ICES
Ostrea edulis
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Fluctuations in the Stock of Oyster (Ostrea edulis) in the Limfjord in Recent Time.

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The oyster stock in the Limfjord in Denmark is a comparatively young population. Until 1825 the western part of the Limfjord which to-day harbours the oyster stock contained brackish water of a salinity of 2-3 ‰ which completely excludes the presence of oysters.

In the year 1825 the North Sea broke through the isthmus which separated the western Limfjord from the sea thus totally changing the salinity and other natural conditions of this water. About 1850 natural oyster beds were found at various places in the western Limfjord, the natural oyster population thus are not more than about hundred years old. Within this period this stock has been subject to pronounced changes in number (Table I), with an increasing stock in the years 1860-70 and 1900-14 and decreasing stocks about 1880-90 and 1914-32 (for further details cf. the papers by Petersen from 1908, Spärck 1925, 1935).

As pointed out in my paper from 1935 it must be considered probable that a new period with an increasing stock of oyster in the Limfjord could be anticipated inspite of the fact that the stock in the period from 1914 to 1932 had been subject to a very considerable decrease in number. In 1932 I presume that the number of oysters on natural beds has dwindled to about 10 % of the number in 1914, which at that time presumably ruled about 150 mill.

The depletion of the stock of oyster on natural beds in the Limfjord in the above-mentioned period was not evenly distributed; in large parts of the fjord the decrease was even greater than 90 per cent. since it has turned out that in a few restricted areas the decrease was much less. It should be pointed out that in the period from 1925 to 1937 there was no oyster fishing at all on the natural beds in the Limfjord, so that the stock decreased only on account of natural conditions. There can hardly be any doubt that the fluctuations are mainly governed by the summer temperature since the periods of increase coincide with periods of warm summers (mean temperature of July of the surface water of the Limfjord about 13° C. or more) while periods of decrease coincide with periods of cold summers (mean temperature in July of surface water in the Limfjord 17° C. or less).

The prediction in 1935 that a turning point in the decrease in the number of natural oysters in the Limfjord had been reached has proved to come true. As it will be seen from Table II oyster spat occurred again in 1932 in considerable numbers in certain restricted areas, and this was repeated in several of the following years, notably in 1939, 1942 and 1943. Finally, in 1945 the production of spat was so large that more than 4 million spat was taken in the winter of 1945-46 on natural beds in that part of the Limfjord which is situated between Oddesund in the west and Nykøbing in the northeast, an area of about 200 sq. km. and transferred to the artificial beds in Nissum Bredning. This spat originates mainly from the warm summers of 1943 and more particularly of 1945. In the winter of 1947-48 this spat has grown up so that a considerable oyster fishery could be based on it. From the natural beds mainly situated between Nygårdshage and Kås in the Venø Bredning 993.387 oysters were dredged in 1948-49. If we look at the age composition of the stock on the natural beds in the Limfjord in 1948-49 compared e.g. to the composition of the majority of the beds in 1934 or 1937 there is a striking difference. In 1948-49 only a few per cent. are older than 5-6 years, while in 1934 and 1937 the majority were of an age of about 8-12 years.

This very considerable increase of the oyster stock on natural beds as (fjord, primarily the large Nissum Bredning and the Løgstør and) said above has been restricted to the Venø Bredning, the waters round Jegindø, the Lysen Bredning, Harrevig and to Klosterbugten near Nykøbing. In great parts of the Livø Bredning, no increase at all has been stated, as it will appear from Table III. In these parts of the fjord it is only possible to dredge two to three oysters in one haul of a length of 15 minutes, just as was the case ten years ago. A conspicuous

change however has taken place, since young oysters of 5-6 years, even in small numbers characterize the very scarce stock in these parts of the fjord. In the northern part of Salling Sund and in the waters south of the island of Fur a certain increase has taken place in the last few years as will appear from Table IV, which gives the results of some dredgingsin the summer of 1949.

It is very striking that the increase of the oyster stock has taken place in parts of the fjord far from that part where there are large artificial beds on which millions of Dutch, French and Norwegian spat has been transplanted during the last 25 years. It looks as if this enormous addition of oyster to the Limfjord on the artificial beds has been without any importance to the increase which has occurred on natural beds in the last 10-15 years. This is further confirmed by the fact that the increase on the natural beds started in that locality - Nygårdshage in Venø Bugt - where the number left of the old natural stock was relatively the greatest.

If we compare the increase in the natural oyster stock in the Limfjord in the last 10-15 years with the particulars available of the original invasion of oyster in the Limfjord about 100 years ago, the resemblance is remarkable. In the years about 1850 the first oysters were taken in the Limfjord in small inlets and bays in the more protected parts of the fjord (Lemvig, Lysen, Harrevig etc.) just the same parts where the new increase in the last few years started. It seems as if such localities are to be regarded as focus from which the stock will spread to the other parts of the fjord in periods with specially favourable conditions to the oyster.

On account of the great fecundity of the oysters one has been inclined to believe that in years with favourable conditions a sudden and an enormous increase of the stock would take place. When we look at the fluctuations of the natural oyster stock in the Limfjord in recent time it is quite clear that the fluctuations well are great but at the same time slow. When the natural stock has been depleted in a high degree as in the years about 1885 and 1930, the increase will not set in suddenly in a single favourable year. A long series of favourable years is necessary. If a series of unfavourable years occurs the natural stock will slowly decrease, at first from the less favourable localities, and will eventually become restricted to a few particularly favourable localities in some inlets. In favourable years the stock will, in the same way, increase slowly starting from these localities, and in case of a number of favourable years the population will spread to less favourable localities. Korringa quite recently (1946) set forth the view that it is impossible to revive an extinct oyster population by transplanting mother oysters from another area. Our experience from the Limfjord to a certain degree confirms this view, since the increase of the natural stock in the last fifteen years evidently has occurred exclusively from the small remains of the natural oyster population without any influence from the large stock of transplanted oysters. On the other hand, our experience from the Limfjord shows that even if a natural oyster population has decreased to one or two oysters per 100 sq.m. the possibility exists that the stock nevertheless in the course of some ten years again will attain such a density that fishery will again be remunerative.

1914 which until 1932 was the last year with a spat fall of any importance in the Limfjord shows an augmentation of about 100 per cent. i.e. that for each adult oyster one grown-up spat settled. In consideration of the great fecundity of the oyster this must appear striking, but the experience from later years confirms this view. Even in the most favourable years the loss of fry is so enormous that only one per million is supposed to survive.

The fluctuations in the natural oyster stock thus is in a certain contrast to the fluctuations in the stock of food fishes. Also among the food fishes the fecundity is very great, but in favourable years the survival of fish larvae seems to be much greater than that of oyster larvae. In favourable years the fishery is based on one or a few abundant year-classes, while the oyster fishery on natural beds in favourable years is based not on one or two year-classes but on a series of year-classes which anticipates series of favourable years with good spawning conditions.

The fluctuations of the native oyster stock in the Limfjord as mentioned above is due to fluctuations in the spat fall which again is governed mainly by weather conditions. To a smaller extent fluctuations are influenced by severe winters which in the years 1939-42 completely depleted the stock of relaid French oysters, and in a certain degree also the Norwegian oysters, but only to a small extent the natives. In certain years also a summer mortality, although small, has been ascertained, but

only among the relaid oysters, not on natural beds. Imported pests which in other areas in Western Europe (Holland, England) seem to be detrimental is of no importance in the Limfjord. The American whelk tingle, Urosalpinx cinera, and the Australian barnacle, Elminius modestus, have not yet been found in the Limfjord, whereas the slipper limpet, Crepidula fornicata, occurred in the Limfjord for the first time about 1932, presumably introduced together with Dutch spat. The latter has now spread throughout the Limfjord and further to the northwestern Kattegat, but occurs in so small numbers that until now it has been of no importance. The shell disease which is so prevalent in Holland has never appeared in the Limfjord among natives, although Dutch oyster spat was imported in large quantities in the period from 1922 to 1931. The so-called disease which was described from western Europe in the years 1920-21 was not ascertained in the Limfjord, either on the natural beds or among relaid oysters. Thus it is obvious that fluctuations in the native oyster stock in the Limfjord is neither due to the influence by fishery nor to pests or diseases, but only to weather conditions.

Our experiences from the Limfjord perfectly confirm the results obtained by Cole and Knight Jones on the gregariousness of the oyster spat, since restocking only took place in any considerable degree in places where the density of the left native oysters was fairly great and since the continued restocking slowly spread from these places. In contradistinction to the experience from English oyster grounds restocking in the Limfjord exclusively was due to the native stocks, while the imported and relaid stock seems to have been of very little importance if of any at all. This difference may be due to the fact that the oysters in the Limfjord live under more unfavourable conditions than in British waters, nearer to the limit of distribution of the species. This seems to indicate that the native stock of the Limfjord, though the population is not more than a hundred years old, has developed into a local race, which has become adapted to the particular conditions near the border of the species. This seems to be the cause of the great difficulties in restocking natural oyster stocks in waters like those on the west coasts of Sweden and Norway. Closer investigations on the local races of oysters and the ecology of these races will no doubt be of great importance also for the oyster industry.

Table I. Production of native oysters in the Limfjord in the period 1852/1949.

1852/53	ab.	30.000
1853/54		
1854/55		
1855/56	ab.	86.000
1856/57		
1857/58		
1858/59		
1859/60		
1860/61	ab.	150.000
1861/62		
1862/63		
1863/64		
1864/65		
1865/66		1.147.350
1866/67		1.207.150
1867/68		1.727.100
1868/69		3.868.500
1869/70		4.620.967
1870/71		5.343.248
1871/72		7.519.030
1872/73		7.511.825
1873/74		7.364.765
1874/75		5.551.155
1875/76		5.933.130
1876/77		5.521.915
1877/78		3.555.735
1878/79		2.628.025
1879/80		2.875.130
1880/81		1.479.295
1881/82		2.075.990
1882/83		1.759.810
1883/84		1.319.465
1884/85		946.865
1885/86		(921.825)
1886/87)		
1887/88)	no fishing	
1888/89)		
1889/90)		
1890/91		586.648
1891/92		774.570
1892/93		871.944
1893/94		765.299
1894/95		890.572
1895/96		1.007.178
1896/97		1.053.828
1897/98		1.164.565
1898/99		1.088.391
1899/1900		993.968
1900/01		1.009.547
1901/02		1.133.171
1902/03		1.024.844
1903/04		1.091.969
1904/05		1.068.673
1905/06		1.238.846
1906/10		no statistics available, the production ab. 1.000.000 a year
1910/11		3.430.000
1911/12		3.752.000
1912/13		3.980.000
1913/14		3.925.000
1914/15		3.956.000
1915/16		5.621.737
1916/17		4.739.096
1917/18		2.465.132
1918/19		3.977.171
1919/20		4.721.972
1920/21		4.171.703
1921/22		3.372.656
1922/23		2.525.753
1923/24		1.142.177
1924/25		490.507
1925/37		no fishing on natural beds
1937/38		11.475
1938/39		7.998
1939/40		24.053
1940/41		7.915
1941/42		22.672
1942/43		55.835
1943/44		46.142
1944/45		19.142
1945/46		274.337
1946/47		162.450
1947/48		889.890
1948/49		993.387

Tabel II. Number of native oyster spat, collected in the Limfjord in the period 1910-49.

1910/11	235.000
1911/12	392.000
1912/13	1.273.000
1913/14	3.240.000
1914/15	2.632.000
1915/16	3.461.800
1916/17	2.497.800
1917/18	585.800
1918/19	577.200
1919/20	1.409.600
1920/21	1.408.500
1921/22	1.193.656
1922/23	394.350
1923/24	149.000
1924/25	58.100
1925/37	No fishing on natural beds and no spatfall of any importance
1937/38	4.350
1938/39	98.421
1939/40	134.030
1940/41	14.265
1941/42	9.251
1942/43	21.595
1943/44	10.850
1944/45	34.251
1945/46	4.172.505
1946/47	922.558
1947/48	1.366.028
1948/49	1.629.087

Table III. Results of oyster dredgings in Livø Bredning in the summer of 1949, each haul 15 minutes.

Locality	Number of oysters
Færker Vig	0
Grønør Odde	0
Livø Tap	0
North-east of Fur	1
North of Fur	0
North of Fur	0
North-west of Fur	1
West of Fur	1

Table IV. Results of oyster dredgings in the Limfjord south of Fur in the summer 1949, each haul 15 minutes.

Locality	Number of oysters	Year-classes
South-west of Fur	21	1937: 2 1939: 4 1940: 1 1945: 5 1947: 7 1948: 2
Trehuse	25 + many from 1949.	1939: 2 1943: 3 1945: 6 1947: 6 1948: 8 1949: many
The Sound between Fur and Salling	14	1943: 3 1947: 8 1948: 3