THE RISE AND FALL OF THE YARMOUTH HERRING FISHERY

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Abstract

This paper traces the rise and fall of, in its day, one of the most important fisheries in the world. Fishing is said to have commenced in 495AD. So prolific were the stocks that the fishery remained sustainable with the expansion of demand brought about by the arrival of the railways in the 1800s. The invention of the steam drifter in 1896 led to a rapid growth in total revenue product and overfishing eventually brought about the complete collapse of the fishery which ended in the 1960s. This paper examines why the sustainable equilibrium forecast by the Gordon-Schaefer model did not materialise and the implications of advances in technology for a local fishery based on a highly migratory species. The model constructed using only output and price data with pure economic theory attempts to estimate the fish stock reserve over the last 60 years of the life cycle of the fishery. In doing so it also estimates the capital employed in the fishery.

Keywords: demand, technological advance, fish stock reserve

JEL Classification: Q22

In Roman times, the coast of Norfolk in eastern England was characterised on its eastern side by a wide estuary stretching from Caister on its northern bank to Burgh Castle on the south side, and where it was guarded by large forts. The estuary allowed water from the Broads to escape into the North Sea.

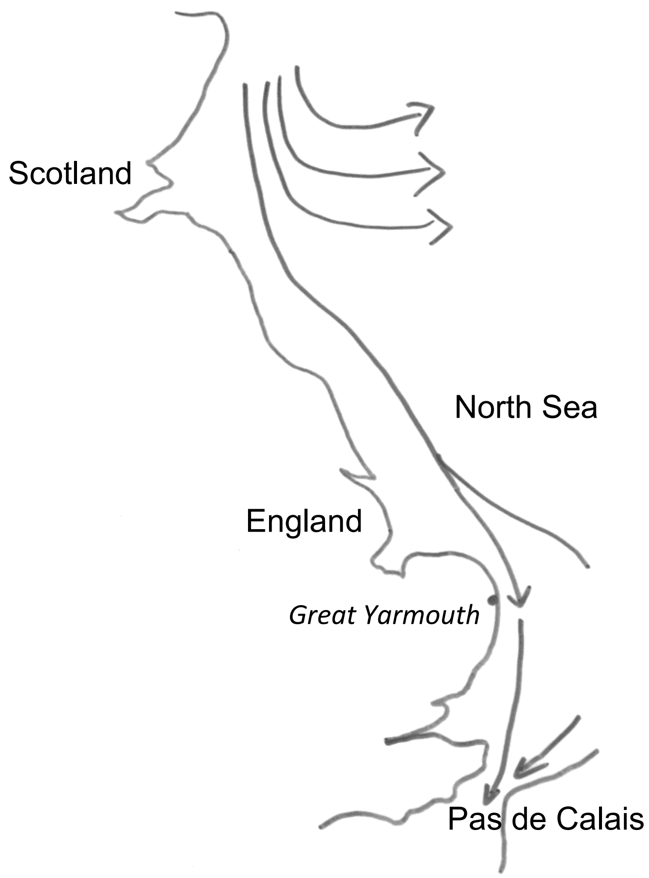
Gradually, sandbanks emerged narrowing the entrance and eventually the largest of them became sufficiently stable for it to become settled and to become the town of Yarmouth. It is said that in the year 495AD, less than a century after the Romans left Britain, Cedric the Saxon founded the autumnal fishery to take advantage of the migrating Banks stock of herring (*Harengus Clupea*) as it migrated from the northern North Sea to its collecting grounds on the Smith's Knoll north east of Great Yarmouth and thence on to the Thames and English Channel to spawn.

By the time of the middle ages, the herring had enabled Yarmouth to become a prosperous town – there had to be some economic incentive to make people want to live on a bleak treeless sand spit out in the North Sea, subject in winter to biting easterly winds from the Russian Steppes. The Domesday Book of 1086 reports a community with the families of 70 Burgesses (men of notable wealth) and 24 fishermen.

King John granted the town it's Charter – the right to local self-government – in 1208. The Wardens of the Cinque Ports, in Kent, claimed the fishery but after a long battle (sometimes with cannon) King Edward III decided that the grounds belonged to Yarmouth.

Eventually, the entrance to the Broads to the north of Yarmouth was allowed to silt up. A similar fate was to befall the southern entrance and the Black Death in 1348, which killed 70% of the town's 10,000 population (Manship 1854), left the town without the means or manpower to properly dredge the channel. Eventually after six failures, for a seventh attempt in 1559, a Dutchman, Joas Johnson, was employed to construct the harbour which still exists today. Bailiffs ensured that every able-bodied man and woman turned out 2 days a week to dig the new channel. It took seven years but was to presage a period of growing wealth.

Figure 1: The Autumn Migration Route of North Sea Herring



The fishery was open access and the profit incentive encouraged its exploitation by a growing number of sailing vessels. Nonetheless, so abundant were the stocks that the short-run equilibrium output, though it continued to rise, did not exceed the long-run equilibrium maximum physical product (the marine scientists' maximum sustainable yield).

Demand was limited by the ability of the on-shore curing operation to preserve and distribute the fish. Perhaps it is worth reflecting at this point on Scott Gordon's conclusion that fishing communities exhibit relative poverty because the resource rent is dissipated in open access fisheries (Gordon, H. Scott 1954). That cannot be said to be the case of the Yarmouth herring fishery which, as an open access fishery, provided enormous wealth to the town.

During these times the fishery was constrained partly by supply, which was limited by the quantity of fish that could be preserved by making red herring, kippers and bloaters. Demand was constrained by the distribution chain available. Until the eighteenth century it was still easier to transport goods by sea than by land. On the supply side technology advanced little with sail and oar being used for propulsion and physical manpower used for hauling the drift nets. Luggers, a two-masted sailing vessel, were the principal vessels used.

However, this position was not to last. In 1844 the railways came to Great Yarmouth, opening up new markets for herring throughout England. The increase in demand however was still insufficient to threaten the long-run stability of the fishery and in 1866, a British parliamentary enquiry reported that the level of supply which was then running at about 50,000 tonnes per annum was sustainable (Caird, Huxley and Lefevre 1866).

However, the first of two major supply-side shocks which were to affect and ultimately help destroy the fishery were to emerge within thirty years. More powerful three-masted vessels began to replace the luggers but in 1896 the steam drifter was introduced.

The fishery continued to be lucrative and enterprises quickly introduced steam power to replace their sailing vessels. It served both to provide reliable and consistent locomotive power to the vessels, with minimum regard to wind strength and direction (save for the difficult cross-tidal harbour entrance), and assisted the hauling of nets by offering steam-powered capstans, though hauling itself still remained a hard physical job because the herring had to be manually shaken from the drift nets, which could stretch to two miles in length, with each roll of the vessel.

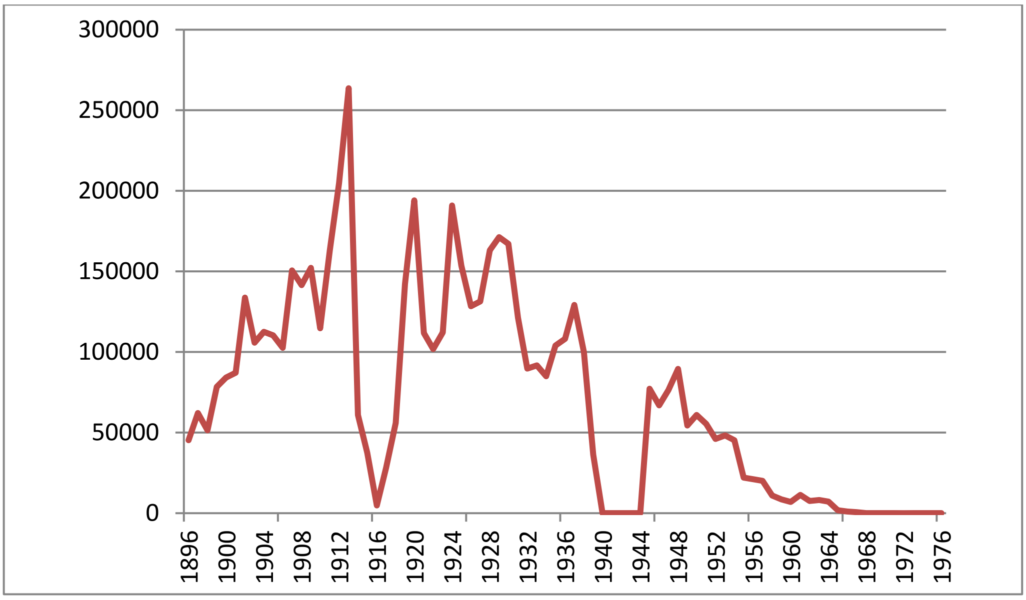
Within four years of the introduction of the steam drifter the output of the fishery had trebled and was to continue rising until 1913 when 1100 vessels landed some 250,000 tonnes of herring into Yarmouth and the neighbouring port of Lowestoft, 8 nautical miles to the south. Despite the stock recovery that should have been permitted by reduction in fishing for the following five years, caused by the intervention of the First World War and the disruption to fishing as vessels were requisitioned for minesweeping and other duties, the fishery was never again to be so productive.

The pattern of fishing for herring in the North Sea that had developed was that an itinerant fleet of vessels from around the coasts of England, Scotland and Ireland followed the migration of the herring southwards, but the developments in technology were taken up throughout the fleet and began to put pressure on the fish stock reserve before the migration reached East Anglia.

Figure 2 shows the physical product of the fishery in the form of the aggregated total volume of landings into Great Yarmouth and Lowestoft recorded in the Sea Fisheries Statistical Tables (HMSO 1896-1976) from 1896, the first available, to 1976. The Yarmouth herring fishery closed for good in 1968 and the North Sea herring stock was soon to be so seriously depleted that a disastrous moratorium on fishing for herring was imposed throughout the North Sea in 1977 (Smit 1988).

A slow if erratic decline is observable after the peak in 1913. Again the decline does not appear to have been arrested by war, this time the six years of the Second World War, 1939-1945. Questions were asked in the British parliament in the late 1950s about the obvious collapse of the fishery and the chart suggests that the decline was terminal even before the final blow, the second shock. This was the invention of the power block in the 1960s (Gordon Daniel V. and Hannesson 2015) which made the (by now, diesel) drifter redundant. It did not end the fishery but guaranteed that it could not recover.

Figure 2: Output by Volume at Great Yarmouth and Lowestoft, 1896 to 1976



Commercial landings of herring into Yarmouth would have been supressed by the moratorium on fishing North Sea herring imposed in 1977, but the fishery had already ended ten years earlier with the last recorded output in 1968. The moratorium was effective in terms of allowing the fish stock reserve to recover, but it all but destroyed the distribution chain (Smit 1988) and the East Anglian fishery has never re-emerged because the technology of purse seining and pelagic trawling is now so powerful that the herring quota is caught before the migration of the Banks stock reaches the southern North Sea.

The progress of the Yarmouth herring fishery throws into question some of the conclusions of Scott Gordon and of the Gordon-Schaefer model (Gordon, H. Scott, 1954, Schaefer 1954, Turvey 1957).

First, the open access fishery produced such prosperity that Yarmouth became in the Middle Ages the second town of England after London. Its significance is indicated by the fact that the powerful men in the Cromwellian revolution signed the death warrant for King Charles I at 4 South Quay in Great Yarmouth, where the herring drifters tied up on a Sunday, avoiding fishing on the Sabbath. The parish church of St Nicholas (patron saint of fishermen) is the largest in England and the town badge displays the tails of three herring juxtaposed against the three Lions heads of the King of England's shield. This is not the peripheral poverty of open access fisheries that Gordon claimed his theory explained.

In the earlier years of the fishery demand was insufficient to threaten the fish stocks reserves but overfishing only developed later through technical advances. In the meantime economic equilibrium is observable within the fleet, the capital employed adjusting very quickly to favourable or unfavourable seasons, but prosecuted by a large number of near identical vessels in an industrial structure that showed many of the characteristics of perfect competition – a homogeneous product, many firms and with a similar cost structure because of the technology and labour used, and so forth.

Secondly, the open access fishery did not achieve the lasting bionomic equilibrium the Gordon-Schaefer model predicts once the fishery had passed its heyday in 1913. Instead there is a continuing decline suggesting that output was, with the occasional exception, always exceeding the growth of the fish stock reserve and that depletion was taking place. This, of course, may have been a consequence of the fish stock reserve declining because it was being taken to the North before the Banks stock component could reach the Smith's Knoll fishing ground off Yarmouth, but in the context of the greater North Sea fishery for herring, bionomic equilibrium should have emerged if the model is to be believed, leaving the local fishery also to achieve its local equilibrium. That did not occur.

However, a third revelation emerges. Scott Gordon did not consider the implications of fish stock migration in either his 1953 or 1954 papers and the Schaefer approach assumed that a fish stock was a continually growing presence. This reflects a gripe of Bromley (2015).

The Yarmouth herring fishery continued whether or not it was being renewed by growth and reproduction. In other words, like a mineral deposit a fish stock may represent a harvestable resource even if it does not grow or reproduce. This creates a life cycle for a fishery which can be modelled when the assumption usually accepted in fishery models is dropped that a long-run non-zero bionomic equilibrium will develop where the catch and growth will be equal (Gordon 1954, Schaefer, 1954). In these circumstances economic theory suggests that in a competitive market the resource should be harvested so long as the increase in the price of the product caused by its depletion and consequent increasing scarcity exceeds the social time preference rate of discount of the owner (Hotelling 1931, and see Pindyck 1977).

This absence of bionomic equilibrium does not prevent short-run economic equilibria developing successively and at the cost of long-run equilibrium. Hence, the Gordon-Schaefer model only reaches bionomic equilibrium because it assumes in the first place that it will be achieved and it requires quite particular conditions to do so.

Hence, growth may be treated as a correction to the size of the fish stock reserve rather like new reserves of a mineral being found but the implication is that there may be no reason for a fishery under open access to come to a biological equilibrium where there is economic activity.

A second consequence is that the independent variable representing the presence of the fish stock in the production function can be redefined to accommodate this. The model below simulates the rise and fall of the fishery from 1896 to 1968.

In open access, economic equilibrium will be achieved in each successive time period at zero profit, $\pi(t)$, or

$$\pi(t) = \bar{p}(t)q_e(t) - c(t) = 0 \qquad (1)$$

where $\bar{p}(t)$ is the price pertaining in time period t, exogenously determined by the competitive availability of fish and other protein substitutes. $q_e(t)$ is the short-run equilibrium total physical product and $c(t)$ represents the total cost of output.

Since

$$c(t) = \gamma k(t) \tag{2}$$

where $k(t)$ represents an index of the capital employed in the fishery, then by assuming that $k(0) = 1$ the constant γ, the unit cost of capital, may be determined from

$$\gamma = \frac{p(0)q_e(0)}{k(0)} \tag{3}$$

The reliability of the estimate of γ is of course prey to the errors in the observations for the three contributing variables at time t and cannot be econometrically tested because the only data available for use in the model relate output and price. The consequent error in γ is thus thrown throughout the remaining solution of the model. No other data are used. However, employing economic theory allows, remarkably, the entire model to continue to be solved recursively from this point.

The availability of an estimate for γ from (3) now enables the index of capital used, $k(t)$, to be determined for each time period from a re-arrangement of (2) with (1) substituted:

$$k(t) = \frac{p(t)q(t)}{\gamma} \tag{4}$$

An estimate of the long run equilibrium maximum total physical product, $q(\tau)$, is obtained by observation by taking its value to be the highest output of the fishery in the year immediately after which an even higher output (which has proved to be unsustainable) was produced.

By assigning a value of unity for $B(\tau)$, the index of the volume of the fish stock reserve, in the year when $q(\tau)$was produced, and also assuming a value for the constant term, α_0, such that $\alpha_0 = 1$, $B(t)$ may be determined by re-arranging the Schaefer function

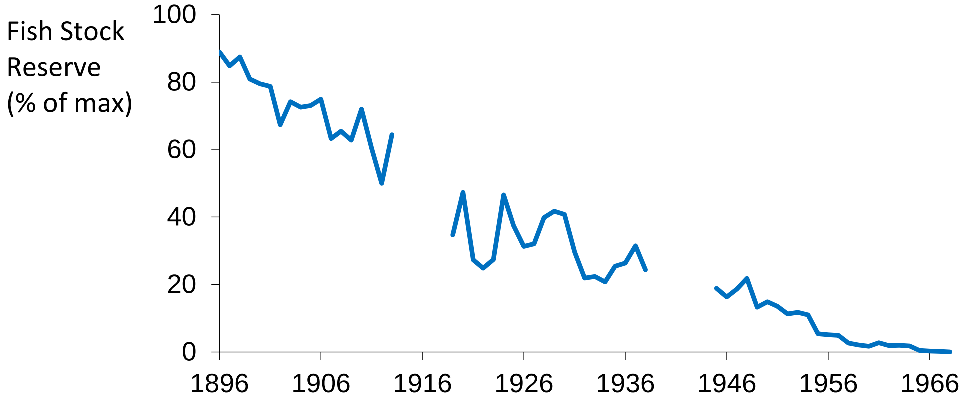
$$q(t) = \alpha_0 B(t)k(t) \tag{5}$$

and cancelling such that

$$B(t) = \begin{cases} 2 - \dfrac{q(t)}{q(\tau)} & if\ t \leq t_{TRPmax} \\ \dfrac{q(t)}{q(\tau)} & if\ t > t_{TRPmax} \end{cases} \tag{6}$$

This produces estimates for the size of the fish stock reserve as a percentage of the maximum and the results are shown in Figure 3. The two periods of the World Wars are omitted. The stacked cases in (6) accommodate the quadratic derivative of the cubic fish stock reserve function assumed to portray the life cycle of the fishery.

Figure 3: Estimated Fish Stock Reserve of the Yarmouth Herring Fishery, 1896 to 1968



Inferences and Conclusions

It is remarkable that it has been possible to trace the development of the fishery and in particular to estimate the fish stock reserve using only two economic time series, output by volume and price, and the postulations of economic theory. As well as these an index of the capital employed in the fishery has been calculated too.

The reliability of the estimates is in particular vulnerable to the proximity of the observed long run maximum total physical product to the short run maximum achieved the following year. In the case of the Yarmouth herring fishery it is some 22.3% lower. This large difference is probably typical of fisheries targeting a pelagic product. It makes the estimates less reliable because, the greater the difference, the greater the range in which the true long run maximum lies and the further may be the value determined by observation from the true value.

The Schaefer function (5) appears deceptively like a Cobb-Douglas function but is in fact a simple production function carrying only a single variable input, *k*. The fish stock reserve is not under the control of the industry as it is assumed to be in the most deterministic theoretical explanations of fishing. As such it must be viewed as part of the state of the art given by $\alpha_0 B(t)$.

Omission of the war years in Figure 3 may lead to an alternative view of the results being overlooked. In those years the model shows the fish stock reserve approaching zero because of the limited amount of capital employed in those years. If (5) were a Cobb-Douglas function (with a rather unduly optimistic assumption of increasing returns to scale of a factor of 2!) then *B* might be taken to represent the amount of the fish stock reserve used (used rather than existing) in the fishing process.

This change in the meaning of *B* would create rather an awkward variable, hypothesizing as it does that *B* is under the control of the fishing industry. In this scenario *B* becomes dependent not only on the fishing technology and capital employed but also on the fish stock reserve which is only partly influenced by human action. This adds to the difficulty of finding an accurate stylized theoretical production function for fisheries but is perhaps an important direction to follow.

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