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Status of the anadromous twaite shad *Alosa fallax* (Lacépède, 1803) in German and adjacent waters of the Baltic Sea

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ABSTRACT

The status of twaite shad in German and adjacent waters of the Baltic Sea was investigated based on the analysis of ichthyological museum collections, historical commercial catch statistics, recent catch records from commercial and recreational fishery and research hauls with different trawls from August 2003 to July 2004. 42 % of the historical records of twaite shad were estimated in subdivisions 24, whereas 21 % were registered in subdivision 26. *A. fallax* was mainly distributed within the areas of Pommeranian Bay and Pommeranian coast, Szczecin Lagoon, Bay of Gdańsk, Vistula Spit, Vistula Lagoon, Kuršiu Spit and Kuršiu Lagoon. Twaite shad was an important commercial species in those areas during the last quarter of the 19th and the first half of the 20th century. The annual catches of twaite shad in the Southern Baltic declined sharply in the 1950s. The mean annual catch of twaite shad amounted to 90 982 kg for the entire Southern Baltic Sea between 1891 and 1960. About 47.9 % of that value were contributed by subdivision 26, comprising the areas of Gdańsk Bay, Vistula Lagoon/Vistula Spit and Kuršiu Lagoon/Kuršiu Spit. The proportion of subdivision 24, comprising the areas of Pommeranian Bay/Pommeranian coast and Szczecin Lagoon, amounted to 37.5 %. Seasonal commercial catches of twaite shad showed maximum values from May to July and peaked in June. *A. fallax* was only occasionally caught in the Baltic Sea region until the mid 1990s. Later on, twaite shad was observed more frequently in Polish, Lithuanian and Estonian waters of the Southern Baltic Sea. A total of 25 individuals were recorded in German Baltic waters from 2000-2004. Most of these new records were obtained from the Szczecin Lagoon and Pommeranian Bay. It must be concluded that the Baltic population of twaite shad is increasing since the middle of the 1990s after about 50 years of its decrease. The starting point of the population increase is probably the eastern twaite shad stock of the Kuršiu Lagoon.

Keywords: twaite shad, Baltic Sea, past distribution, commercial catch, recent records

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INTRODUCTION

Like the other shad species, twaite shad *Alosa fallax* (Lacépède, 1803) belongs to the subdivision Clupeomorpha and is a member of the family Clupeidae. The determination of the six subspecies of *Alosa fallax* which have been recognized by Quignard & Douchement (1991a) based mainly on the number of gill rakers on the first gill arch and geographical location of the different subspecies. Recently, Kottelat (1997) concluded that some of those previously recognized subspecies should be reclassified as species. However, the correct nomenclature for the twaite shad population(s) in the Atlantic seabord including the Baltic Sea has not finally be determined. Aprahamian et al. (2003a) proposed to refer to the anadromous species of *Alosa fallax* inhabiting the Baltic Sea as *Alosa fallax fallax*. This subspecies is distributed in the Baltic Sea and in the whole Atlantic seabord including the North Sea (e.g. Saemundsson 1949, Kartas 1981, Taverny 1991, Sabatié 1993). The general characteristics of *Alosa fallax fallax* have been described by Svetovidov (1952), Wheeler (1969), O'Maoileidigh et al. (1988), Quignard & Douchement (1991b), Sabatié (1993) and Alexandrino (1996).

Winkler et al. (2000) evaluated the distribution status of twaite shad within the framework of their checklist of fish species in the Baltic Sea. The authors described the distribution status of *A. fallax* in the Baltic Sea as “present” for Denmark, as “common” for Poland and Lithuania and as “very rare” for Russia, Finland, Latvia and Germany. Generally, the twaite shad, which was very common in a number of Baltic and other European waters about hundred years ago, is now very rare or completely extinct in many waters of its former distribution area. There are just a few rivers left with strong populations like the Garonne-Dordogne river system in France or the Elbe River in Germany (Quignard & Douchment 1991a).

Due to its decrease in number and distribution, the twaite shad has meanwhile been included in Appendix III of the Bern Convention and Annexes II and V of the EC Habitats Directive. Especially, the incorporation of this species into the EC Habitats Directive places an obligation of members of the European Union to assess numbers and exploitation of the populations and to designate Special Areas for Conservation (SAC) / Sites of Community Interest (SCI) to safeguard populations (Aprahamian et al. 2003b).

In conclusion from recently published reviews on twaite shad (Aprahamian et al. 2003a, Aprahamian et al. 2003b), there is a great need to get detailed information about the status of *A. fallax* in most parts of its distribution area. Especially for the Western and Southern Baltic Sea, a complete description of the past and present distribution and a detailed analysis of the temporal and spatial development of the commercial catches are completely lacking. However, the results of those studies are the basis to define measures, e.g. to designate SACs / SCIs for the conservation of Baltic stocks of twaite shad as a contribution to safeguard the species in its whole distribution range. In this regard, the aims of this paper are to describe and analyse: (1) the past distribution of twaite shad in subdivisions 21-26 of the Baltic Sea, (2) the temporal trends and spatial characteristics of the commercial catch of

twaite shad in the Southern Baltic (3) the recent records and trends in the distribution of twaite shad in German Baltic waters.

MATERIAL AND METHODS

During a 12 months period from August 2003 until July 2004 the following different sources of already existing data and new estimated data concerning twaite shad in the Baltic Sea have been analysed and compiled:

- relevant ichthyological collections from Germany, Denmark and Sweden,
- historical commercial catch statistics from the Southern Baltic Sea,
- recent catch records from commercial and recreational fishery in German waters of the Baltic Sea,
- results of research hauls which were performed with different trawls in the Baltic Sea region between the Islands of Rügen, Usedom and Bornholm.

Analysis of ichthyological collections

The ichthyological collections of museums and universities of Germany, Denmark and Sweden which are known to contain individuals of twaite shad from the Baltic Sea in their collections were analysed. All records of twaite shad with useful information about locality and date of their catch were summarized in Table 1 and presented in Figure 1. In unclear cases of scientific determination, the specimens were re-determined. Ichthyological collections of the following institutions were analysed:

- Museum of Natural History of the Humboldt University in Berlin (NHMB), Germany,
- Zoological Institute and Museum of the University of Hamburg (ZMUH), Germany,
- Museum of Natural History Stuttgart (NHMS), Germany,
- Zoological Museum of the Christian-Albrechts-University Kiel (ZMUK), Germany,
- Department Biology of the University of Rostock (DBUR), Germany,
- German Oceanographic Museum (GOMS), Stralsund, Germany,
- Zoological Institute and Museum of the Ernst-Moritz-Arndt-University Greifswald (ZMUG), Germany,
- Zoological Museum of the University of Copenhagen (ZMUC), Denmark,
- Swedish Museum of Natural History, Stockholm (NRMS), Sweden.

Synopsis of data from historical commercial catch statistics

Data from papers containing original information about catch statistics of twaite shad in the Southern Baltic Sea were assessed, selected and then compiled (Table 1-2, Figures 1-4). Such data were used from Anonymus (1887-1920), Ehrenbaum (1921), Eichelbaum (1926-1940), Mohr (1941), Manyukas (1989), Winkler (1991), Maksimov & Toliušis (1999) and Repečka (1999). The data were compiled in units of kilogram, metric tons and number of individuals. For the period 1887-1900, data for a few locations were only available in an old

German unit of measure (Schock) which corresponds to 60 individuals. These values were converted into weight units, assuming that one kilogram of catch contains about three individuals of twaite shad. Some of the annual yields from 1901-1915 were only available in currency (Mark). Conversion of those values into weight units was performed assuming that one kilogram of catch is equivalent to 0.7 Mark. The number of individuals was obtained using the assumption that one kilogram of catch contains three individuals of twaite shad. Converted number values were rounded to the nearest hundred individuals. To allow a clear presentation, records from the same localities and time periods were summarized in Table 1.

Compilation of recent catch records from commercial and recreational fishery

An information sheet containing drawings with the most important determination characteristics of twaite shad was developed to achieve that commercial and recreational fishermen communicate actual catch records of *A. fallax*. This information sheet was distributed to selected reliable persons along the Baltic coast of Germany. Furthermore, a catch award was announced to those fishermen communicating doubtless catches of twaite shad. Records of twaite shad which were summarized by Thiel et al. (2004) are presented in Table 3 and Figure 5.

Evaluation of hauls from research fishery

The actual occurrence of twaite shad in the Baltic Sea region between the Islands of Rügen, Usedom and Bornholm was investigated based on research fishery with otter trawls. Fish sampling was carried out at 41 stations in autumn 2003 and in spring and summer 2004. Overall, 82 hauls were performed. Trawls were towed during daylight and lasted for 30 min. After collection adult and larger juvenile individuals were identified to species, counted, weighed, measured and released back into the water immediately. Fish larvae and small juveniles were investigated in the laboratory. More details of the construction of the trawls, the sampling procedures and catch efficiencies of the gears are given in Thiel et al. (2004). Furthermore, we used the records of twaite shad in the German Baltic waters resulting from research fisheries from 1990-2002 which were analysed by Kloppmann et al. (2003). More details regarding the sampling regime are presented in the paper by Kloppmann et al. (2003). Table 3 and Figure 5 contain the records of twaite shad resulting from research fishery.

RESULTS

Past distribution of twaite shad in subdivisions 21-26

The analysis of relevant ichthyological collections and catch statistics resulted in 73 records, each of between 1 and 1 776 600 individuals of twaite shad from 1800-1949 (Table 1). About 75 % of the recorded individuals date from the first half of the 20th century. The totality of the records could be attributed to 33 different localities in subdivisions 21-26 (Figure 1). Most

records from different localities were estimated for subdivisions 24 (42 %) and 26 (21 %). Taking into account both the number of different localities where twaite shad was found and the estimated numbers of individuals of twaite shad, the species was mainly distributed within the three following areas of the Southern Baltic Sea (Figure 1):

- Pommeranian Bay/Pommeranian coast including Szczecin Lagoon (subdivision 24),
- Bay of Gdańsk, Vistula Spit and Vistula Lagoon (subdivision 26),
- Kuršiu Spit and Kuršiu Lagoon (subdivision 26).

The oldest record of twaite shad with a precise date of catch dates back to the year 1836 from the Greifswald Bodden (Pommeranian coast), south of Ruegen Island, and was received from the Zoological Institute and Museum of the Ernst-Moritz-Arndt-University Greifswald (ZMUG) in Germany (Table 1). The longest time series of historical records of *A. fallax* was obtained for the Kuršiu Lagoon with the first record in 1875 and the last one in 1949 (Table 1).

Commercial catch of twaite shad in the Southern Baltic

Although high variations of annual catches are evident (Figure 2a-f), it must be concluded from catch statistics that twaite shad was an important commercial species of clupeid fishes in the Baltic Sea during the last quarter of the 19th and the first half of the 20th century.

The first useful official records of commercial catches of twaite shad are available for the Pommeranian Bay/Pommeranian coast and for the Szczecin Lagoon for 1887 and 1888, respectively (Figures 2a and 2b). However, catch statistics for those and the other areas is interrupted during the time periods 1920-1925 and 1941-1946 (Figures 2a-f).

The highest annual catch of twaite shad in a distinct area amounted to 260 620 kilogram (kg) and was registered in the area of Pommeranian Bay/Pommeranian coast in 1898 (Figure 2a). High annual catches of twaite shad of 167 430 and 164 860 kg were also estimated in the region Kuršiu Lagoon/Kuršiu Spit in 1918 and 1919, respectively (Figure 2f), whereas the highest value for the Bay of Gdańsk (162 056 kg) was registered in 1918 (Figure 2c). The maximum annual yield in the area of Vistula Lagoon/Vistula Spit (102 900 kg) was estimated in 1934 (Figure 2d). In 1892 the maximum annual catch of twaite shad (101 600 kg) occurred in the Szczecin Lagoon (Figure 2b). The maximum annual yield of twaite shad in the entire Southern Baltic (406 425 kg) was registered in 1918 (Figure 2f), afterwards the yield of *A. fallax* decreased in the Southern Baltic Sea (Figure 2f).

After World War II regional catch values were only available for the Pommeranian Bay/Pommeranian coast and the Kuršiu Lagoon (Figure 2a, e). In the 1950s the annual catches of twaite shad in the Southern Baltic declined sharply. Since 1960 no continuous catch statistics of twaite shad is available for the Southern Baltic Sea or one of its parts.

The mean annual catch of twaite shad between 1891 and 1960 amounted to 90 982 kg for the entire Southern Baltic Sea (Table 2). About 47.9 % of the mean annual catch were contributed by subdivision 26, comprising the areas of Gdańsk Bay, Vistula Lagoon/Vistula

Spit and Kuršiu Lagoon/Kuršiu Spit. The proportion of subdivision 24, comprising the areas of Pommeranian Bay/Pommeranian coast and Szczecin Lagoon, amounted to 37.5 %.

However, the most important area for commercial twaite shad fishery was Pommeranian Bay/Pommeranian coast, where in average 20.3 % of the total yield were caught from 1887-1960 (Table 2). From 1887 to 1900 the areas of Pommeranian Bay/Pommeranian coast and Szczecin Lagoon reached their highest importance, contributing together almost 100 % to the twaite shad fishery in the Southern Baltic Sea (Figure 3). The contribution of Pommeranian Bay/Pommeranian coast and Szczecin Lagoon decreased remarkable from 1901 to 1940 (Figure 3). Generally, commercial catches of twaite shad were more or less equally distributed over the different fishery areas during the period 1901-1940, but did mainly concentrate in subdivision 26. Twaite shad has nearly exclusively been caught in the area of Kuršiu Lagoon/Kuršiu Spit from 1941 to 1960 (Figure 3).

Seasonal catches of twaite shad showed maximum values from May to July and peaked in June for each of the areas compared (Figure 4). In all three areas, catches sharply increased from April to May, whereas they decreased more slowly between July and September (Figure 4).

Recent distribution of twaite shad in German Baltic waters

From the 1970s to the 1990s only three specimens of *A. fallax* were found in German coastal waters of the Baltic Sea, after the last two records with higher numbers of individuals were obtained in 1967 and 1970 (Table 3). A total of 25 individuals of twaite shad were recorded in German Baltic waters from 2000-2004 (Table 3). Since 2000 the greatest number of records was obtained from the Szczecin Lagoon and Pommeranian Bay (Figure 5). From May 2003 until June 2004 records from seven different localities were registered in both areas (Figure 5), representing 92 % of all individuals observed since 2000 (Table 3). All records from the Szczecin Lagoon and adjacent waters date from May to July, whereas all the individuals from the Pommeranian Bay were caught between August and October (Table 3). Recently, only juvenile individuals of age group 0 were caught in the Pommeranian Bay. All individuals of twaite shad from the Szczecin Lagoon and adjacent waters were recorded as adult specimens.

DISCUSSION

The results of the present paper clearly indicate that the German, Polish and Lithuanian waters of the Southern Baltic Sea were the main distribution and as well fishery areas of twaite shad in the past. Parts of the mentioned waters were use as spawning areas by twaite shad. Around Scandinavia, *A. fallax* has been reported infrequently (Arahamian 2003a). Although juveniles were caught off the Swedish coast around the Skåne peninsula and adult individuals were found in the Swedish rivers Lagan und Nissan, it remains unclear but uncertain that a Scandinavian spawning population exists (Arahamian 2003b). The most

northerly reported certain spawning population of *A. fallax* was from the Nyamunas River in Lithuania (Manyukas 1989).

However, in the 1930s numerous individuals of *A. fallax* were observed in the Gulf of Finland and Gulf of Riga and also in the Narva River in Estonia (Mikelsaar 1984). Therefore, this area may represent the northern limit for a spawning population (Aprahamian 2003b), but the use of this region as spawning and nursery area is probably related to distinct climatic conditions. In this regard, Drimmelen (1951) observed similar patterns of recruitment in relatively disparate stocks of twaite shad which were mainly in dependence from flow and temperature. Aprahamian & Aprahamian (2001) suggested that there may exist a relationship between the latitude of north wall of the Golf Stream and the year class strength of twaite shad in the Severn Estuary.

However, instead of climatic variation, the main reasons for the proved decline of Baltic stocks of twaite shad from the 1970s to the 1990s are probably the construction of weirs and water pollution (e.g. Repečka 1999) which made it difficult for *A. fallax* to reach the original spawning grounds to reproduce successfully (Gerken & Thiel 2001). For instance in the Nyamunas River in Lithuania, the spawning stock of twaite shad originally ascended approximately 400 km up the Nyamunas river. After the construction of the Kaunnaskiy hydroelectric dam in 1959, access to the upper reaches of the river was blocked. Additionally, the discharge of industrial wastewater from paper mill into the lower stretches of the Nyamunas River and into the Kuršiu Lagoon and an increase in tonnage of marine shipping, including the Klaypedskiy railroad crossing, greatly impeded the migration of twaite shad and other anadromous fishes to their spawning grounds (Manyukas 1989). Hence, the population declined (Maksimov & Toliušis 1999, Repečka 1999). According to Aprahamian et al. (2003b) the effects of weirs or other barriers may have been exacerbated by overfishing as fish congregate and become easier to capture below obstructions.

An important commercial fishery on twaite shad existed in the Southern Baltic Sea during the last quarter of the 19th and the first half of the 20th century. Based on the present study, the mean annual catch of twaite shad amounted to about 91 tons for the entire Southern Baltic Sea between 1891 and 1960. This results clearly indicate that the values of mean annual catch of 2 100 tons for the time period 1919-1914 and of 1 700 tons for the time period 1915-1919 which were presented in some papers for the Southern Baltic (e.g. Svetovidov 1952 and Manyukas 1989) must be wrong. In their original papers, Ehrenbaum (1921) and Mohr (1941) already published the correct values of 210 and 170 tons for commercial catch of twaite shad in the Southern Baltic for the time periods 1919-1914 and 1915-1919, respectively.

Pommeranian Bay/Pommeranian coast was the most important area for commercial twaite shad fishery in the Southern Baltic during the past. The highest annual catch of twaite shad of about 261 tons was estimated there in 1898. The Szczecin and Vistula Lagoons were probably spawning places of twaite shads caught there. Wilkońska & Garbacik-Wesołowska (1996) estimated annual catches of *A. fallax* of 20-175 tons in the Szczecin Lagoon and of 20-56 tons in the Vistula Lagoon in the time period 1916-1920. After World War II no

remarkable catches of twaite shad were registered in the Szczecin or Vistula Lagoons anymore. Although, swarms of adult twaite shad were observed in the Szczecin Lagoon in 1953 and 1955 (Skóra 2003), the species has not been a commercial fish species in German, Polish and Lithuanian waters of the Southern Baltic Sea since the end of the 1950s (Peczalska 1973, Manyukas 1989, Winkler 1991, Wilkońska & Garbacik-Wesołowska 1996). Until the mid 1990s *A. fallax* was only occasionally caught in the Kuršiu Lagoon (Mileriene 1997, Repečka 1999) as well as over the Baltic Sea region (Wiktor 1989, Winkler 1991). During that time twaite shad was found sporadically in the lower reaches of the Vistula River (Chmielewski 1965), Oder River (Waterstraat 1986) and Szczecin Lagoon into which the Oder River drains (Peczalska 1973).

A. fallax was observed more frequently again in Polish and Lithuanian waters of the Southern Baltic Sea since the middle of the 1990s (e.g. Wilkońska & Garbacik-Wesołowska 1996, Więcaszek & Krzykawski 1999, Hesse 2000, Skóra 2003, Zolubas & Surunas 2001). A relatively large amount of 160 kg of twaite shad was caught in the Kuršiu Lagoon in 1997 (Maksimov & Toliušis 1999). This could be interpreted as an effect of decreased water pollution and of the opening of a shipping lane (1984-1986) which improved water quality in the lagoon and access to the Naymunas River (Repečka 1999). More western, 248 individuals of twaite shad were caught in the Bay of Gdańsk between December 1999 and March 2002 (Skóra 2003). Additionally, Saat & Eschbaum (2002) reported a few gill net catches of juvenile individuals of twaite shad with total lengths between 20.2 and 20.6 cm in Estonian waters closed to Saarnaki Island and within the Matsalu Bay in the Väinameri in 2000. The increased number of records in Estonian, Lithuanian and Polish waters are in agreement with the results of the present study which clearly indicate that with overall 25 individuals the number of records of twaite shad in German Baltic waters, especially in the Pommeranian Bay and in the German part of the Szczecin Lagoon, increased remarkable since the turn of the millennium.

Based on these observations, it must be assumed that the Baltic population of twaite shad is increasing since the middle of the 1990s after about 50 years of its decrease. Furthermore, the results indicate that the starting point of the population increase is probably the eastern twaite shad stock of the Kuršiu Lagoon.

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Table 1. Historical records of twaite shad in subdivisions 21 – 26 of the Baltic Sea in the time period 1800 – 1949. For abbreviations see chapter "Material and Methods".

No.	Time	Sub-division	Country	Locality	Number of individuals	Data source
1	1800-1899	22	Germany	Eckernförde	3	ZMUK
2	1800-1899	22	Germany	Holstein (Wiek)	3	ZMUK
3	1800-1899	22	Germany	Kieler Hafen	5	ZMUK
4	1800-1899	22	Germany	Schleswig	3	ZMUK
5	1800-1899	21	Denmark	Aalborg	1	ZMUC
6	1800-1899	23	Sweden	Øresund	3	NRMS
7	1836	24	Germany	Greifswald Bodden	1	ZMUG
8	1837	24	Germany	Greifswald Bodden	2	ZMUG
9	1845	23	Denmark	Øresund	1	ZMUC
10	1853	23	Denmark	Gilleleje	1	ZMUC
11	1867	24	Germany	Greifswald Bodden	2	ZMUG
12	1875	26	Lithuania/Russia	Kuršiu Lagoon	1	NHMB
13	1876	24	Germany	River Peene	1	ZMUG
14	1882	24	Denmark	Amager, Dragor	1	ZMUC
15	1885	21	Sweden	Halmstadbukten Bay	2	NRMS
16	1886	23	Denmark	Snekkersten	1	ZMUC
17	1887-1888	24	Poland	Mouth of River Dievenow	3 500	Anonymous (1887-1920)
18	1887-1890	24	Germany/Poland	Szczecin Lagoon	142 500	Anonymous (1887-1920)
19	1887-1890	24	Poland	Mouth of River Swine	81 500	Anonymous (1887-1920)
20	1888	24	Germany	Rostock	1	DBUR
21	1888-1890	24	Germany	Mouth of River Peene	7 400	Anonymous (1887-1920)
22	1891	22	Denmark	Faaborg	1	ZMUC
23	1891	22	Denmark	Kalundborg	1	ZMUC
24	1891-1896	24	Poland	Mouth of River Dievenow	8 700	Anonymous (1887-1920)
25	1891-1897	24	Germany	Mouth of River Peene	191 700	Anonymous (1887-1920)
26	1891-1897	24	Poland	Mouth of River Swine	836 000	Anonymous (1887-1920)
27	1891-1899	24	Germany	Greifswald Bodden and Strelasund	105 500	Anonymous (1887-1920)
28	1892	22	Denmark	Faaborg	1	ZMUC
29	1892	22	Denmark	Kalundborg	1	ZMUC
30	1892-1900	24	Germany/Poland	Szczecin Lagoon	1 601 900	Anonymous (1887-1920)
31	1894	24	Germany	North and east coast of Ruegen Island	1 100	Anonymous (1887-1920)
32	1894-1899	24	Germany	West coast of Ruegen Island	3 100	Anonymous (1887-1920)
33	1894-1900	26	Lithuania/Russia	Kuršiu Spit	41 700	Anonymous (1887-1920)
34	1896	22	Germany	Eckernförde	2	ZMUK
35	1898-1900	24	Germany/Poland	Coastal waters of Usedom and Wolin Islands	446 000	Anonymous (1887-1920)
36	1900	26	Lithuania/Russia	Kuršiu Lagoon	7 700	Anonymous (1887-1920)
37	about 1900	23	Sweden	Øresund	2	NRMS
38	1901-1903	26	Poland	Hela	9 100	Anonymous (1887-1920)
39	1901-1910	24	Germany/Poland	Szczecin Lagoon	268 300	Anonymous (1887-1920)

Table 1. Continued

No.	Time	Sub-division	Country	Locality	Number of individuals	Data source
40	1901-1910	26	Lithuania/Russia	Kuršiu Lagoon	198 900	Anonymous (1887-1920)
41	1901-1910	26	Poland	Vistula Lagoon	577 900	Anonymous (1887-1920)
42	1901-1910	24	Germany/Poland	Coastal waters of Usedom and Wolin Islands	240 600	Anonymous (1887-1920)
43	1901-1910	26	Lithuania/Russia	Kuršiu Spit	169 500	Anonymous (1887-1920)
44	1902-1910	24	Germany	West coast of Ruegen Island	3 100	Anonymous (1887-1920)
45	1904	22	Denmark	Kalundborgfjord	1	ZMUC
46	1904-1909	26	Poland	Vistula Spit	44 800	Anonymous (1887-1920)
47	1905-1907	24	Germany	North and east coast of Ruegen Island	2 100	Anonymous (1887-1920)
48	1910	26	Poland	Mouth of River Vistula	60 600	Anonymous (1887-1920)
49	1911-1919	24	Germany/Poland	Szczecin Lagoon	500 100	Anonymous (1887-1920)
50	1911-1919	26	Lithuania/Russia	Kuršiu Lagoon	1 206 900	Anonymous (1887-1920)
51	1911-1919	26	Poland	Mouth of River Vistula	1 303 100	Anonymous (1887-1920)
52	1911-1919	26	Poland	Vistula Spit	48 500	Anonymous (1887-1920)
53	1911-1919	26	Poland	Vistula Lagoon	736 900	Anonymous (1887-1920)
54	1911-1919	24	Germany	North and east coast of Ruegen Island	6 700	Anonymous (1887-1920)
55	1911-1919	26	Lithuania/Russia	Kuršiu Spit	56 100	Anonymous (1887-1920)
56	1913-1919	24	Germany	Greifswald Bodden	2 200	Anonymous (1887-1920)
57	1913-1919	24	Germany/Poland	Coastal waters of Usedom and Wolin	97 900	Anonymous (1887-1920)
58	1915-1918	26	Poland	Hela	4 300	Anonymous (1887-1920)
59	1923	21	Denmark/Sweden	Kattegat	1	ZMUH
60	1926-1930	24	Germany/Poland	Pommeranian Bay and western Pommeranian coast	73 700	Eichelbaum (1926-1940)
61	1926-1930	26	Poland	Bay of Gdańsk	120 300	Eichelbaum (1926-1940)
62	1927-1930	24	Germany/Poland	Szczecin Lagoon	68 000	Eichelbaum (1926-1940)
63	1927-1930	26	Poland	Vistula Lagoon	472 800	Eichelbaum (1926-1940)
64	1928	26	Lithuania/Russia	Kuršiu Lagoon	3 600	Eichelbaum (1926-1940)
65	1928	24	Germany	Wiendorf, Oberwarnow	1	NHMB
66	1931-1938	24	Germany/Poland	Pommeranian Bay and western Pommeranian coast	106 200	Eichelbaum (1926-1940)
67	1931-1940	24	Germany/Poland	Szczecin Lagoon	304 200	Eichelbaum (1926-1940)
68	1931-1940	26	Poland	Vistula Lagoon	1 126 800	Eichelbaum (1926-1940)
69	1932-1938	26	Poland	Bay of Gdańsk	50 500	Eichelbaum (1926-1940)
70	1933-1940	26	Lithuania/Russia	Kuršiu Lagoon	1 776 600	Eichelbaum (1926-1940)

Table 1. Continued.

No.	Time	Sub-division	Country	Locality	Number of individuals	Data source
71	1934-1938	25	Poland	Eastern Pommeranian coast	11 700	Eichelbaum (1926-1940)
72	1939	23	Denmark	Gilleleje	3	ZMUC
73	1947-1949	26	Lithuania/Russia	Kuršiu Lagoon	328 500	Eichelbaum (1926-1940)

Table 2. Mean annual catch (kg) of twaite shad in the entire Southern Baltic Sea and in selected areas from 1887 – 1960.

Time period	Total catch Southern Baltic	Subdivision 24			Subdivision 26	
		Pommeranian Bay/ Pommeranian coast	Szczecin Lagoon	Bay of Gdańsk	Vistula Lagoon/ Vistula Spit	Kuršiu Lagoon/ Kuršiu Spit
1887-1890	33 154	21 279	11 875	0	0	0
1891-1900	152 111	93 171	57 109	0	0	1 831
1901-1910	67 036	8 194	8 945	2 321	20 757	12 282
1911-1920	218 569	3 954	18 504	48 422	28 754	46 766
1921-1930	52 446	4 911	4 535	8 022	31 518	3 460
1931-1940	85 970	3 930	10 140	5 050	37 560	29 200
1941-1950	34 825	0	0	0	0	34 825
1951-1960	6 511	89	0	0	0	6 422
1891-1960	90 982	18 431	15 692	9 160	16 659	17 776
		20,3 %	17,2 %	10,1 %	18,3 %	19,5 %

Table 3. Recent records of twaite shad in German waters of the Southern Baltic Sea. For abbreviations see chapter "Material and Methods".

No.	Time	Locality	Number of individuals	Total length (cm)	Gear	Data source
1	1967	Wismar Bight	50	-	-	Winkler (1991)
2	1970	Strelasund/ Greifswald Bodden	1000	-	-	Winkler (1991)
3	1974	Baltic Sea off Warnemuende	1	-	-	NHMB
4	about 1985	Greifswald Bodden	2	-	-	Winkler (1991)
5	2000 - 2001	North of Ruegen Island	1	-	Otter trawl	Kloppmann et al. (2003)
6	2000 - 2001	North east of Ruegen Island	1	-	Otter trawl	Kloppmann et al. (2003)
7	May 2003	Szczecin Lagoon – east of Ueckermuende and closed to Altwarp	6	37.5 - 43.0	Gill net	Thiel et al. (2004)
8	July 2003	Szczecin Lagoon	2	-	Gill net	Thiel et al. (2004)
9	July 2003	Peenestrom, Zecherin Bridge	1	41.5	Gill net	Thiel et al. (2004)
10	August 2003	Pommeranian Bay, Station 6	2	4 - 4.5	Otter trawl	Thiel et al. (2004)
11	September 2003	Pommeranian Bay, Station 4	1	6.5	Otter trawl	Thiel et al. (2004)
12	October 2003	Pommeranian Bay, Station 10	2	8.5 - 9	Otter trawl	Thiel et al. (2004)
13	June 2004	Szczecin Lagoon – closed to Ueckermuende	9	≤ 43	Gill net	Thiel et al. (2004)

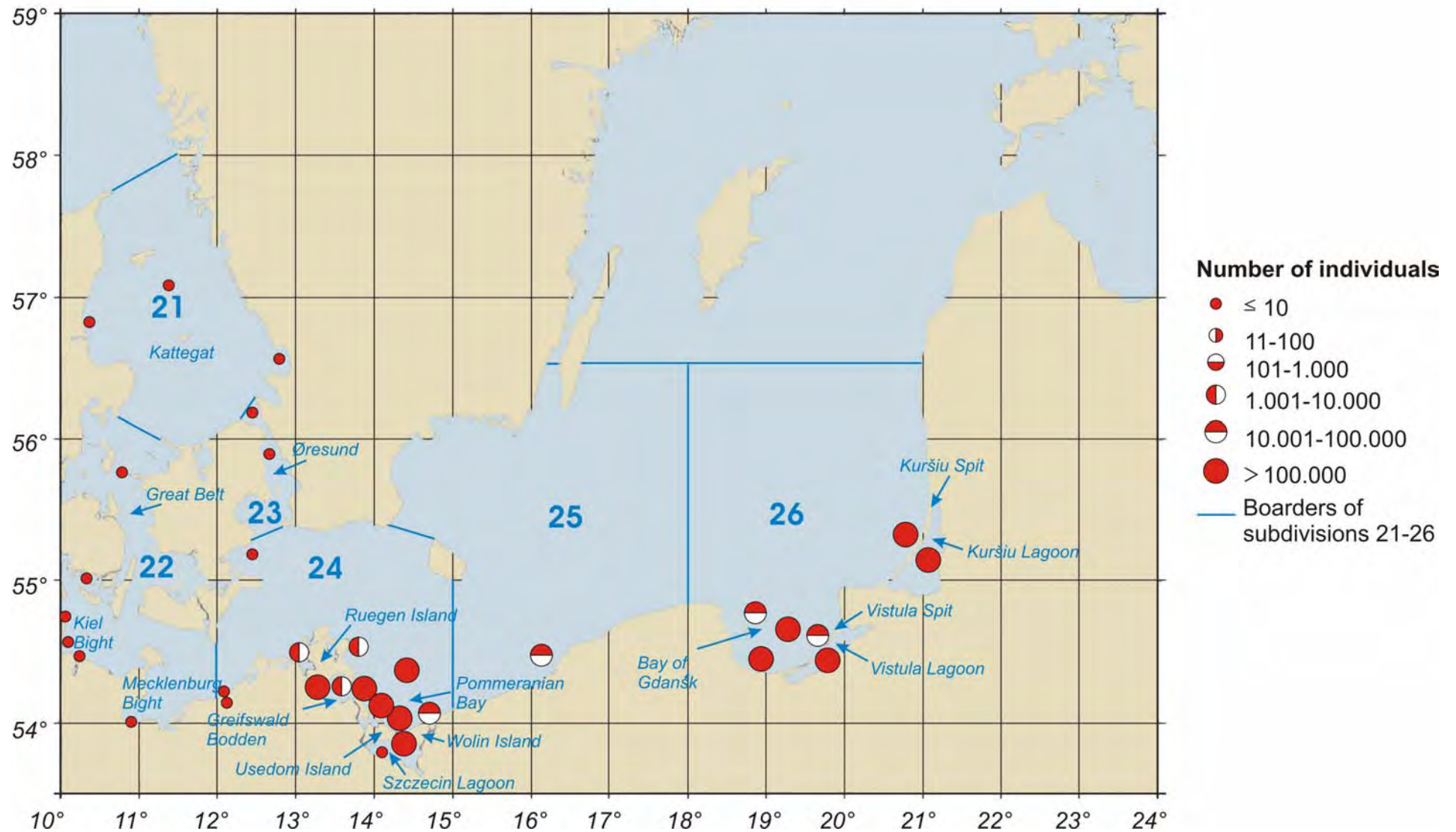


Figure 1. Distribution of historical records of twaite shad in subdivisions 21 – 26 of the Baltic Sea in the time period 1800 – 1949.

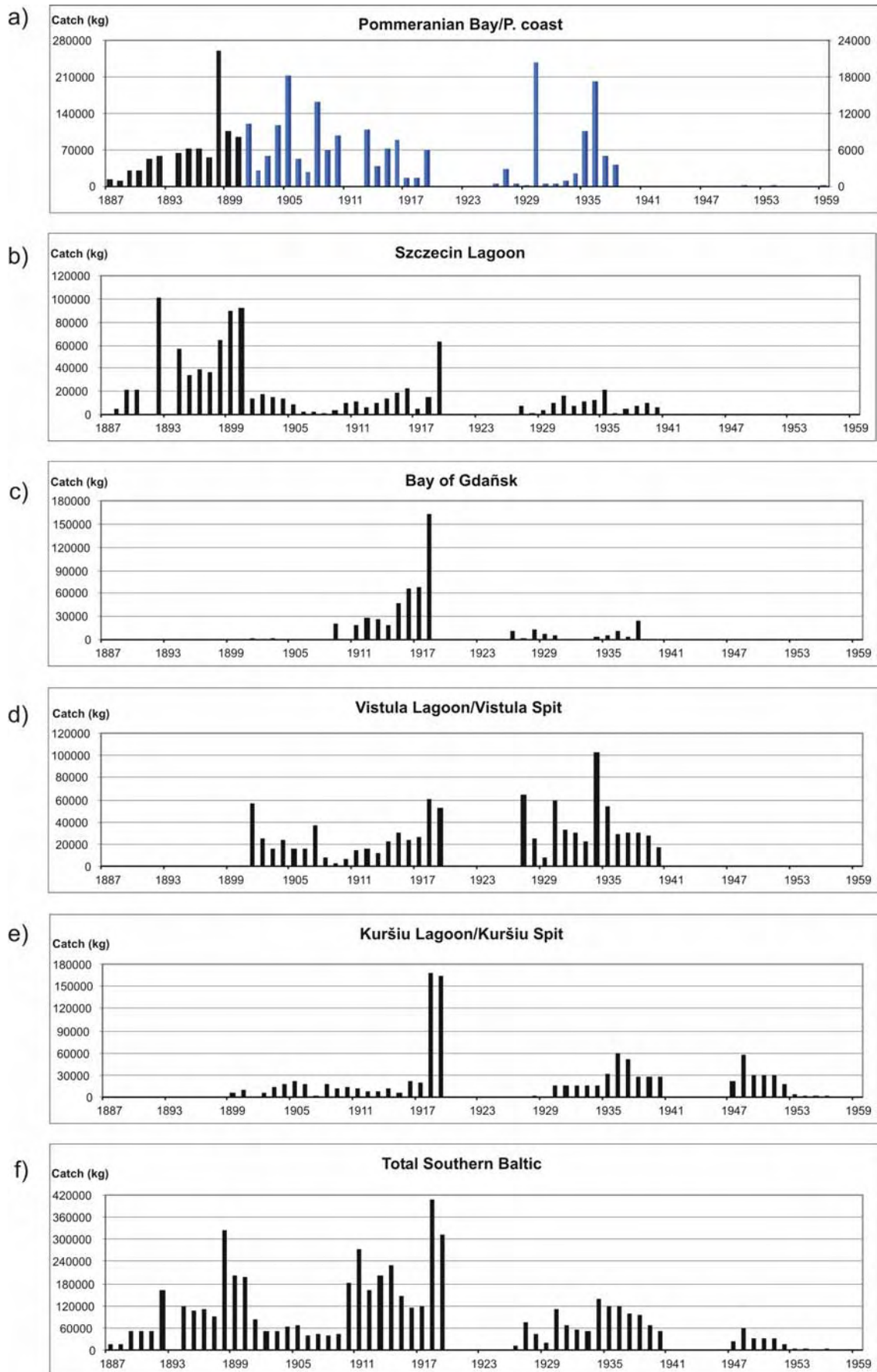


Figure 2. Total landings of twaite shad from the main fishery areas in the Southern Baltic Sea from 1887 – 1959.

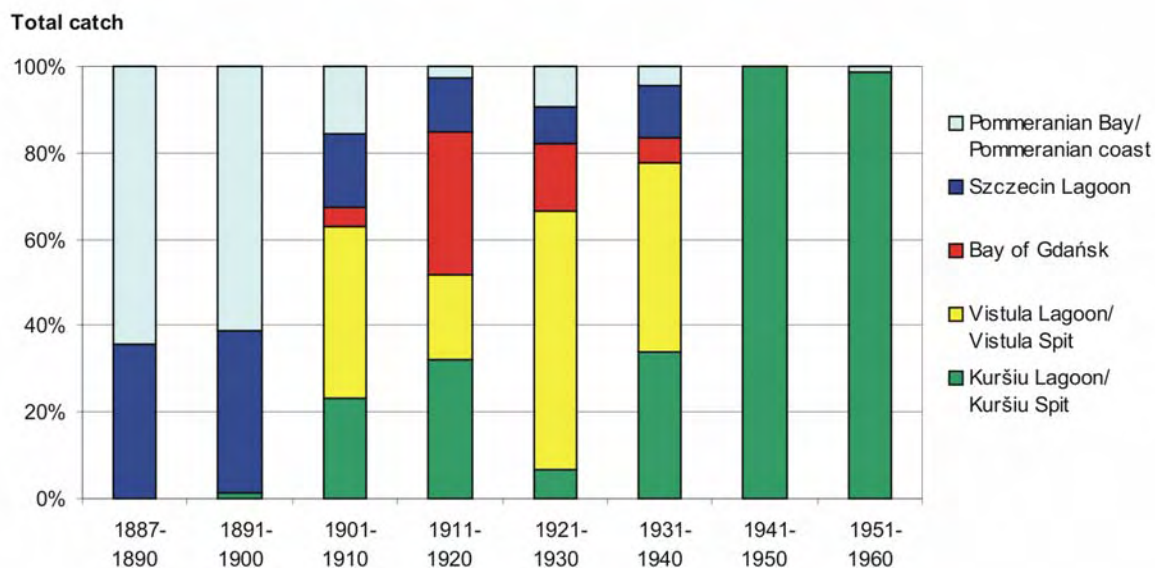


Figure 3. Contribution (%) of the main fishery areas in the Southern Baltic Sea to the total annual yield of twaite shad for different time periods from 1891 – 1960.

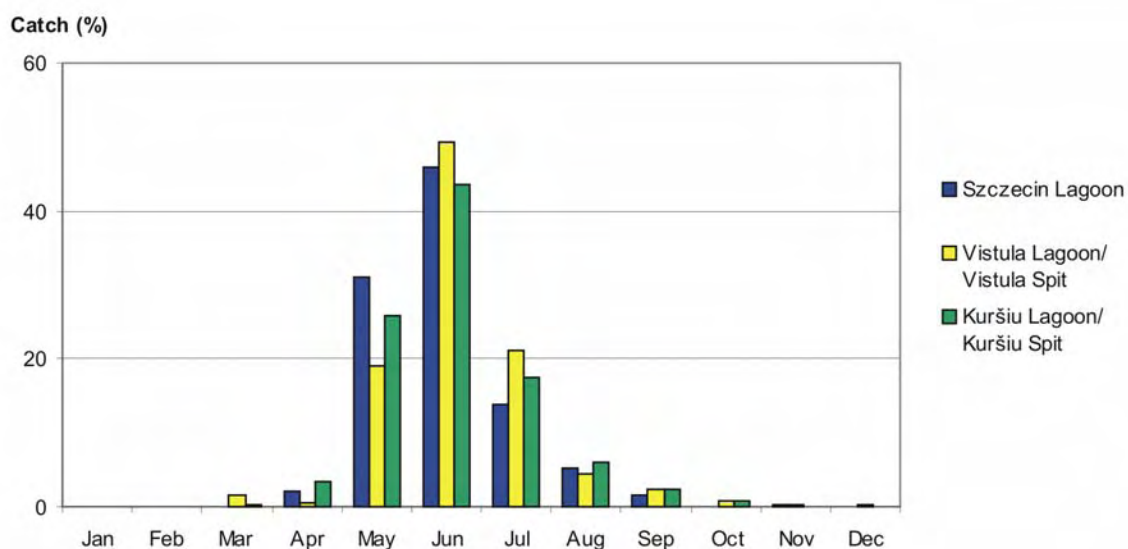


Figure 4. Seasonal variation of total catches of twaite shad in the areas of Szczecin Lagoon, Vistula Lagoon/Vistula Spit and Kuršiu Lagoon/Kuršiu Spit from 1901 – 1919.

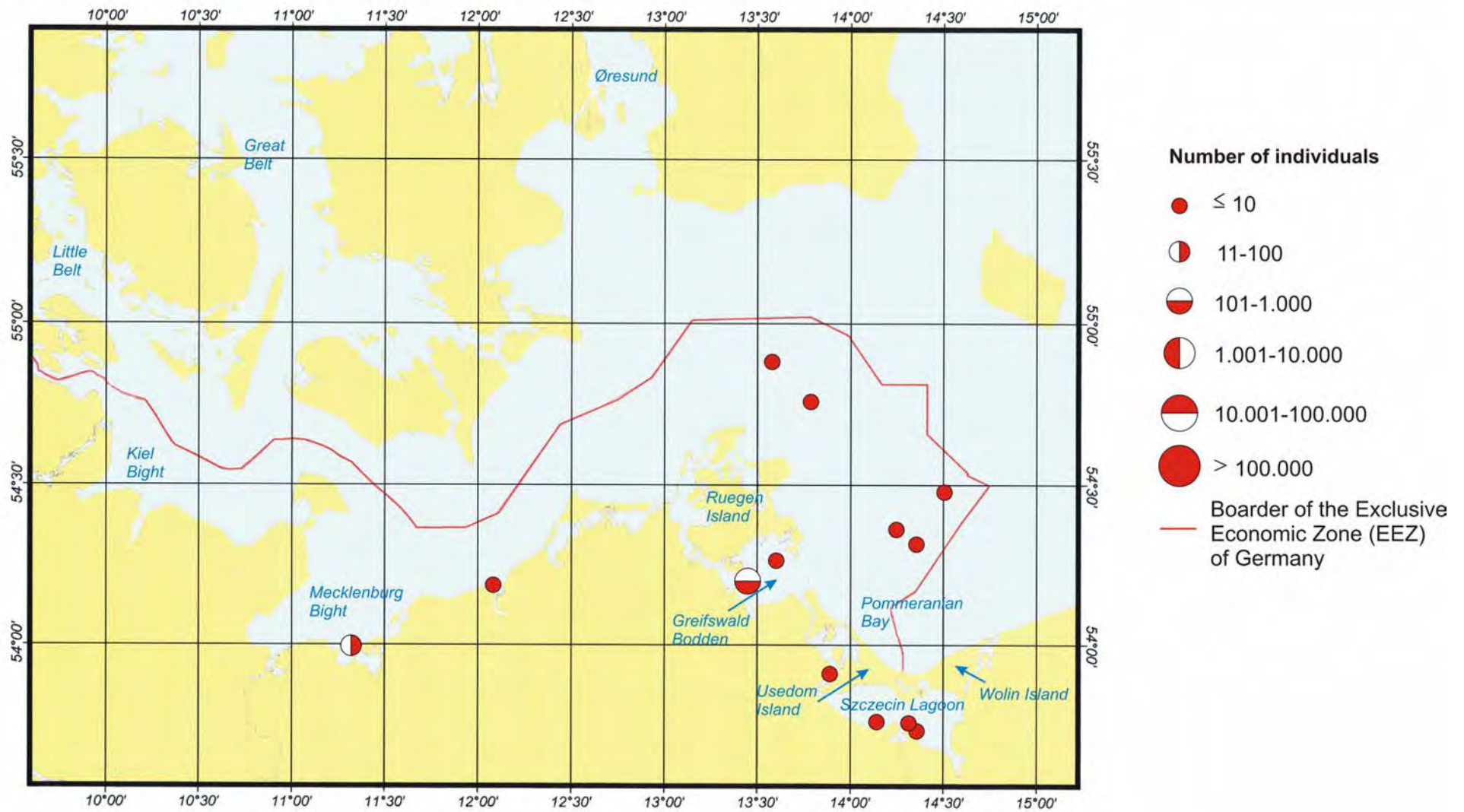


Figure 5. Distribution of recent records of twaite shad in German waters of the Southern Baltic Sea from 1950-2004.