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Ways to Investigate the Problems of the Sustainability of Eel Stocks

Abstract

The stocks of the different species of the genus *Anguilla* have a life cycle one part of which takes place in the ocean and the other in the continental shelf area including sea and freshwater.The part of the eel life cycle that has been investigated in closest detail is the continental phase. Unfortunately the oceanic phase has not been studied in that detail, and the studies cover only a few species. The lack of knowledge on the ocean life of the eel is especially serious because the latter comprises the most important part of the reproduction. In terms of marine ecology it is lamentable that the commercially most important species of the present day- *A. japonica* - is scientifically far less known than expected considering its great commercial importance.

Details of the two phases of the continental life stage are essential for gaining knowledge on reproductive success: the annual quantity of the young eels and the annual escapement of the migratory eels or the stock of the preceeding yellow eels. For several reasons the calculation of the number of spawners expected is a difficult task. This reduces the possibilities for a calculation of the spawning success on the basis of the number of spawners and this poses the question whether these numbers are important. The better measure for spawning success is therefore the number of arriving young eels and, more favorable, the quantity of ascending glass eels. The little older elvers would also do.

The first step towards calculating the relationship between spawning stock and number of recruits is therefore the consideration of a long series of annual young eel ascents. In Europe we have a number of glass eel and elver ascent statistics from different regions and locations derived from the Working Party on eel. Only the longest series are considered here. Also, from the other side of the North Atlantic, catch statistics of elver and commercial eels (*A. rostrata*) are known which unfortunately have not such a long range as the European ones and so are the statistics for *A. japonica* which are even shorter.

The longest series of young *A. anguilla* catch originates from Northern Europe. Since the mid fifties, the series presents a downward trend and, in contrast to other European areas, shows no peak until the present years. But before the peak in the fifties, around 1943, a time of low catch is visible. Another minimum between peak catches is around 1920. All statistics of glass eel catch in more central parts of Europe, France, The Netherlands and Germany showed a unique peak in the mid seventies. This peak is so pronounced that the following decrease which reaches up to the recent years looks like dropping down to a level which is below the sustainability of the stock. But there are also strong valleys (1970,1947) and peaks (1965, 1955) nearly in all sampling areas in earlier years.

North America provided data of eel landings between 1950 and the present. They show a peak in the mid seventies and then, until 1996, a decline, but the increase to the peak in 1975 started from a very low valley in 1962. The drop to this lowest level started from a comparatively high level in 1950. Experimental trawl surveys in Virginia on eels smaller than 180 mm showed contradicting results. The commercial eel landings in USA should perhaps be considered with caution although dicussions were presented that the decline since 1975 occurred parallel to the decline in Europe. This would be an indication for similar oceanic influences on the two species spawning in similar areas and depths.

The time series available for *A. japonica* are too short for similar conclusions made for the Atlantic *Anguilla*. The Japanese time series comprises not more than 30 years and the decline began probably about 25 years ago. That is in the range of the earlier fluctuations exhibited for the Atlantic species. Oceanic influences may play the main role for the Pacific species as well.

This means that, with the assistance of glass eel statistics, oceanic investigations are the only means of finding the critical stage and environment that determines the number of recruits. These studies are expensive because of the shipping time, equipment and manpower. But the high commercial value of the eel justifies that kind of studies. In addition, experience and specialized knowledge are required. International cooperation therefore is important and is necessary considering the requirement of enough shipping time of appropriate vessels. The high shipping time is especially necessary when the dense and extensive network of sampling stations during a limited time of the year is considered.

There is also still the question of the feasibility of the species for the studies. I can imagine that the population of *A. japonica* is rather small and the density of the larvae stock low. This requires higher effort of sampling, perhaps the size of the known gears is too small for the low density of this species. The biggest population of the genus is probably that of *A. anguilla* and together with *A. rostrata* even still bigger. Also, the fundament of knowledge on these species is best. With this fundament one could build up with ease the final fundament for the judgement of the level of sustainability. Application to *A. japonica* then could work on a known scheme which on the basis of surveys would provide the limits of sustainability. This procedure would probably be more successful and cheaper. A second aspect should be mentioned: *A. anguilla* at present supplies an essential part of the East Asia aquaculture with glass eels, therefore an economic dependency on the Atlantic species already exists.

Key words: Sustainability, Time-series, Eel stocks

The sustainability of an exploited fish stock falls short when the amount of spawners is too small for a further useful exploitation. Two thirds of the fish stocks in the world are overexploited [1]. In addition the exploitable stock size is determined by environmental factors, especially during early life stages. The main losses occur between late larval stage and the early juvenile stage[2]. Whether this assumption is true for the eel is another question because it has a very long larval stage which extends its vulnerability for a long period. To ascertain the vulnerability during the eel's late larval stages, I

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compared the stock sizes of two different juvenile stages of *A. anguilla.*[3]. It was concluded that the density of the glass eel/elver stage is a good measure of the survival of a year class essentially during earlier life stages. Long term published annual catch statistics of the glass eel/elver stages show whether the present decline of some eel populations have parallels during earlier periods. This seems likely and the consequences are discussed.

Figure 1 shows the amount of glass eels ascending the estuary of the River Ems. For comparison one can see the density of the next younger stages occurring off the European coasts at water depths of more than 500 m one year earlier. The two stages exhibited a strikingly similar frequency in all of the compared years except 1979/80. This is a year when larval collections differed regionally and seasonally from the other years. I conclude that between the stages under consideration no serious environmental factors influenced the stock size. The glass eel catches near the costs and in the estuaries therefore should be a good measure of the stock size coming from the ocean. It is the only indicator which can provide insight into the spawning success of the special year classes.

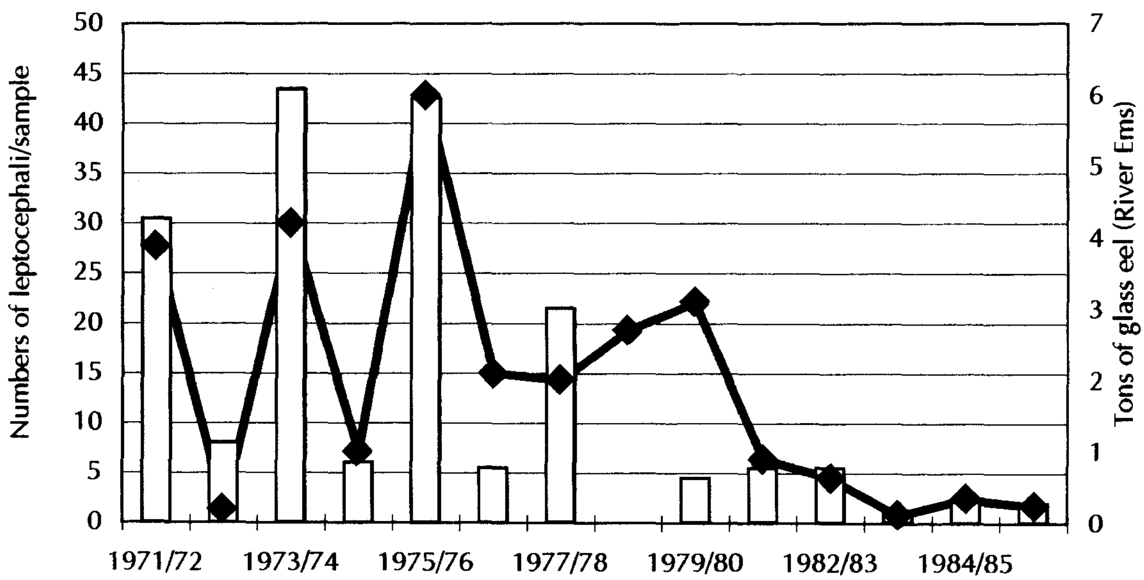

Fig 1. *A. anguilla* glass eel catch (line) in the German River Ems and leptocephalus catch by IKMT at the European west coasts and water depths of >500 m (columns), one year earlier (after Tesch 1985[3]).

The European countries have studied the annual glass eel ascent in many places but unfortunately mostly for not a long series of years. I preferably will compare here the long time-series. The first one comes from Northern Europe (Fig. 2). It includes not only glass eels but also elvers, and started as early as 1900. It exhibits a striking downward trend from the late nineteen-thirties on, but, in addition a probably similar but shorter downward trend from the beginning of the century up to the nineteen - twenties.

The more central European statistics show a different development. In Fig. 3, catch statistics in the estuaries of the Rivers Loire and Ems are provided. Both rivers exhibited a strong maximum around the late 'seventies which then decreased to the recent low level. Less distinct maximum catches occurred around 1967 and 1960. The previous years the catches were at a low level similar to the low level measured in recent years. In both rivers a small peak appeared around 1947.

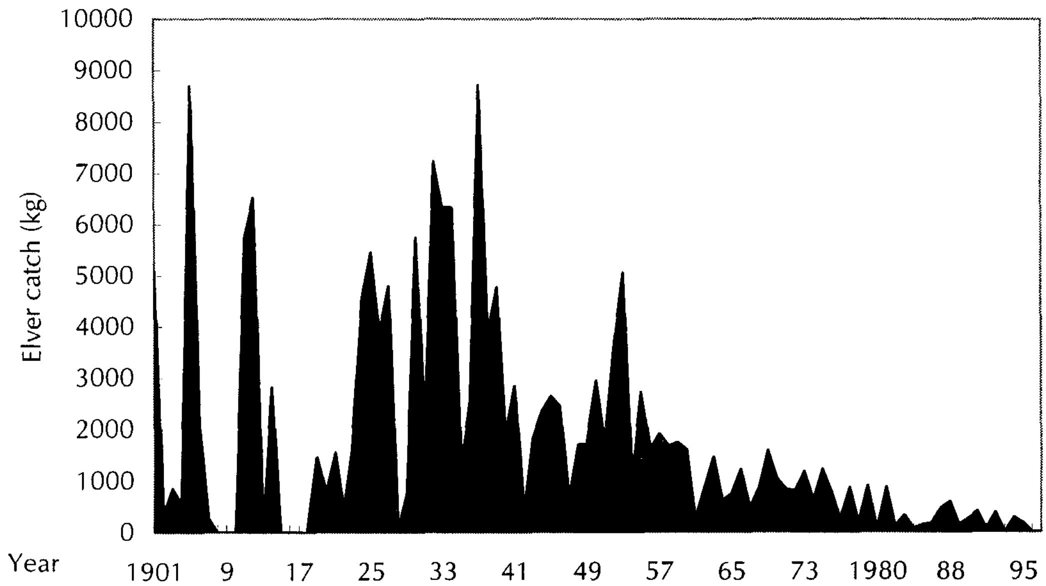

Fig. 2. Elver catch in the River Götaelv in Sweden including glass and young eel (from Tesch 1999[4], after Wickstöm personal communication).

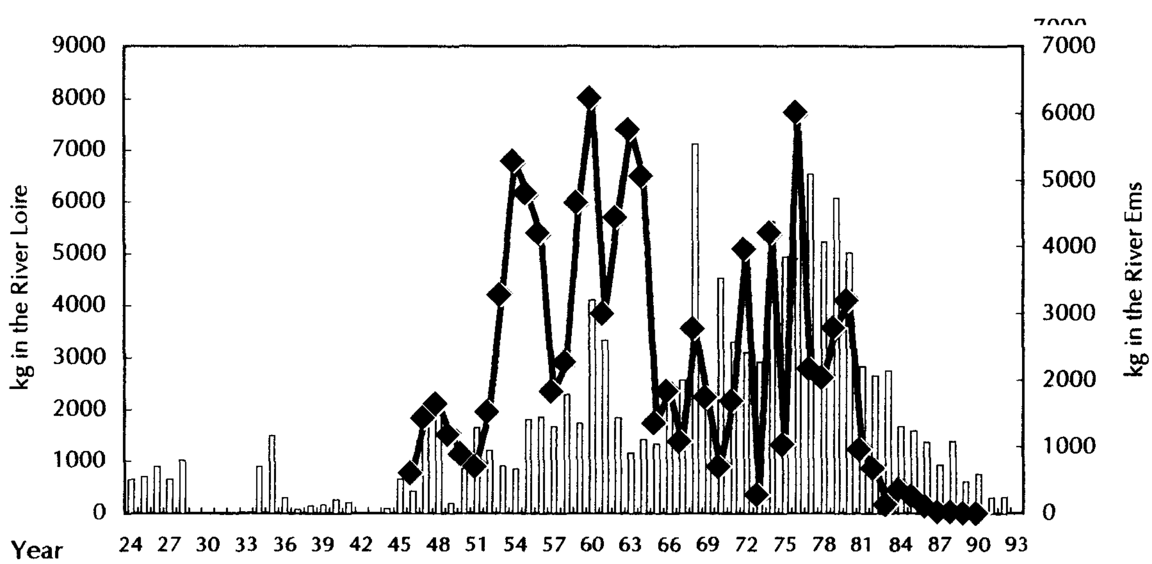

Fig. 3. Glass eel catch in Loire (colums) and Ems (line) (from Tesch 1999[4], after Moriarty 1990[5] and Moriarty & Tesch 1996[6]).

A further, comparatively long registration, more than fifty years, took place in an area in between, in Holland (Fig 4). It was carried out by a kind of dip net samplings between salt- and freshwater and is calculated by deviations from the mean. The graph based on the Holland results shows features similar to those of the glass eel ascent in the two previously mentioned rivers, especially the peak around 1977 which occurred at the beginning of the decline to the present low level. A peak occurred also during the early sixties which developed after a low level similar to that of recent years. As a whole it should be said that the long series catch curves recently show a comparatively long-term downward trend but similar trends are also visible in earlier periods.

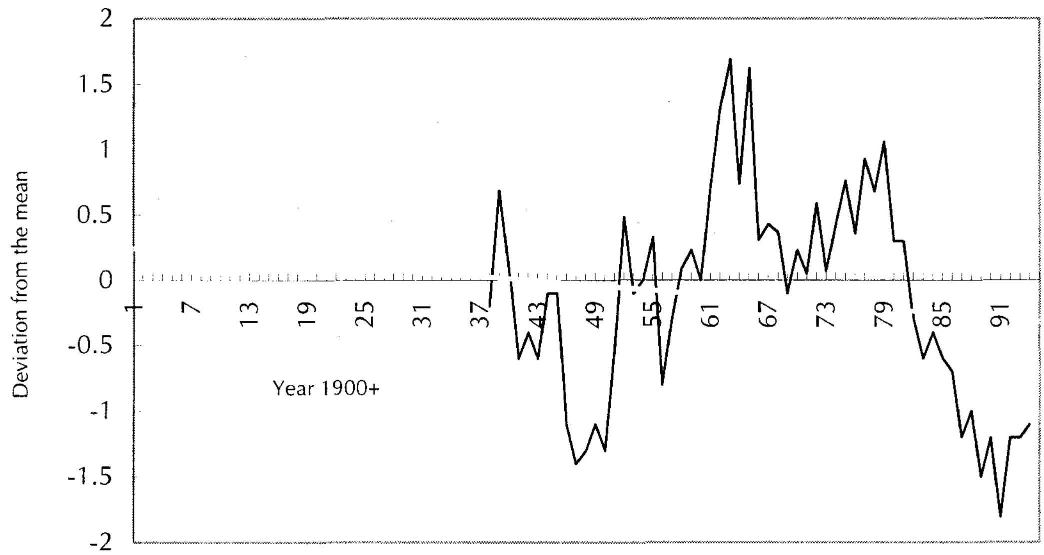

Fig. 4. Glass eel experimental catch by dipnet in Den Oever, The Netherlands, calculated by deviation from the mean (after Moriarty 1990[5] and Moriarty & Tesch 1996[6]).

On the basis of the experience with the European long-term catch registrations, one should consider the shorter term registrations of other eel species. *A. rostrata* is geographically and genetically nearest to the European eel and perhaps, during recent years, has downward trend features comparable to those of the European eel[7]. Fig. 5 shows a 40-year series of trawl catches in Virginia. Elvers and eels of all sizes exhibited similar features during the whole time series. A maximum occurred around 1984 together with a maximum in 1991. The two maxima were preceded by 20 years of low catches. I have compared these experimental catches with the USA eel landings of commercial eels (Fig. 6). Essential differences between the graphs are visible. The peak of the commercial eel landings is followed by a more than 20-year decline until the last years. This decline is temporarily similar to the last European glass eel decline, but it is not comparable because of the more than 8 years age difference of the commercial eels compared with glass eels. From this point of view the big maximum around 1984 of Virginia trawl surveys and the following decrease agrees well with the recent European glass eel decline. From the North American curves, it is also obvious that the extended decline of the European eel recruitment has parallels in earlier periods of this century in both continents.

How can we apply these experiences in the North Atlantic area for East Asia?

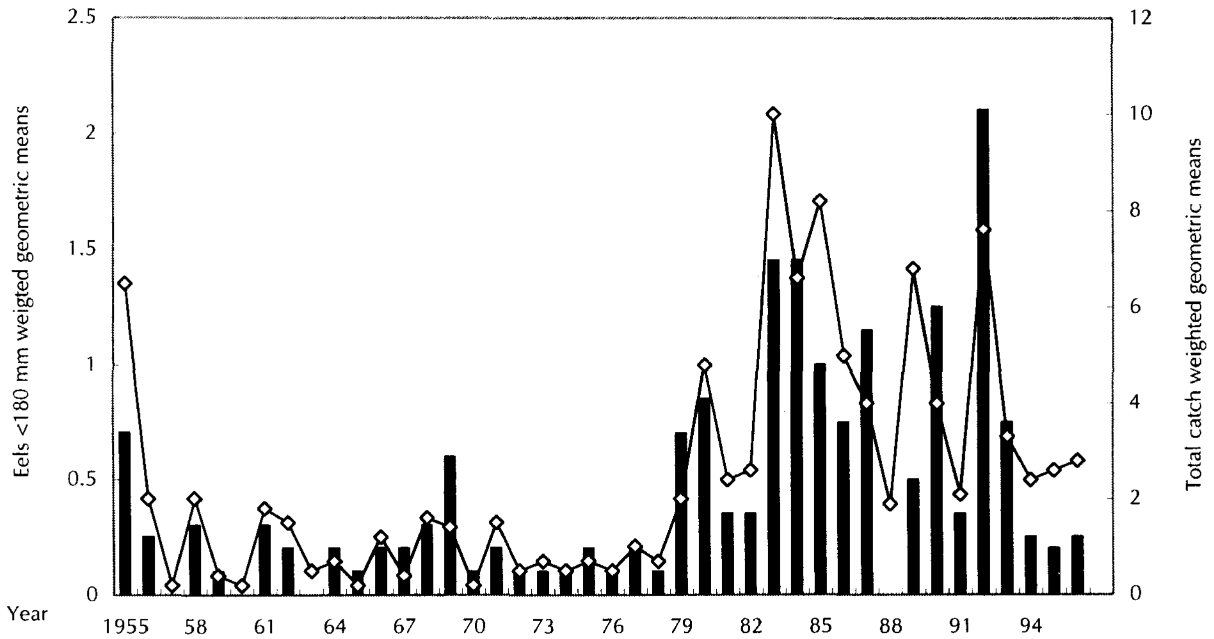

Fig. 5. Virginia trawl catches of eels <180mm (columns) and total catch (lines) weighted geometric means (after RICHKUS & WHALEN 1999[7]).

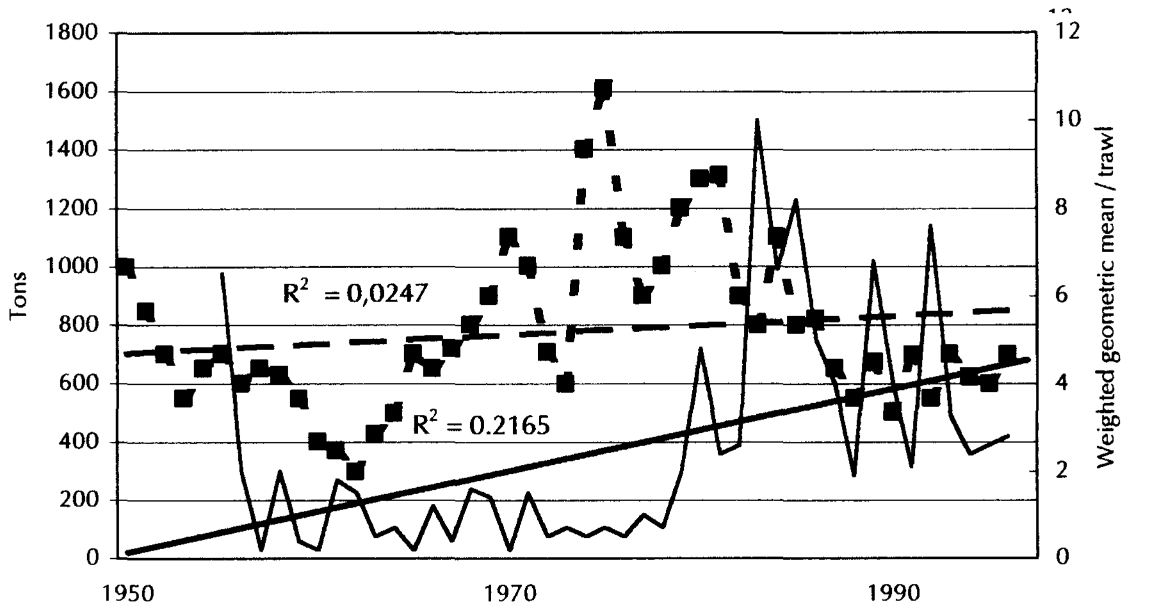

Fig. 6. USA landings (dashed line) and experimental catch in Virginia (line) (after RICHKUS & WHALEN 1999[7]). R^2= Coefficient of determination of linear regression lines.

The time series of *A. japonica* which I had at disposal are even shorter than those of the American eel. Fig 7 compares two statistics: one of the elver, the other of the commercial eel landed from natural waters in Japan. Both series covering the about thirty years of observation show a distinct downward trend which is documented by the coefficient of determination. I will not discuss here the reliability of the statistics. Perhaps the data in Figure 7 are an underestimation, which can also occur with the eel or other expensive fish in Europe: the lower the yield the more tax is avoided and governmental statistics incorrect. However, that there is a period of decrease cannot be denied.

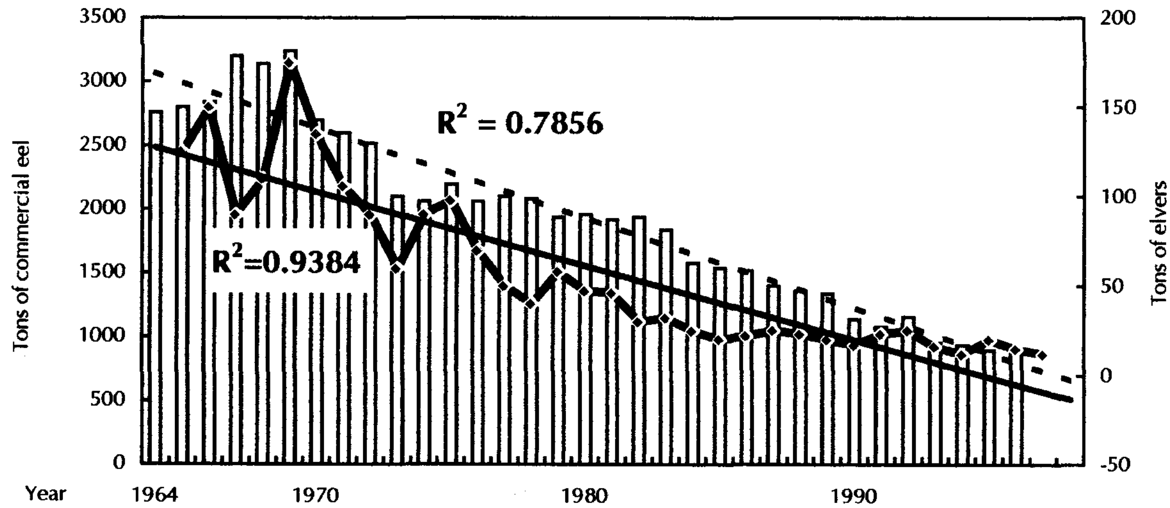

Fig. 7. Eel and elver catch in Japan (after TATSUKAWA & MATSUMIYA 1999[11]), R^2= Coefficient of determination of linear regression lines.

The situation becomes more complicated when the statistics of the Taiwanese glass eel catch is compared with those of the Japanese figures (Fig. 8). The development during the 30-year period is completely different. Neither a decrease nor an increase can be observed in Taiwan which is also documented by the very low coefficient of determination. My only conclusion is that the recruitment in the South is different from that in the North. Results on the size and the number of myomeres or vertebrae as well as on the genetics may resolve this problem. *A. anguilla* exhibited differences in size and in vertebrae counts between north and south[8-10] and also the features of the catch statistics between both regions differed as well as the genetics[12]. In this case differences in the migratory paths of the two groups are likely.

From a comparison of the long-term and short term young eel catch statistics one can conclude that "short" periods of, for example, twenty to thirty years cannot indicate the beginning of a decline caused by anthropogenic influences. Such declines have their parallels in earlier periods but recoveries subsequently followed. The ever-increasing antropogenic damage on the continents therefore could not be the main cause of the declines.

I know there is a danger if one neglects the antropogenic damage. To a certain extent it must be considered to at least contribute to the declines registered. One should not forget the worldwide changes in the atmosphere and the increases of the oceanic water temperature. These changes have oceanographic consequences which can have effects on the marine life of the eel. Altogether, we have no knowledge of the oceanic mechanisms which are decisive for the mortality of the eel's most vulnerable stages. Studies on the biological/oceanographical needs can only assist in forecasting the fluctuations of its recruitment and in addition perhaps towards learning the critical environmental conditions for its artificial propagation.

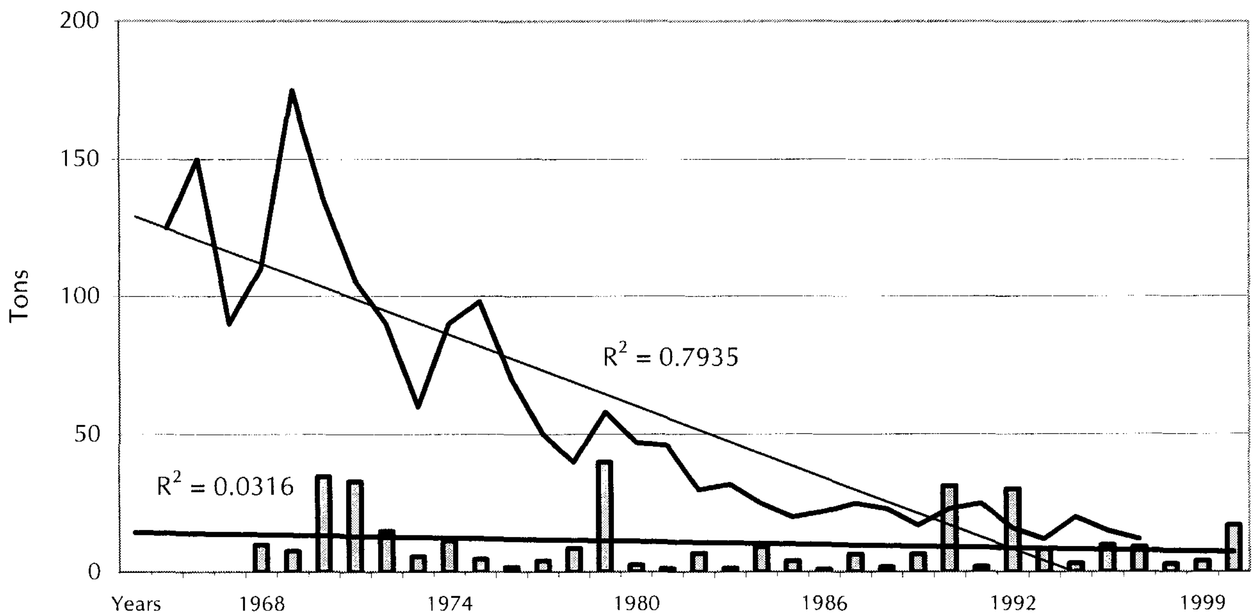

Fig. 8. Glass eel catch in Japan (line) and Taiwan (columns) (after TATSUKAWA &MATSUMIYA 1999[11] and W.N.TZENG personal communication), R^2= Coefficient of determination of linear regression lines.

The lack of knowledge must be deplored, especially as was caused by the lack of financial support in this field. For commercially important marine fishes money in abundance is invested in the study of their critical phase of reproduction; the income of the sea fishery justifies the expense for marine investigations. For the eel this is seemingly not the case. This fish provides mainly a "continental" income furthering investigations on the continent. The marine studies are expensive because of the shipping time, equipment and manpower. But the high commercial value of the eel justifies the studies although the money comes from the continental industry of aquaculture.

There is still the additional question of the suitability of the different eel species for such studies. I can imagine that the population of *A. japonica* is rather small and the density of the larvae stock low. This requires comparatively high effort of sampling. For example, the size of the known sampling gears is too small for the low density of this species. The biggest population of the genus is probably that of *A. anguilla* and together with *A. rostrata* it is even bigger. Also, the marine-biological knowledge on the Atlantic species is profound enough that it already forms a solid basis that can be supplemented to build on *A. japonica,* thus facilitating the evaluations of the level of its stock sustainability. This procedure would probably be more successful and cheaper than concentrating on *A. japonica* alone. A second aspect should be mentioned: *A. anguilla* at present supplies an essential part of the East Asian