brevé, F.T. Vriese, H. Wanningen en A.D. Buijse, 2008. Nederland leeft met vismigratie. VisAdvies report 2007-33. 71pp.

Rijn, S.H.M. van, and M.R. van Eerden, 2002. Aalscholvers in het IJsselmeergebied: concurrent of graadmeter? Vogels, vissen en visserij in duurzaam evenwicht. RIZA rapport: 2001-058. ISBN 90-369-5416-9.

Thillart, G. van den (2005). Estimation of the reproduction capacity of European eel. EELREP 2001-2005. Summary and recommendations. Editor: van den Thillart. 18pp.

Vriese, F., J. G.P. Klein-Breiteler, M.J. Kroes, and I.L.Y. Spierts, 2008. Duurzaam beheer van de aal in Nederland. Bouwstenen voor een beheerplan. Visadvies BV Utrecht. Report VA2007-01. 178 pp.

Winter, H.V. and H.M. Jansen, 2006. De effecten van waterkracht en visserij tijdens de stroomafwaartse trek van schieraal in de Maas: zender-onderzoek gedurende 2002-2006. IMARES-report CO72/06, 67pp.

Annex 1. Targets and current escapement of silver eel in the Netherlands

1. *Production in similar waters*

An overview of available data on eel catch yields and biomass was provided by Tesch (1999 The table below summarises the data for streams, lakes and coastal waters in the temperate zones. (tables 3.1, 3.2, and 3.3)

Table 1 Eel yields and biomass in European streams, 1951-1988 (Tesch, 1999). Averages calculated on basis of minimum and maximum values in the range

Locatie	Year	Eel kg/ha(/year)		Type of water
		Range	Average	/fish species
Yields				
Baltic, Oder	1961-'63	32-60	46	river, bream zone
Baltic, various small	1958-'64	8-38	21	streams 2-20 m wide
North Sea, Ems/Weser/Elbe	1954-'63	3-12	7	Bream and perch zone
North Sea, Elbe tidal zone	1956-'63	25-50	38	Bream zone
North Sea, Weser	ca. 1960	8-46	21	Red mullet, trout zone
North Sea,: Rhine Moezel/Lahn	1951-'61	4-9	7	
Biomass				
Denmark, Jutland	1950		75	Streams 1 m wide beek
Denmark	1971-'88		163	0,2-13 st/m^2
Ireland	1988		52	Streams 4-22 m wide
England	?	36-328	182	
Averages				
Yields		13-36	25	
Biomass			118	

Table 2 Eel yields and biomass in European lakes, 1949-1966/1996 (Tesch, 1999). Averages calculated on basis of minimum and maximum values in the range

Location	Year	Eel kg/ha(/year)		Type of water
		Range	Average	/fish species
Yields				
Lough Neagh (N-Ierland)	-1966	20	20	Whitefish
Schleswig-Holstein, average.	1954-'64	3-16	9	Bream
Schleswig-Holstein, average	1949-'64	4-8	6	Roach
Niedersachsen	1957-'62	2-5	3	BR-SB en S-Z type
Schwerin & Berlijn	1949-'63	1-5	2	BR, S, SB
Mecklenburg, Conventer See	1954-'61	29-45	37	
IJsselmeer	1954-'62	10	10	
Biomass				
Schotland, Lochs	1990-'96	220-250	235	
Averages				
Gemiddelde vangst		10-16	13	

*) Salm = salmoniden, BR = bream, SB = pike (perche), S = pike, Z = tench

Table 2 Eel yields and biomass in European coastal waters, 1947-1978 (Tesch, 1999). Averages calculated on basis of minimum and maximum values in the range

Location	**Year**	**Eel Yields kg/ha/jr**		**Type of water**
		Range	**Average**	**salinity**
Yields				
Baltic, various waters	1947-'65	1-7	4	Haf, rivermouth, coast
Biomass				
Denmark	1958		150	S = 2-20 ‰
German Bight	1978		3	20-50 m diep

Yields vary widely as shown. It should be noted however that these figures are catch yields, and not the actual biological production of mature silver eels. During periods of subsequent years, yields probably do not exceed the actual production of mature silver eels (see box below)

Box 3-1 *Why is eel production special?*

Simulation models (*Eenvoudig rekenmodel Aalbeheer*, Dekker et al., 2008) show that the highest production of mature silver eel (expressed in kg/eel) is achieved in the absence of anthropogenic mortality and that total yields at whatever fishing intensity are always lower than the quantities produced.

The models do not take into account density related processes. In classic fishery studies growth and mortality are generally considered density related. In situations where food supplies are finite and limited, growth falls when density (number/ha) and biomass (kg/ha) reach threshold levels or the limit of the system's carrying capacity. This happens with many fresh water species. With fish grown in ponds for instance (monocultures mostly) and also with eels farmed in ponds (Klein Breteler et al., 1990) It may, in theory, also be influenced by intra-specific competition between species. This means that with increasing biomass, growth decreases and net biological production (biomass increase per unit of time) shows an optimum curve. Highest production therefore is not achieved at highest densities but at optimum densities. Classic fishery studies say that this provides room for fisheries. In fisheries an increase in net biological production (and harvest or catch) may be achieved by a decrease of biomass resulting from fishing activities.

This is different with eels. First, because fisheries studies deal with kg of fish meat, not with kg of oldest year classes, the subject of this chapter. Another factor is that eels at the end of their growing stage in fresh or coastal waters migrate to the sea as mature silver eels. The fish themselves cause a thinning out of mass which is why growth need not stagnate. Also when densities become too high sex ratios shift This happened in former times when glass eel was still abundant and this still occurs in easily accessible waters near the coast. This implies that the number of male eels maturing is greater than the number of females. Males are smaller than females and they mature earlier. In this way year, class fluctuations can be counterbalanced without growth slowing down. And, finally, a proportion of eels in high densities moves on, upstream or to coastal waters. In times of abundance the marginal habitats are used. With mechanisms such as these, depending on available local densities and biomass, eels optimise their own production at local population levels.

These mechanisms in terms of quality are well-known but scientific foundations in terms of quantity are still lacking. Models are now being developed (see question 8).
In theory it remains possible that in former times, when eel stocks were still safe, production was not optimal in places as a result of density related processes. In practice, this would also have happened locally. It is known that substantial densities of glass eel could be found in small

rivers around the Gulf of Biscay or in the then embanked local polder waters where eel had been introduced. But given the eel's flexibility in making use of biomass at population levels it is thought unlikely that this played a significant role at national level in the Netherlands with its many possibilities in its coastal areas and extensive hinterland of its major rivers.

Often, eel that have escaped from fishery are counted as biologically produced. This alone makes the estimates in the tables not very reliable. The ratio between silver eel and brown or yellow eel in the waters and fisheries referred to is not clear either. Brown or yellow eel included in the yields might, had they not been caught, have matured into silver eel which is another factor that might lead to underestimating real production. The tables should therefore be seen as minimum estimates of eel production in waters geographically similar to Dutch waters in the period 1950-1970.
Eel production is streams was 25 kg/ha, in lakes 13 kg/ha and in coastal waters 4 kg/ha. The latter figures are based on a single study.

2 Production in Dutch waters around 1950

Van Drimmelen (1952, 1953) described fisheries yields in polder waters and larger water bodies in 1948-1953. Polder waters supported pike, larger bodies of water pike or pike perch (see figures 3.1 and 3.2 and tables 3.3 and 3.4).

The author describes fair to high mortality rates in polder waters in the winter of 1946/47 (except in section 6). Larger water bodies (sections 11 and 12 are describes as 'bogs with many narrow water courses' and sections 16 and 17 as 'pools connected to polder ditches.' The figures and tables show that production was substantially higher in some waters . These outliers are not taken into account in some of the averages. The cause of these peaks in production is not known but these are waters stocked with elvers and glass eel to a smaller or larger degree (figures 3.3 and 3.4). This may have affected yields provided the eels were given time to mature. Nothing is known about these waters before 1948. Presumably not much stocking had taken place during the war. Only eel introduced after the war may have affected production. With average growth rates of 3 to 4 cm this might go some way to explain the ca. 25 cm eel in 1946-'47 in figure 3.3 and 3.4. Waters at the time were stocked with eel when natural recruitment was thought to be low (after migration bottlenecks).
In a workshop on 13-5-2008 where Van Drimmelen's data were presented, participants found it odd that polders had lower eel production than the larger bodies of water. (Enclosure 1). This may be explained by lower migration (migration obstacles) The winter mortality rates mentioned earlier might also have played a role. Stocking waters to increase production is therefore only of importance here as it helps estimate production potential.

Workshop participants also said that eutrophication at the time might have had a positive effect on production and yields which would imply that the targets are set too high. But Van Raaphorst & De Jonge (2004) and Lindeboom et al. (2007) show that eutrophication in the Netherlands began in the 1950s via the River Rhine but cannot have had much effect until the 1960s and cannot therefore have affected fisheries yields studied by Van Drimmelen (1953). Local pollution of waters with organic substances may have affected yields but not on a national scale.

It was also mentioned that the bream caught from those waters may have had a positive effect on eel production but the quantities caught are not known. Many waters supported species of pike and tench, and there was not therefore much bream. But traditionally bream was a predominant species and the question of whether they had any effect on eel may well be asked. Tesch affirms this but does not provide sound arguments. Lammens et al. (1985) demonstrate this but water management authorities had created exceptional circumstances with invasions of smelt. In practical pond research, Klein Breteler et al. (1990) demonstrated that bream did not affect eel stocks. It is assumed that locally this may have been the case but not on a large scale, not to an extent that is relevant here.

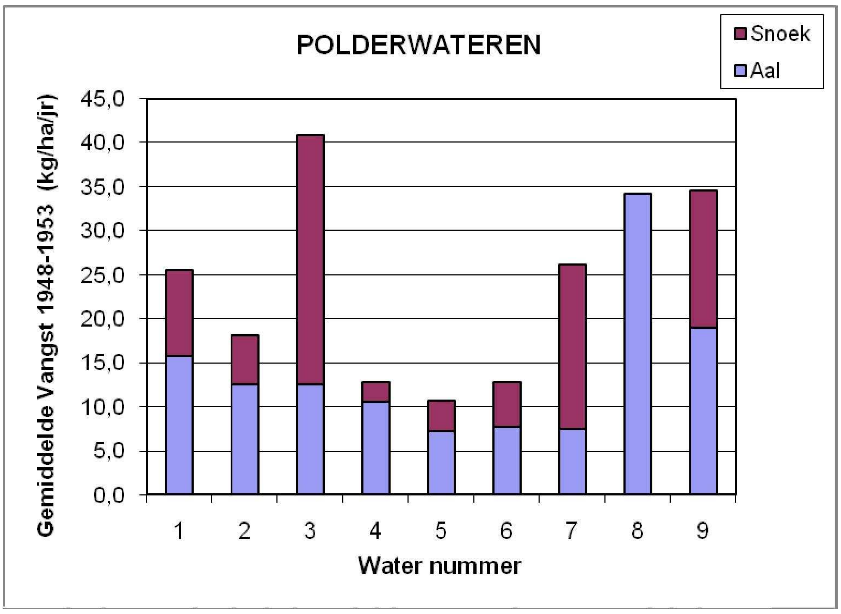

Figure 1 Average annual yields of eel and pike in 9 polder waters 1948-1953 (kg/ha) (Van Drimmelen 1953)

Larger bodies of water pike perch, pike, eel

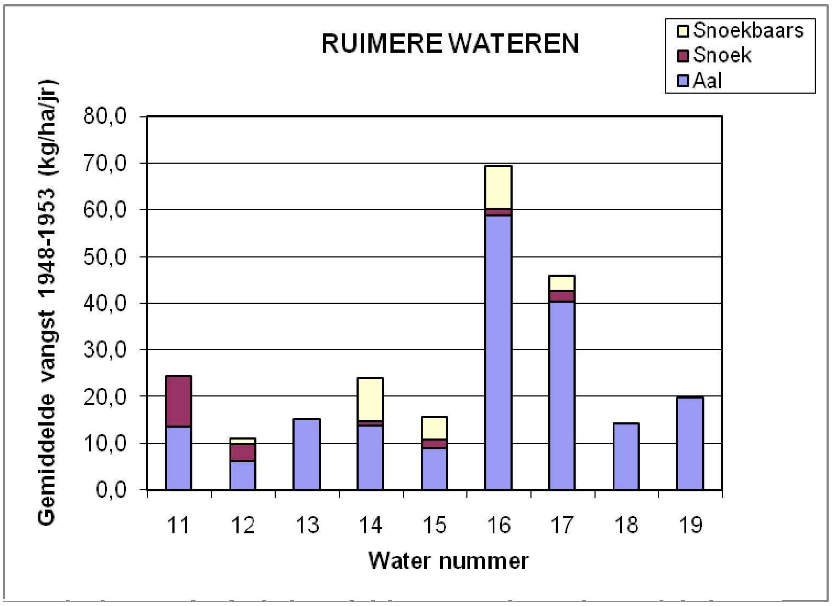

Figure 2 Average annual yields of eel and pike in 9 larger bodies of waters 1948-1953 (kg/ha) (Van Drimmelen 1953)`

Tabel 3 Eel yields (kg/ha) in Dutch polder waters 1948-1953

(Van Drimmelen 1953)

	WaterNr	1948/'49	1949/'50	1950/'51	1951/'52	1952/'53	Averages	st.dev
	1	14,5	15,5	12,0	19,5	17,5	15,8	2,9
	2	6,5	13,0	17,5	16,0	10,0	12,6	4,5
	3	12,5	14,5	11,0	15,5	9,5	12,6	2,5
	4	2,5	7,0	8,5	18,0	17,0	10,6	6,7
	5	9,0	3,0	5,0	10,0	9,5	7,3	3,1
	6	4,0	4,5	6,5	10,5	13,0	7,7	3,9
	7	1,0	11,5	2,0	1,5	21,5	7,5	9,0
	8	21,5	34,5	52,0	37,0	26,0	34,2	11,8
	9	21,5	19,5	21,5	17,0	15,5	19,0	2,7
Averages		10,3	13,7	15,1	16,1	15,5	14,1	
SD		7,7	9,5	15	9,6	5,7		9,8
Averages (outliers not included)							11,6	6,0

Tabel 4 Eel yields (kg/ha) in larger bodies of water

	WaterNr	1948/'49	1949/'50	1950/'51	1951/'52	1952/'53	Averages	st.dev
	11	13,5	16,0	13,5	10,0	15,5	13,7	2,4
	12	7,5	6,0	7,0	6,0	5,0	6,3	1,0
	13	10,5	13,0	12,5	18,5	21,0	15,1	4,4
	14	12,0	11,5	14,0	14,0	18,0	13,9	2,6
	15	6,5	7,0	8,5	12,0	10,5	8,9	2,3
	16	61,5	74,5	47,5	43,0	67,5	58,8	13,3
	17	37,0	43,0	40,5	39,0	42,5	40,4	2,5
	18	24,0	8,5	6,0	14,0	18,5	14,2	7,3
	19	9,0	27,5	20,5	17,5	24,5	19,8	7,1
Averages		20,2	23,0	18,9	19,3	24,8	21,2	
SD		18	23	15	13	19		17,2
Averages (outliers not included)							13,1	5,8

It can be concluded that eel potential in Dutch polder waters in the mid-20th century stood at 14 kg/ha, possibly much more and in larger bodies of water at least 20 kg/ha. This is higher than the average values Tesch (1999) gave for lakes in temperate zones (see 3.1). It may illustrate higher exploitation of Dutch waters at the time, in which case it might come closer to biological production.

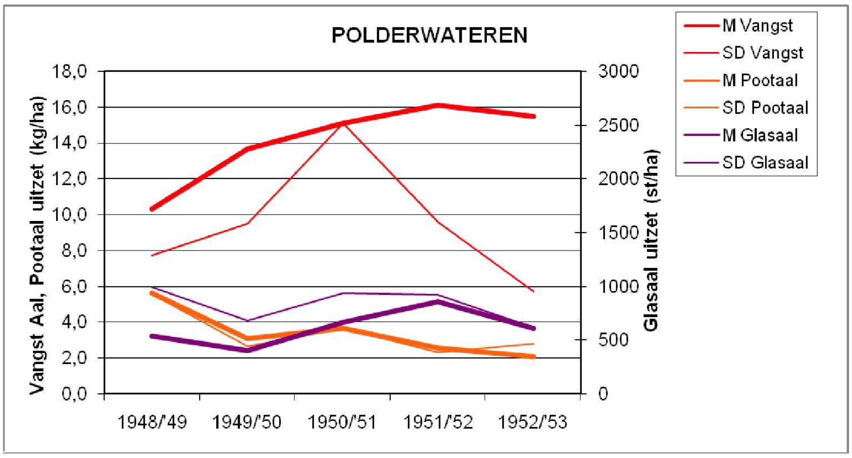

Figure 3-3 Eel yields and stocking of eel in polder waters 1948-1953 (Van Drimmelen 1953).
Vangst: Yield
Pootaal: Elvers
Glasaal: Glass eel
M: Mean
SD: Standard Deviation

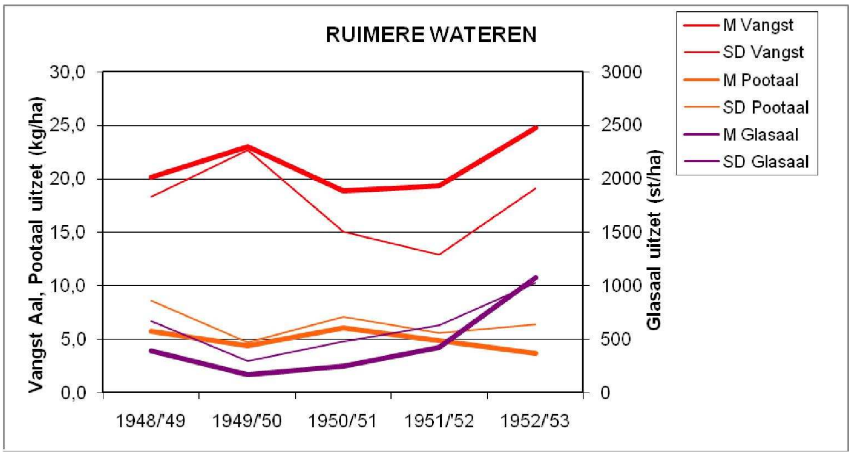

Figure 3-4 Eel yields and stocking of eel in larger bodies of water 1948-1953 (Van Drimmelen (1953).
Vangst: Yield
Pootaal: Elvers
Glasaal: Glass eel
M: Mean
SD: Standard Deviation

3 Dutch targets for mature silver eel migration

The Dutch targets for mature silver eel migration are based on yields and the available production area (table 3.5) to determine these targets a workshop was held on 13 May 2008, to which the Eel Sounding Board Group had also been invited. The workshop produced a number of comments and conclusions (see enclosure 1, 9.1.2). Yields were seen as minimum estimates of real biological production (see 3.1 and Box 3.1) . On the basis of the data in 3.1 and 3.2 production targets in streams and channels might be set at 10-16 kg/ha and for lakes 19/25 kg/ha (Van Drimmelen 1953). For coastal waters targets are set at 4 kg/ha and for running water 25(13-36) kg/ha (Tesch, 1999 and see 3.1).
The production area ("habitat for the eel") is given in Dekker (2007). Freshwater lakes in Zeeland are however treated as coastal waters. This has been done to ensure that targets fit in as closely as possible with the situation in the middle of the 20th century. The IJsselmeerpolders were not included in the eel habitat calculations (see 2.1) and are no longer included in the eel regulation. Partly for this reason an estimate has been made of the situation before the closing of the Zuiderzee (now Ijsselmeer) (Table 3.5). This area was then coastal water and had a lower level of production.

Table 5 Fishery yield on the basis of Tesch (1000) and Van Drimmelen (1053) in the Netherlands in the mid-20th century *The IJsselmeer is also compared with the former Zuiderzee (see text)*

	Area	Fisheries yield (kg/ha/year)			Fisheries yield (ton/year)		
	(ha)	average	from	to	average	from	to
Situation with drained IJsselmeer							
Ditches and channels	67515	14	10	16	945	675	1080
Lakes	214887	21	19	25	4513	4083	5372
Rivers	20867	25	13	36	522	271	751
Coastal waters	377673	4	1	7	1511	378	2644
Comparison of drained IJsselmeer with Zuiderzee							
Zuiderzee	327000	4			1308		
IJsselmeer after closure	327000	21			6867		
Draining	145000	0			0		
IJsselmeer now	182000	21			3822		
Total with Zuiderzee	680942				4976		
Total with IJsselmeer now	680942				7490	5407	9847

The calculation would then result in a total fisheries yield in the Netherlands, including part of the drained IJsselmeer, of an average of approximately 7,500 tonnes of eel (Table 3.5). If the Zuiderzee situation is included, than the amount is 5,000 tonnes of eel. In streams and rivers it must be assumed that eel production from other States has to be added. That has not been allowed for here. In addition it must be assumed that in the mid-20th century some eel was not caught and some had not developed into mature silver eels and were caught as yellow eels, which resulted in loss of yield. It is not known how large a proportion of the yield this was.

Probably in many polders relatively more silver eels or yellow eels were caught than in larger systems. Furthermore, this was before hydroelectric power plants, and there were fewer pumping stations, but the effect on the eel at the time is unknown. On the basis of the above considerations, a conservative estimate of the total yield of silver eel without anthropogenic influence and including part of the drained IJsselmeer would amount here to 15,000 tonnes for the Netherlands. If this is based on the former Zuiderzee, instead of the partly drained IJsselmeer, then the estimate would amount to approximately 10,000 tonnes. These estimates must be considered as a minimum. Because of the lack of information on yields in coastal waters, the difficulty of fishing them and the relatively large area of coastal water in the Netherlands, both of the above estimates could be easily doubled.
From an ecological point of view that would imply that the coastal waters of the Netherlands are equally important for the production of eel as inland waters. In the present situation this would not be a true reflection of practice, but we do know that in the mid-20th century there were large numbers of elvers in the waters of Zeeland, Zuid Holland and the Wadden Sea and these were harvested. The target percentage migration for silver eel in the eel regulation is 40% of the original migration without anthropogenic influence. On the basis of the above estimates this would amount to 4,000 – 6,000 tonnes for the Netherlands.

4 Estimate of current migration

The current migration of silver eels can be estimated in several ways:
1. Based on direct measurement or counts
2. By calculation on the basis of the reference situation, the trend and the anthropogenic mortality of silver eel
3. By calculation based on mark-recapture studies
4. By calculation using models based on actual stocks of glass or yellow eels, and the mortality rate up to and including maturity

Combinations of the second and third methods have been used below in respect of the IJsselmeer, where relatively numerous data are available, and analyses based on applying the fourth method have also been used. In the Netherlands there is no measuring system available, or probably even possible, which could be used to apply the first method. The fourth method, in addition to adequate monitoring, required the development of adequate population dynamic models, which are already available for the IJsselmeer and are otherwise currently being processed and will be available in the second phase of the current project. With all methods except the first it is also necessary in principle to take account of the spatial distribution of the eel over the various habitats (including costal waters and upstream areas). Where data was available these factors have been taken into account below.
We note here in advance that the estimates given below are surrounded by great uncertainty. Much of the available information comes from fisheries data and as such applies specifically to the eels which <u>do not</u> escape or migrate to sea.

A global estimate of the migration of silver eels for the whole of the Netherlands can be calculated using the second method. However, it is no more than an estimate of the scale of migration. The reference situation is described in section 3.3. The European trend in catches of yellow and silver eels can be derived from the best described European multi-year datasets, which originate from the yellow eel fisheries in the IJsselmeer (to 2001) and fisheries in Sweden (to 2007). These show a decrease to 25% of the 1960 level (Dekker, 2003) which has since dropped to 15% (Dekker, press release). That can be applied to the Dutch target for migration (the reference situation), taking account of the different production figures for each habitat as given in Table 3.5. This results in an estimated production of 1169 tonnes of yellow and silver eel, which must be doubled, as in section 3.3: thus in total around 2300 tonnes per year. Next the production loss for all manner of anthropogenic mortality factors must be deducted. Vriese et al. (2008) estimated that loss at 1250-1550 tonnes per year. Of the difference between production and production loss due to anthropogenic factors (750-1050 tonnes) a proportion will also actually migrate as silver eels. The remainder represents the increase in the biomass of yellow eel, which has not (yet) migrated. Because the longitudinal distribution of the eel is not known on the scale of the Netherlands, all we can estimate here is the order of magnitude of the actual current migration of silver eels from the Netherlands, based on the catch distribution as recorded in Dekker (2008). That would be 30% of 750-1050 tonnes and thus an estimated 225-315 tonnes of silver eel.

In principle it is possible, using mark-recapture studies (3rd method) to arrive at an estimate of silver eel migration independently of the above considerations. However this does not cover the whole of the Netherlands. The studies were carried out in recent years in relation to the Rhine population and the Meuse population, in which there is also an influx of eels originating from other countries (upstream areas).
Mark-recapture estimates are available of the entire downstream-migrating Rhine population of female eels (larger than 50 cm), which passes the Lek, Nieuwe Merwede and Beneden Merwede areas and the Afsluitdijk (Klein Breteler et al., 2007). Including the IJsselmeer part of the Rhine stock, the total biomass of these was 600-1000 tonnes in 2004 and 2005. Because there were no recaptures at all in the IJsselmeer, the estimate is very much open to debate. The estimate for those years excluding the IJsselmeer (and IJssel) is 366-730 tonnes. The estimates were made using coloured marks, but there is doubt about how recognisable the marks are, and how long they last. These estimates must therefore be regarded as maximum estimates. In 2006 a different marking method was used (Floy tag) which did not have this problem (Vriese et al., 2007). The female eel population > 50 cm that migrated via the Waal (Nieuwe Merwede and Beneden Merwede) was then estimated at 398 tonnes. Based on these studies an annual migration in the order of around 400 tonnes of female silver eel > 50 cm along Nieuwe Merwede, lower Merwede and Lek was taken as the best estimate of the Rhine population. Here it must be noted that beyond (seawards of) these locations there are still substantial fisheries which can reduce the cited quantity of silver eel. A maximum estimate of that influence, based on known silver eel catches in the Rhine (Dekker et al., 2008), is 90 tonnes. This reduces the order of magnitude to 310 tonnes.
These eels originate partly from the Netherlands and partly from other countries (mainly Germany). Telemetry studies clearly show that at least half of such female silver eels released in Cologne reach Xanten (near the Dutch border) in the same year. In theory this could indicate 1) a passage of 2 x 400 = 800 tonnes of such eels by Cologne, and a production of 0 tonnes at the Dutch end of the Rhine, or 2) a negligible migration by Cologne, (and by the Dutch border) and a production of 400 tonnes at the Dutch end of the Rhine, or 3) a combination of these scenarios. If a quantity of 400 tonnes was supposed to have been produced in Dutch waters (here estimated as being in the order of 100 km^2 of Rhine branches (according to Dekker, 2008), this would imply a higher production in recent years in this Rhine section of the great rivers than in the historical situation. This does not seem likely. The alternative of a production of 800 tonnes in Germany and the absence or temporary standstill of the migration of 400 tonnes in Germany is also fairly unlikely, for the same reasons.

The production in the Dutch section of the Rhine is derived, as above, from the estimated historical situation, (25 kg/ha/year in rivers; See Table 3.5) and the European trend in catches of yellow and silver eels, which shows a decline to 15% of the 1980 level. For a water surface in the order of 100 km^2 of the Rhine branches (according to Dekker, 2008) this means 10000 x 25 x 0.15/1000 = 37.5 tonnes of silver eels. Minimum and maximum estimates of the quantity of silver eel entering the Netherlands from Germany via the Rhine are therefore 0 and (400 – 37) tonnes = 363 tonnes of female silver eels respectively; both of which are considered unlikely here. The actual quantity entering from Germany will be somewhere in between, and is more likely to be in the order of 300 tonnes, in view of the limited opportunities for production in the Rhine branches. Telemetric studies show that around 11% of the 'German' eels, migrate through the IJsselmeer. This would result in a quantity of no more than 0.11 x 300 = 33 tonnes. As the same research also shows that 10% of the silver eel coming out of the IJssel also passes the Afsluitdijk, this would imply a migration via the Afsluitdijk of 3.3 tonnes of 'German' eels. It would also mean that the entire silver eel catch in the IJsselmeer is based on catching "German" eels. The total silver eel production of the IJsselmeer itself would then, through the premature catch of yellow eels, be estimated at zero. And the total migration from the IJsselmeer would then be estimated at 3 tonnes, in round figures. This estimate of the migration from the Ijsselmeer is thus based on the maximum estimate of the 'German' silver eel.

The IJsselmeer produces a catch of 40 tonnes of silver eel (Dekker et al., 2008). Based on the minimum estimate of German silver eel, this would imply that that catch of 40 tonnes of silver eel in the IJsselmeer is the Ijsselmeer's "home-grown'" production. However, there seems no reason to assume that the fisheries mortality figure of 90%, taken from the telemetry study, should not apply to such 'home-grown' silver eel. Migration via the Afsluitdijk would then be estimated at around 4 tonnes. This is in the same order of magnitude as the maximum estimate and the estimates made by Dekker (Table 5.10, see 5.3).

A mark-recapture estimate was also made of female silver eel in the Maas (Winter et al, 2007). This was also carried out with female silver eel marked with transponders. The migrating population was estimated near Linne and near Lith/Alphen. Assuming a comparable weight per fish to the Rhine silver eel, the biomass at Lith was estimated at 76-115 tonnes. At Linne the biomass was smaller by a factor of 2.5. The difference is explained by the influx (immigration) from tributaries (in the case of the Rhine this was far less significant in the Dutch section). The Meuse therefore yields in the order of 100 tonnes of silver eel. With the existing data it is not easy to estimate what proportion of these eels originate from other countries. But considering the significantly lower estimate of the Meuse population in Linne (compared with Lith), and estimates made by the Belgian researcher Verbiest (verbal comments), the quantity is presumed to be small.

Pilot projects which have been running in the Rijnlands Boezem and the Veluwe Randmeren since 2007, have also produced migratory data on silver eel (Spierts & Caldenhoven, 2008). Using the mark-recapture method it was estimated that around 140,000 and 35,000 female silver eel migrated from the Rijnlands Boezem and Veluwe Randmeren respectively. That would suggest that more migrate from Rijnland than the production level according to the target.

Based on the above information the following conclusions can be drawn. The total current migration of silver eel from the Netherlands, as far as this can be extrapolated from the target and trend, and based on native Dutch production, is in the order of 225 to 315 tonnes. This refers to both males and females.

Mark-recapture estimates of the currently migrating female eel populations of the Rhine and Meuse lead to migration estimates of 300 and 100 tonnes respectively. Of these a proportion originate from other countries, mainly from the Rhine, and the quantity is estimated here as being in the order of 300 tonnes. This still refers just to females. It is not possible to determine from existing data how many male silver eels are produced in these river basins. They will largely have originated in the lower-lying polder areas in the Netherlands, where a proportion of professional fishing is concentrated (Tien & Dekker, 2005). A supplementary migration of silver eel from the Scheldt and Eems of male eels from the more isolated polder areas which belong to the Rhine basin (Friesland, Noord-Holland) of an estimated total of 100 tonnes (order of magnitude) is not inconceivable, but cannot be further corroborated by the existing data. Given the annual catch of 140 tonnes of silver eel in the “other” inland waters (Dekker et al., 2008) and the relatively effective fishing which can be achieved there, that is considered here to be a maximum estimate. Based on the river basins, a total quantity of 300 + 100 – 300 + 100 = 200 tonnes of migrating silver eel from native Dutch production can be calculated in this way. This is of the same order of magnitude as the estimate using the target and the trend. Moreover, there is a non-Dutch proportion of (in the magnitude of) 300 tonnes, mainly from the Rhine, which migrates into the Netherlands, and of which (also in the magnitude of) 100 tonnes are caught in the Netherlands, and 200 tonnes migrate. The total estimated migration from the Netherlands thus comes to 400 tonnes.

Annex 2

Eel Management Plan The Netherlands

Supplement: ICES comments

VIVION-09.003
Opgesteld in opdracht van: Directie Visserij (LNV)

juli 2009

door: J.G.P. Klein Breteler

Contents

1. Introduction

The Netherlands has sent its Eel Management Plan (EMP) to the European Commission on December 15 2008 (MinLNV, 2008) and a revision of the plan, due to a debate in the Dutch Parliament, on April 1 2009. Comments and additional questions to be answered on the EMP have been formulated by the International Council for the Exploration of the Sea (ICES). These imply:

1. The methods used and assumptions made at the calculation of effects of measures in Table 5.3 of the EMP are not clear. These should be elucidated concisely.
   The estimates of the effects of pumping stations/barriers (measure 1 in Table 5.3) are relatively high. The calculation method and assumptions should be given more specifically.
2. The suggested time scale of recovery of the European eel stock in Table 5.3 is much shorter than expected by international eel scientists. Could this be motivated and is it possible to calculate the effects of the measures given under the assumption of a full recovery of recruitment in 80 years?

This report deals with these two questions in Chapters 2 and 3 respectively.

2. Effects of measures

a. Method and assumptions

The effects of measures on silver eel escapement from The Netherlands to the sea in 2012, 2027 and 2050 have been estimated in Table 5.3 of the EMP. These are based on assumptions and calculations by Klein Breteler (2008). The objective of these calculations was to enable comparison of the effects, costs and risks and uncertainties of different measures and to support decision making with regard to these measures. It was expected that effects, costs, risks and uncertainties would change in time, but not in a similar way or to similar levels for different measures. As an example: yearly stockings of fixed amounts of glass eels may result in a stable output of silver eels in time, but yearly efforts/investments in substituting high-mortality pumping stations by low-mortality pumping stations will result in increasing escapement of silver eels in time. Therefore it was considered important to compare the effects etc. not only in a short term but also on a medium and longer term.

A basic line and starting point in these calculations is that the quantitative effect of measures on the silver eel escapement (in MT/year) not only depend on these measures themselves but also on the biomass of the population.
As an example: a reduction in fishing effort of 50% e.g. may result in a 50% reduction of fishing mortality F and in an effect of for instance 10 MT/year in a population with Spawning Stock Biomass SSB=100 MT. But in a population with SSB=1000 MT the same measure will then result in an effect of 100 MT/year.
Therefore effects of measures in MT/year can only be estimated, as was asked for by the Dutch Ministry of Agriculture, Nature Management and Food Quality, if SSB is known.
The EU-Eel Regulation uses biomasses, not mortalities. To comply with that, The Netherlands also worked with biomasses.

The biomass of the silver eel population SSB in The Netherlands is a result of (1) recruitment of glass eels 1 generation time earlier, (2) growth, mortalities (natural and anthropogenic) and immigration and emigration between recruitment and escapement of silver eels and (3) measures taken to influence the processes in (1) and (2). Silver eel output from The Netherlands therefore partly depends on recruitment.
As recruitment is determined on the European stock level and probably depends on the combined efforts of EU-memberstates (because of the status of the stock in the stock-recruitment relation), the effects of Dutch measures on spawner escapement therefore also depend on the efforts of other EU-memberstates. There is one exception to this: stocking glass eels or pre-grown eel fingerlings. In theory it would be possible to buy and stock enough glass eels to compensate for existing anthropogenic mortalities and produce 40% of the historic SSB in one generation time (approximately 15 years). But the quantity needed in The Netherlands is not available in Europe in the near future (EIFAC/ICES, 2008) and cannot be financed with Dutch and European funds. Recovery of natural recruitment is essential therefore, but (re)stocking of glass eels in smaller quantities is one of the measures distinguished in Klein Breteler (2008) and below.
As these combined efforts of EU-memberstates and the recruitment in the future were not known when drafting the EMP, but decisions were needed on the measures to be taken by The Netherlands, assumptions were needed on the recovery of the recruitment of the stock and on the recovery of the Dutch silver eel population.

It was firstly assumed that the EU-memberstates are ambitious enough to take firm measures, allowing for a fast recovery of the eel stock. Secondly that the Dutch silver eel population would recover from 2% of historic levels (years 1950-1960) now to 10% in 2030 and to 30% in 2050, so a five-fold increase in 2030 and 15-fold increase in 2050. And thirdly that the recovery of the Dutch silver eel population will occur with the same rate as the recovery of the recruitment of the stock on a European level.

An increase of the SSB from 2% to 10% in 2030 would imply a five-fold recruitment 1 generation earlier. At an assumed generation time of 15 years this would be in 2015. A five-fold recruitment in 2015 implies on its turn a five-fold silver eel escapement about 1 year earlier. A five-fold increase of escapement of silver eels in 2014 does not seem impossible if very rigid measures are taken by all countries in increasing the silver eel escapement with priority. It may not be expected from a 50% reduction of the eel fisheries, as made possible by the EU-Eel Regulation.

This supposed increase of the eel population in The Netherlands has been interpreted as a partly externally driven (by implementation of EMP's of all EU-memberstates) and autonomous process (see above). And it has been used in Klein Breteler (2008) and in the EMP in the calculation of the effects of different measures. These have been questioned by ICES and are discussed extensively in Chapter 3 of this report.

Below we continue with a concise description of the methods and assumptions underlying specific measures described in the Dutch EMP (MinLNV 2008, 2009). In 2.b the effects of measures at pumping stations have been treated in more detail.

<u>Measure 1: Pumping stations/barriers</u>
See 2.b.

<u>Measure 2: Hydro-electric stations</u>
There are only a few hydropower stations in The Netherlands (MinLNV, 2009) and the current effect on the silver eel population on a countrywide scale is relatively low (15.5 MT/year) when compared with other anthropogenic factors (Vriese et al., 2008). Proven effective fish- or eelguidance systems (including bypass) are currently not existing (worldwide) and only experimental. But for smaller scale hydropower stations (< 2 MW, about 0.5% of total hydropower production in The Netherlands) there are. Relatively "fishfriendly" turbines are existing, but expensive, and may be installed after depreciation of investments.
The assumptions made implied: no increase in number of hydropower stations, "fishfriendly" turbines in small hydropower stations in 2027, fish guidance systems according to the Best Available Technology in large hydropower stations from 2015 onwards, "eelfriendly" turbine management combined with catch and release of silver eels above respectively below the dam until 2015.
The effect of the measures at small hydropower stations in 2012 was calculated from the 0.5% share of total hydropower production, 15.5 MT total silver eel mortalities and reduction of mortality from 50% to 10% at eel passage. The effect of the measures at large hydropower stations was calculated in a comparable way but with a supposed reduction of mortality by 50% at eel passage. Five-fold and 15-fold increases of effects were expected in 2030 and 2050 respectively.

<u>Measure 3: fishery-free zones</u>
Obstacles in migration routes increase mortality risks for the migrating species. This is known by many predator species but, with regard to the eel, also known by fishermen. Such migration obstacles for eels are dams, weirs, sluices, hydropower stations, shiplocks and pumping stations. The lakes and canals in The Netherlands are much better fishable than the large rivers. The commercial catch in recent years was 100 MT silver eel per year in the large rivers and 180 MT /year in other inland waters (Dekker et al., 2008). By closing fisheries in fishery-free zones it was assumed that a 20% reduction of fisheries mortality in the large rivers and 50% reduction in other inland water would be obtained. This would result in an immediate effect of 110 MT and five-fold and 15-fold increases in 2030 and 2050 respectively.

Measure 4, 5, 9: Angling and recreational

The total catch by angling in recent years amounted to 93-317 MT/year (Table 2.3.3 in EMP). Silver eels are seldom caught by anglers; they mostly catch yellow eels. The sportfisheries organizations in The Netherlands have voluntarily decided to oblige anglers to release caught eels immediately. As the age- or length distribution of the eel population on a countrywide scale is unknown, it was assumed that 50% on a weight basis would recruit to the silver eel stage in 2012. Assuming a total catch of 200 MT/year, the effect in 2012 would be 100 MT and 5-fold and 15-fold increases would be expected in 2030 and 2050 respectively.

Measure 6: Transport of silver eel

This measure occurs in the last version of the EMP (MinLNV, 2009), not in the earlier EMP (MinLNV, 2008). It is an inverse quotum of silver eels caught that first should be released into the sea before commercial fishermen are allowed to sell silver eels. It is a fixed quantity of 157 MT/year continuing during the years as long as the organisations of commercial fishermen are able to carry this out properly. If not, the measure is replaced by closure of eel fisheries in the months September and October (see below).

Measure 7: Sniggling

The total catch by sniggling in 2007 amounted to 10 MT/year (Table 2.3.3 in EMP). Silver eels are never caught by snigglers; they only catch yellow eels. The sportfisheries organizations in The Netherlands have voluntarily decided to oblige snigglers to release caught eels immediately. As the age- or length distribution of the eel population on a countrywide scale is unknown, it was assumed that 50% on a weight basis would recruit to the silver eel stage in 2012. The measure would result then in an effect of about 5 MT in 2012 and 5-fold and 15-fold increases would be expected in 2030 and 2050 respectively.

Measure 8: (Re)stocking

(Re)stocking will be carried out in The Netherlands, as a measure in the EMP, according to the (re)stocking protocol in Klein Breteler (2008). The protocol has a format of a decision tree of conditions to be fulfilled on a national level and on a regional/local level and is supported by all currently available knowledge on stocking of eels. The information in the protocol has also been used partly in drafting the chapter on (re)stocking in the EIFAC/ICES (2008) report. Key elements of the decision trees are considerations on management policy, ecology, fisheries, socio-economics, implementation constraints and ecological, economic and social uncertainties (Figure 3.2.1 in the EMP). The structure of the decision tree is supported by EIFAC.

The use of the protocol will be enforced by in the adjudgement of subsidies for (re)stocking.

There are many conditions in the protocol. One of the ecological conditions is that the eels are to be stocked only in waterbodies from where free and safe migration is possible to the sea or when provisions have been made at migration obstacles in the migration routes to the sea. Such waterbodies have not been chosen at the moment, but the conditions for subsidization of (re)stocking will guaranty that the eels will be stocked in waters with open access to the sea or with provisions (fish passes, fish guidance systems , trap-and-transport) to facilitate silver eel migration to the sea.

Measure 6 in MinLNV (2008): Closed season

The total commercial catch of silver eels in The Netherlands in recent years was 280 MT/year and the catch of yellow eels amounted to 640 MT/year. A closed season in September and October will decrease the silver eel catch by 73% and the yellow eel catch by 23% (Hoefnagel & Dekker, 2005).

As the age- or length distribution of the eel population on a countrywide scale is unknown, it was assumed that 50% of the yellow eel population on a weight basis would recruit to the silver eel stage in 2012. The calculated effect in 2012 would then be 278 MT and 5-fold and 15-fold increases would be expected in 2030 and 2050 respectively.

Measure: Waterquality
This measure has not been included in Table 5.3 of the EMP, but has been mentioned in the text beneath. The geographical distribution of the eel in The Netherlands is given in Figure 1.2.6b of the EMP. Most of this area (polders) is at or below sea level and consequently dammed. These polders are drained by pumping stations (Figure 1.2.7 EMP) and ditches and predominantly have an agricultural function. Risks in these habitats are mainly oxygen deficits, but also ammonia from agricultural sources can be mentioned. At a supposed lifetime of 25 years (female eels) and a risk of such mortal event of 1% per year (once in 100 years) this would result in 10% mortality on a lifetime basis. There are only anecdotical data to support such mortalities. It was assumed that all current measures and measures already foreseen in the near future will result in an effect on 50% of the total area of water and of 90% of the eels in that area (as quantified by the estimated effect of closure all fisheries). The calculated effect will then be 317 MT in 2012 and 5-fold and 15-fold increases would be expected in 2030 and 2050 respectively.

b. Effects of pumping stations

Large parts of The Netherlands are lying at or below sea level and are kept dry by pumping stations. The lakes, canals and ditches in these polders are considered suitable habitat for the eel (Fig. 1.2.6b and 1.2.7 in the EMP) and are known for a high occurrence of eels in the past (Van Drimmelen, 1952; 1953).
According to the EMP there are 4671 pumping stations in The Netherlands. Pumping stations actually function as inversed hydropower stations (input is energy, output is waterflow). Designs of turbines and pumps are comparable and the effects of pumps with regard to fish injuries and mortalities are comparable with the effects of hydroturbines. The problem with pumping stations with regard to migrating silver eels in The Netherlands is comparable therefore with the problem with hydropower stations in hilly and mountainous areas elsewhere. It is substantial and is to be qualified as an important anthropogenic mortality factor for the eel. Total mortality of silver eels on a weight basis due to pumping stations in The Netherlands in recent years is estimated 15-65 MT/year and of yellow eels 27-83 MT/year. The higher estimates are for the case of low fishing mortality, as these mortalities are competing.
If fisheries mortality would be reduced and the eel populations increase, it is expected therefore that mortalities in pumping stations increase, reducing the effects of measures on fisheries.

Pumping stations are only one element of the obstacles for migration of eels. Other types of migration obstacles are weirs and sluices in The Netherlands. The EMP describes that the program that is in operation on solving these migration barriers. Of the 2700 identified barriers, 1800 are considered of particular importance for the migration of eels. A ‘top-30’ has recently been made (Buijse et al., 2009).
A map has been constructed (Fig. 2.5.1 in the EMP) from which can be read which barriers are to be solved before 2015, after 2015 and for which a solution has not yet been scheduled.

The effects of measures on pumping stations in the EMP were calculated as follows.
It was supposed that after depreciation time, or at large renovations, the pumps would be replaced by ‘fishfriendly’ pumps according to the Best Available Technology in a total of 3000 pumping stations. ‘Fishfriendly’ designs for pumps are available and have proven effectiveness. At an assumed depreciation time of 50 years this would result in 60 pumps per year during 50 years.
It was also assumed that in 2027 fish guidance systems are installed at those pumping stations in prioritary migration routes of silver eels that had not been provided with ‘fishfriendly’ pumps by that time. And it was assumed that, until 2027, 25% of the pumps that have not been provided with ‘fishfriendly’ pumps or fish guidance systems will be turned off during 100 days per year during the

nocturnal hours in September – November. Besides it was assumed that at the remaining 75% of the pumping stations where no ‘fishfriendly’ pumps or fish guidance systems are in operation, 50% of the silver eels are caught below the pumping station by professional fishermen and released above.
Furthermore it was assumed that the mortality rate during passage of a pump is reduced from 50% in a ‘normal’ pump to 10% (silver eels) or 0% (yellow eels) in a ‘fishfriendly’ pump. And that, by the choice of the pumping stations to be provided with fish guidance systems, 80% of the migration needs of eels are covered and that 90% of the eels survive passage through such guidance systems.
The measures are supposed to act on the whole population that is not effected by fisheries (and that are assumed to increase 5-fold in 2027 and 15-fold in 2050: see 2.a) and the calculated effect in 2012 is 265 MT in 2012 with an approximate 5-fold increase in 2027 and 15-fold in 2050.

3. Scenarios for recovery: time scale

a. Method and assumptions

In the EMP of The Netherlands the estimated effects of measures on the silver eel escapement from The Netherlands in 2012, 2027 and 2050 have been given in Tabel 5.3 (MinLNV, 2008, 2009). The original objective of these estimates in Klein Breteler (2008) was to facilitate comparison of effects, costs and risks of different Dutch measures on a short, medium and longer term; not to make assumptions about time scale of recovery of the stock. And the intention was to facilitate decision making on the measures to be taken. The time scale in Klein Breteler (2008) has been arbitrarily set therefore to approximately 3 generations (2050), as was done by STECF (2006). It was believed that the differences in effects, costs and risks would become clear by that way, irrespective of the time scale of recovery. ICES commented on the latter and questioned the effects calculated, if the time scale of recovery would have been set on a more ‘realistic’ longer time scale.

The data given in Table 5.3 of the EMP also seem to suggest that 40% of the historical spawning stock biomass of eels in The Netherlands seems to be reached earlier than 2050. But such a ‘total effect’ in Table 5.3 cannot be calculated by summing the effects of the different measures to a total because of dependencies (Klein Breteler, 2008; and see 2.a). A basic assumption in the calculations has been that, once an eel was ‘saved’ by a measure, it was also saved from other anthropogenic factors. In that way, the calculated effects of the measures can be used for comparison of effectiveness, not for estimation of a total effect of all measures combined.
When 40% of the historical spawning stock biomass of eels in The Netherlands will be reached in the future is unknown. It depends on recovery of recruitment on an European level, and hence on the contents and implementation of the EMP’s of the EU-member states (see 2.a). It is possible to set a time schedule of recovery of recruitment on the level of the European eel stock, as Åström & Dekker (2007) have done (see below). With the assumptions that (1) this also holds for recruitment in The Netherlands, (2) the anthropogenic mortality on an European level is reduces to zero and (3) the implementation of the Dutch EMP is still convenient by that time, the moment of recovery of 40% of the historical spawning stock biomass of eels in The Netherlands will be one generation time later.

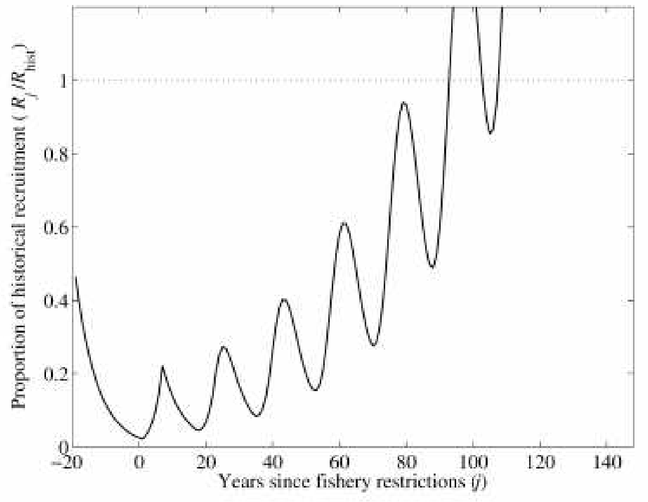

Figure 3-1 *Expected eel recruitment after a complete closure of fishing at j = 0 (eels are assumed to mature over a range of eight different ages) according to Åström & Dekker (2007) and Dekker et al. (2008).*

Åström & Dekker (2007) and Dekker et al. (2008) modeled the recovery of the European eel stock (Figure 3.1) under the condition of complete absence of fisheries (fisheries mortality $F_f = 0$) and ages at maturity ranging 14-21 (modal 15) years. They focused on fisheries only, not on other anthropogenic factors (F_a), that should also be mentioned (but that will not change the figure, provided that $F_f + F_a = 0$).
The heavy oscillations are generated by the decreasing stock in the years before the measures are taken. These are believed to be inherent to the specific population dynamics of the eel, given the decrease in the past (Åström & Dekker, 2007).

It is concluded by these authors that, once the EU-memberstates have implemented their EMP's and the recovery process of the eel stock occurs according to Figure 3.1, it will take at least 80 years (5 generations) until full recovery of recruitment (100%). So, starting in 2010 that point might be reached in 2090. With that full recruitment in 2090 it would be possible to get to the point of a Spawning Stock Biomass (SSB) of 40% of pristine levels in one generation (approximately in 2105).
As can be seen from the figure, such a recovery in 80 years is only possible if recruitment is observed at the peaks of oscillations R/R_{hist}. It then runs along the peaks of oscillations at t = 45, 60 and 78. At t < 45 it crosses the oscillations and at t = 0 it is approximately $R/R_{hist} = 0.02$. The associated values for R/R_{hist} , as read by eye from the figure, are given in Table 3.1.

Table 3-1 *Proportion of historical recruitment of eel R/R_{hist} on a stock level and proportion of historical escapement of eel SSB/SSB_{hist} from t = 0 (2012) onwards, if full recovery of recruitment occurs in 80 years in complete absence of anthropogenic mortality. Data for R/R_{hist} from Figure 3.1. Data for SSB/SSB_{hist} calculated from R/R_{hist} 15 years (1 generation) earlier (see text).*

Year	European Stock R/R_{hist}	NL population SSB/SSB_{hist}
2012	0.02	0.05
2027	0.14	0.05
2035	0.20	-
2050	0.34	0.11
2075	0.70	-
2090	1.00	0.29
2105	1.00	0.40

An estimate of the current silver eel escapement from The Netherlands is 400 MT/year and total anthropogenic mortality of silver eel is approximately 350 MT (MinLNV, 2009). Therefore the current SSB for The Netherlands amounts to 750 MT/year.

A conservative estimate of the historic SSB of eels from The Netherlands (SSB_{hist}), amounts to 10,000 - 15,000 MT, depending on the status (dammed or not) of Lake IJsselmeer, (Klein Breteler, 2008). This results in a targeted 40% SSB of 4,000 – 6,000 MT (MinLNV, 2009). Eijsackers et al. (2009) concluded that it is impossible to determine a 'correct' estimate of the 40% SSB, suggested a wider range of 2,600 – 8,100 MT and a most probable lower estimate than 4,000 – 6,000 MT. Because of this impossibility of making a 'correct' estimate, and because of the overlapping intervals, and mainly for reasons of comparison with the calculations in the EMP, the estimate of SSB_{hist} = 15,000 MT is again used in the calculations below. The latter might be an overestimate therefore.

The current status of the 'Dutch' spawning population of eels (SSB/SSB_{hist}) amounts then to 750/15000= 0.05, or 5%. This is slightly higher than the current recruitment level (European scale) and lags 1 generation time behind the downward trend of recruitment in the last decennia.
As stated above the fastest way to reach the targeted 40% SSB is according to Table 3.1 and that point will be reached in 2105 when SSB/SSB_{hist} = 0.4. The values for SSB/SSB_{hist} between 2012 and 2105 have been calculated here by fitting the curve R/R_{hist} in the time period between 2012 and 2090 to SSB/SSB_{hist} between 2027 and 2105, so 1 generation time (assumed to be 15 years) later. This has been done ('quick and dirty') by using the relative increments Δ of R/R_{hist}.
The increase $\Delta SSB/SSB_{hist}$ from *t=2027* to *t=i* ($2027 \leq i \leq 2105$) was calculated in Table 3.1 from the increase $\Delta R/R_{hist}$ from *t=2012* onwards, assuming a generation time of 15 years, and according to the formula (1):

$$\Delta(SSB/SSB_{hist})_i = \{(R/R_{hist})_{(i-15)} - (R/R_{hist})_{2012}\} * \{(SSB/SSB_{hist})_{(2105)} - (SSB/SSB_{hist})_{2012}\} \quad \text{at } t=i \qquad (1)$$

And as $(SSB/SSB_{hist})_{(2105)} - (SSB/SSB_{hist})_{2012} = 0.40 - 0.05 = 0.35$ (see above), (1) results in:

$$\Delta(SSB/SSB_{hist})_i = 0.35 * \{(R/R_{hist})_{(i-15)} - (R/R_{hist})_{2012}\} \quad \text{at } t=i \qquad (2)$$

$(SSB/SSB_{hist})_i$ at *t=i* is then obtained from:

$$(SSB/SSB_{hist})_i = SSB_{2012}/SSB_{hist} + \Delta(SSB_i/SSB_{hist})_i = 0.05 + \Delta(SSB_i/SSB_{hist})_i$$

As a consequence, the SSB/SSB_{hist} at t=2027 equals SSB/SSB_{hist} at t=2012. This seems realistic because only minor improvements (at best) in recruitment are to be expected on a short term (2012), and the resulting SSB 15 years later also will show not more than minor improvements.

The calculation of the effects of measures at the t=40 scenario was done according to Klein Breteler (2008) and as described in 2.a. Identical calculations have been made here for the t=80 scenario, using similar assumptions. Underlying both scenario's was an historic spawner biomass (silver eels) in The Netherlands of 15,000 MT and a generation time of eels in The Netherlands of 15 years.
Specific assumptions with regard to the recovery of the eel stock in 80 years were:

1. Anthropogenic mortality of the eel is zero on a lifetime base: $F_f + F_a = 0$
2. Recovery of stock-wide recruitment and recovery of the SSB in The Netherlands occurs according to Table 3.1.

b. Recovery in 80 years and effects of measures

The effects of measures in The Netherlands were calculated for the same measures as in Klein Breteler (2008). Those for the t=40 and t=80 scenario's are given in Table 3.2 and Table 3.3. Table 3.4 gives the effects of measures selected in the EMP.

The conclusion that can be drawn from the tables is that the estimated effects of the measures build up more slowly in time and reach a lower level in the t=80 scenario than in the t=40 scenario. But the differences between the measures remain. The basis for decision making on the measures to be chosen has not been changed therefore by the scenario choice.

Table 3-2 *Effects of measures on silver eel escapement (MT/year) in different years and at different scenarios for recovery times of recruitment (year) at t = 40 and t=80. The effects for t=40 are described by Klein Breteler (2008) and also in MinLNV (2009) (the Dutch EMP). The data for the t=40 scenario in this table are given to facilitate comparison with the scenario at t=80.*

		Recovery time t = 40 years					Recovery time t = 80 years				
		2009	2012	2027	2050		2009	2012	2027	2050	2090
1	Immigration	0	0	40	600		0	0	0	378	1428
2	Restocking	0	0	100	100		0	0	100	100	100
3	Fisheries	280	705	3525	10575		280	705	705	1593	4061
4	Translocation silver eel to sea	308	765	3631	10575		308	765	726	1641	4061
5	Eel diseases	0	0	0	0		0	0	0	0	0
6	Pumping stations	88	265	1342	3843		88	265	268	606	1476
7	Hydropower	11	11	41	122		11	11	39	40	118
8	Predation	0	25	38	56		0	25	38	38	56
9	Cooling water	0	0	0	0		0	0	0	1	0
10	Water quality	0	317	1586	4759		0	317	317	717	1827
11	Silver eel quality	0	0	9	529		0	0	2	4	203
12	Growth	0	0	6762	31725		0	0	1352	3056	12182

Table 3-3 *Effects of specific fishery measures on silver eel escapement (MT/year) in different years and at different scenarios for recovery times of recruitment (year) at t = 40 and t=80. The effects for t=40 are described by Klein Breteler (2008) and also in MinLNV (2009) (the Dutch EMP). The data for that scenario in this table are given to facilitate comparison with the scenario at t=80.*

		Recovery time t = 40 years				Recovery time t = 80 years				
		2009	2012	2027	2050	2009	2012	2027	2050	2090
1	Quotum silver eel	280	280	1400	4200	280	280	280	633	1613
2	Angling	0	100	500	1500	0	100	100	226	576
3	Sniggling	0	5	25	75	0	5	5	11	29
4	Fisheries silver eel	280	280	1400	4200	280	280	280	633	1613
5	Fisheries yellow eel	0	320	1600	4800	0	320	320	723	1843
6	Eel fishing rights	0	40	1200	1200	0	40	240	542	542
7	Comm. fish. arrangement	0	0	0	0	0	0	0	0	0
8	Licenses	39	215	1076	3228	39	215	215	486	1240
9	Eel fishing gear	280	600	3000	9000	280	600	600	1356	3456
10	Minimum size 37 cm	0	160	800	2400	0	160	160	362	922
11	Mesh size ~ 37 cm	0	160	800	2400	0	160	160	362	922
12	Minimum size 32 cm	0	42	208	624	0	42	42	94	240
13	Closed season sep+oct	204	278	1390	4170	204	278	278	628	1601
14	Closed season sep	64	116	578	1734	64	116	116	261	666
15	Closed season 50%	140	300	1500	4500	140	300	300	678	1728
16	Fishery-free zone 50%	140	300	1500	4500	140	300	300	678	1728
17	Fish. free zone hotspots	110	110	550	1650	110	110	110	249	634
18	Fisheries Lake IJsselmeer	40	120	600	1800	40	120	120	271	691

Table 3-4 *Effects of selected measures on silver eel escapement (MT/year) in different years and at different scenarios for recovery times of recruitment (year) at t = 40 and t=80. The selection has been made in MinLNV (2009, 2008) The effects for t=40 are described by Klein Breteler (2008) and also in MinLNV (2009) (the Dutch EMP). The data for that scenario in this table are given to facilitate comparison with the scenario at t=80.*

The measure 'Closed season' is mentioned in MinLNV (2008) only and 'Transport of silver eel' in MinLNV (2009) only. The 'Closed season' measure from the earlier version of the EMP (MinLNV, 2008) has been included to show the differences between the 'old' measure 6 and the 'new' measure 6 on the longer term. Note that measure 6 results in 157 MT/year on the longer term, not in >157 MT/year as suggested in MinLNV (2009).

No	Measure	Recovery time t = 40 years			Recovery time t = 80 years			
		2012	2027	2050	2012	2027	2050	2090
1	Pumping stations/barriers	265	1342	3843	265	268	606	1476
2	Hydro-electric stations	11	41	122	11	39	40	118
3	Fishery-free zones	110	550	1650	110	110	249	634
4,5,9	Angling & recreational	100	500	1500	100	100	226	576
6	Transport of silver eel	157	157	157	157	157	157	157
7	Sniggling	5	25	75	5	5	11	29
8	Restocking	0	100	100	0	100	100	100
(6, old)	Closed season	278	1390	4170	278	278	628	1601

References

Åström M., and Dekker W. 2007. When will the eel recover? A full life-cycle model. ICES Journal of Marine Science, 64: 1–8.

Buijse A.D., Van den Belt T., Brevé N. & H. Wanningen, 2009. Knelpunten en migratievoorzieningen op de migratieroutes voor aal naar de belangrijkste leefgebieden in Nederland. Migratiemogelijkheden voor aal door Nederland. DELTARES-report, Project 1002104-000, 24 p.

EIFAC/ICES, 2008 (draft). Joint EIFAC/ICES WGEEL Report 2008. ICES CM 2008/ACOM:15. Report of the Joint EIFAC/ICES Working Group on Eels (WGEEL), 3-9 September 2008, Leuven, Belgium, 206 p.

Eijsackers H., Nagelkerke L.A.J., Van der Meer J., Klinge M. & Van Dijk J., 2009. Streefbeeld Aal. Een deskundigenoordeel. Een advies op verzoek van de minister van LNV, 17 p + 8 bijlagen.

Dekker W., Ch. Deerenberg & H. Jansen, 2008. Duurzaam beheer van de aal in Nederland. Onderbouwing van een beheerplan. Wageningen IMARES IJmuiden. Rapport C041/08, 99 p.

Hoefnagel, E. & W. Dekker, 2005. Gevolgen van vangstbeperkingen in de Schieraalvisserij; Bedrijfseconomische consequenties van verschillende beperkingen van de schieraalvisserij en meningen van vissers. Den Haag, LEI, Rapport 6.05.08 70 p.

Klein Breteler J.G.P., 2008. Herstel van de Aalstand II. Bouwen aan een beheerplan. Het streefbeeld, de huidige uittrek, een nadere verkenning van de mogelijke maatregelen en een protocol voor het uitzetten van aal. VIVION BV, Utrecht. Projectnummer VIVION 08.002a, 118 p.

MinLNV, 2008. The Netherlands Eel Management Plan. The Ministry of Agriculture, nature and Food Quality, 15 December 2008, 48 p.

MinLNV, 2009. The Netherlands Eel Management Plan. The Ministry of Agriculture, nature and Food Quality, 1 April 2009, 47 p.

STECF, 2006. Commission staff working document - Report of the second meeting of the subgroup on review of stocks. (SGRST-06-02) of the Scientific, Technical and Economic Committee for Fisheries (STECF) - Eel Management - Ispra, 21-24 March 2006. SEC(2007) 475. 13 pp.

Van Drimmelen D.E., 1952. Opbrengsten van het viswater bij de Binnenvisserij. Visserij-Nieuws 5: 137-140.

Van Drimmelen D.E., 1953. Opbrengsten van het viswater bij de Binnenvisserij. Visserij-Nieuws 6(8): 114-117.

Vriese F.T, J.G.P. Klein Breteler, M.J. Kroes & I.L.Y. Spierts, 2008. Duurzaam beheer van de aal in Nederland. Bouwstenen voor een beheerplan. VisAdvies BV Utrecht. Projectnummer VA2007_01, 178 p+bijlagen.