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An Economic Approach to Measuring Fishing Effort: Application to a Dutch Cutter Fleet

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Introduction

Data on the development of fish stocks, catches, fleet capacity, and fishing effort are indispensable for purposes of fisheries management. When there are data available on these items, one of the main problems is to find denominations for common use in economic modeling. Data on fish stocks and catches are mostly in quantities by species; data on fleet capacity in numbers of vessels, tonnage, or engine capacity of selected fleet segments; and data on effort in various denominations (*e.g.*, days fishing, days sailing, perhaps horsepower- or ton-days, by fleet segments and/or possibly by gear type). Another popular indicator is 'fishing mortality,' again by species. Familiar problems arise when several fleets and gear types fish the same stocks, and when fishing multi-species fisheries. An additional complication is that, over time fleets tend to change in size, and particularly in composition, and most likely in productivity. The purpose of this paper is to report on an on-going attempt to assess fishing capacity and fishing effort for a range of years on the basis of common definitions.

Dutch North Sea Demersal Fisheries

In the North Sea, Dutch cutters are active in demersal fisheries. Others also active are European Union (EU) member states' fleets since the North Sea was declared a common EU sea. Fisheries management takes place predominantly by EU Total Allowable Catch (TACs) by species, divided into national quotas.

The Dutch fleet consists of vessels, so called cutters, ranging from 100 to 4,000 horsepower (hp). Most vessels (notably the largest) fish predominantly on flatfish (sole and plaice) with double-beam trawls. A number of medium-sized vessels fish on roundfish (cod and whiting) with single or pair trawls, and some fish seasonally on herring with pair trawls, besides some flatfish beam trawl fishing. Finally, a number of small vessels fish on brown shrimp with adapted double-beam trawls. This fishery is reserved for vessels up to 300 hp. The high-horsepower vessels in this group are also active in the flatfish beam trawl fishery and the roundfish fishery.

The development of the Dutch cutter fleet, represented in horsepower, appears in figure 1. A general development has been one toward ever bigger vessels. It must be noted that the number of the biggest vessels will not continue to grow because the government declared a 2,000 hp limit for new vessels beginning in 1988, allowing for an extended "extinction" period for the existing ones. Also, the group of 201 to 300 hp vessels has been growing as a result of the rule that within twelve miles

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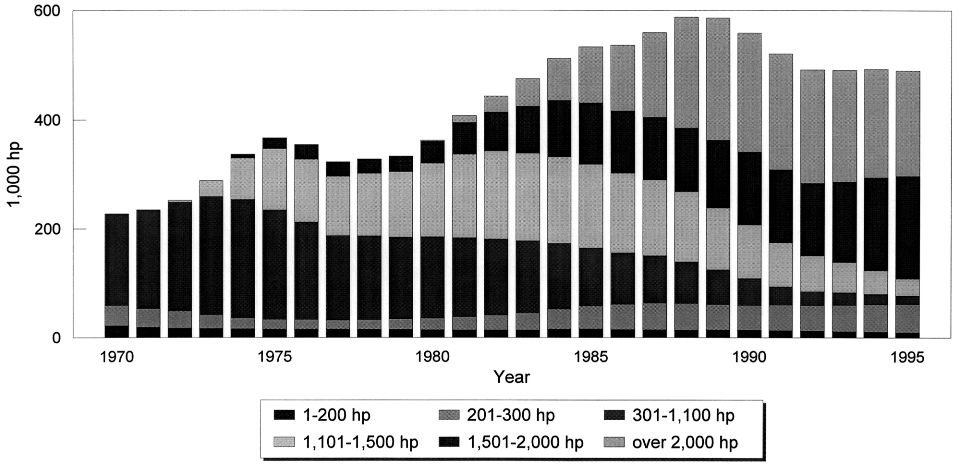

Figure 1. Engine Power Dutch Cutters (according to hp-class)

vessels up to 300 hp may fish with beam trawls. In the 1980s this development was triggered by the EU, subsidizing investments in this type of vessel ("Euro cutters").

Within the quota handed out by the EU, national fisheries management is generally carried out by individual transferable quotas (ITQs) for species like sole, plaice, cod, whiting, and herring. In the last decade this policy has been supported by input limitations in the form of maximum numbers of days at sea (individually calculated on the basis of vessel size and ITQs). Landings of this fleet are represented by total proceeds as shown in figure 2. The importance of flatfish is clear. However, in recent years plaice proceeds declined as a result of decreasing stocks. Roundfish proceeds have fallen back in the last decade, also as a result of poor stocks (mainly cod).

Productivity of Fishing Vessels

To gain an insight to the aggregate (potential) fishing capacity of the fleet, and the capacity used (*i.e.*, effort exercised), capacity and effort of individual vessels of varying type and size must be added together in some fashion. As the fleet is overwhelmingly fishing with active gear (trawl fisheries in several forms), engine power can be used as a measure of capacity, and engine power times number of days at sea (hp-days) as a measure of effort.[1] The accuracy of these assumptions cannot be easily checked against actual data, since this is a multi-species fishery, where size and catchability of fish stocks vary within a wide range, both over time and between species.

An alternative method of measuring aggregate fishing capacity of the fleet is to look at gross proceeds. Over a short period, say one year, one may assume that financial proceeds will fairly represent the vessels' productivity. The fact that, in general, more abundant species may yield considerably lower prices than scarcely available species does not detract from that assumption. Moreover, the public auction system ensures that market opportunities are evenly spread amongst the suppliers. While catch limitations influence total proceeds in one year, they hardly have an im-

[1] The topic of possibly increasing productivity over time has been raised only occasionally, without much scientific evidence. The assessment of productivity data on vessels or fleet segments also did not get much attention in this study. Thus, implicitly, the assumption used was that of a constant productivity of one horsepower, in time as well as over vessels of different size.

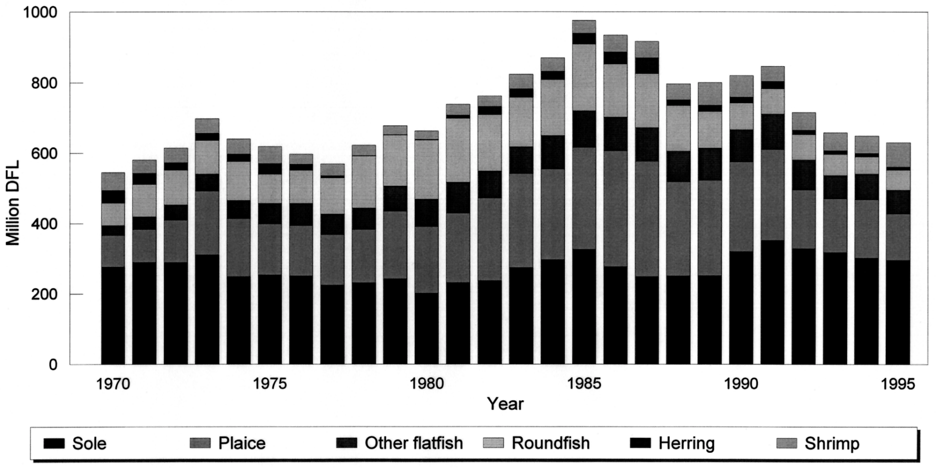

Figure 2. Proceeds of Dutch Cutters (by main species, in deflated Dutch Florins)

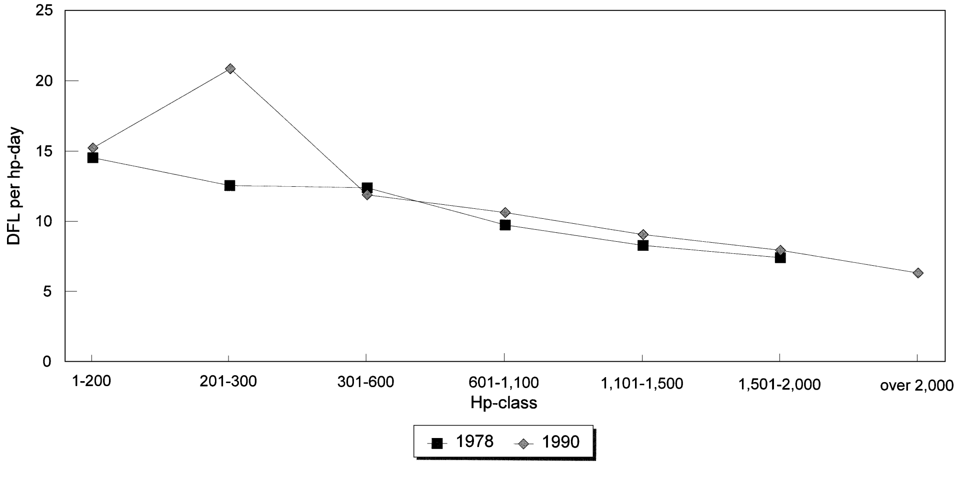

Figure 3. Gross Proceeds per HP-Day for Beam Trawl Vessels by HP-Class (deflated to 1990 prices)

pact on proceeds per day. Using proceeds per hp-day within that short period, average productivity for different vessel classes can then be calculated. An example of the ranges of that indicator is shown in figure 3 for two selected years.

The primary finding on productivity using this measure is that hp-days appearing in bigger vessels yield decreasing proceeds. In 1978, the relationship is negative and smooth. However, in 1990 an outlier appears for the 201 to 300 hp group. A likely explanation is that vessels data for this group are influenced by investments in a highly-efficient new fleet of Euro cutters, which are allowed to fish inside the 12-mile zone. Moreover, it is suspected that the limit of 300 hp is not quite as real as it should be, as a number of skippers may have succeeded in installing more horsepower than officially registered.[2]

[2] This anomaly is the reason these calculations were done by hp-group rather than estimated from regressions.

Time Series on Productivity

Clearly, nominal proceeds per hp-day cannot be used to assess a time series of productivities of vessels by various hp-groups. Fish prices tend to vary each year and inflation must be considered. While productivity relations between groups can be calculated for each year using the method described, linking them together into time series requires an index.

To establish an index, a standard group must be carefully defined. A first requirement is that the fleet in the standard group must have a constant (relative) productivity. Therefore, a group should be selected in which “nothing has happened” in the considered period: no investments in new and probably more efficient vessels, no drain of “good” skippers to new vessels in other groups, *etc*. The 1,101 to 1,500 hp group satisfies that condition over a long range of years. Only in the beginning of the 1970s and in the 1990s has there been a switch to other, better conditioned groups. The result, productivity per hp-day by hp-class relative to the 1,101 to 1,500 hp group, is shown in figure 4.

Assuming the base group is well-chosen, the general trend is indeed decreasing productivity of hp-days of bigger vessels. However, some groups show interesting trends. The 201 to 300 hp group has clearly been influenced by the factors mentioned above. The groups of smallest and medium size vessels underwent a big reduction in numbers and probably the strongest survived, increasing the group’s average (relative) productivity. Productivity of the largest vessels felt the establishment of a maximum length of trawl beams in 1988 (with the purpose of limiting aggregate fishing effort).

Time Series on Fishing Effort

During the period 1970–95 documented hp-data have been standardized, using the yearly index to make vessel effort comparable across time. The development of aggregate realized standard hp-days is shown in figures 5 and 6. Logically, the devel-

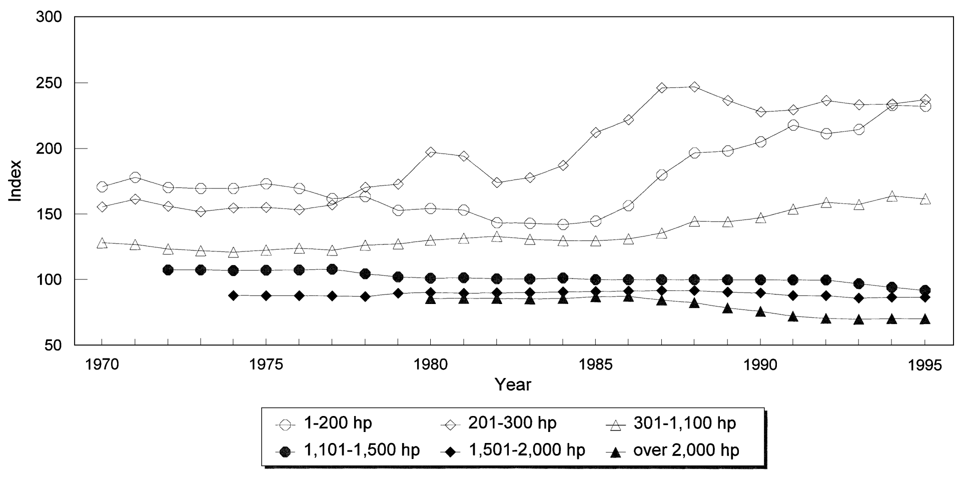

Figure 4. Index of Productivity per HP-Day by HP-Class (based on five year moving averages of 1,101–1,500 hp = 100, adjusted for 1970–77 and 1993–95)

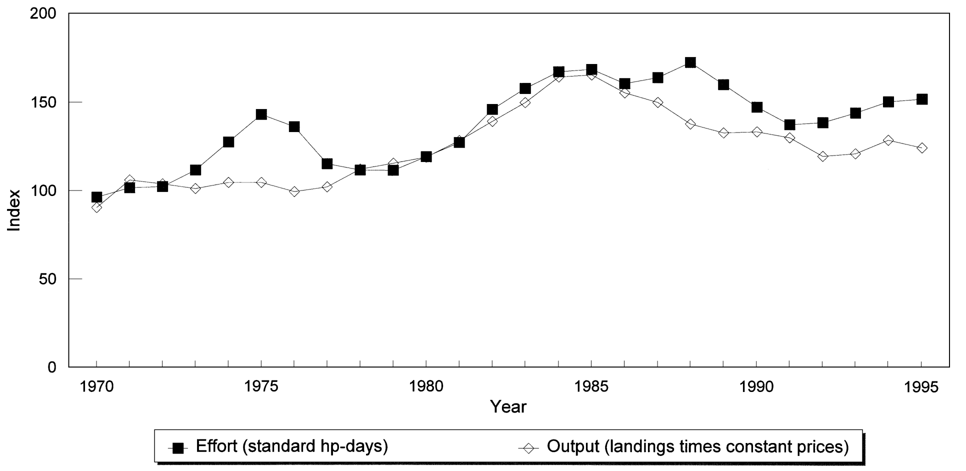

Figure 5. Index of Effort and Output of Dutch Cutters
(standard hp-days and landings times constant prices, 1970–72 = 100)

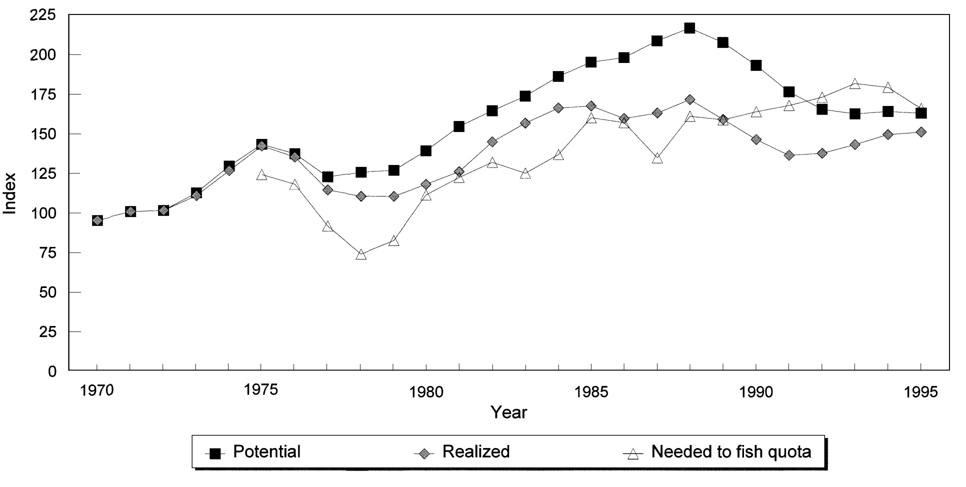

Figure 6. Index of Potential, Realized, and Needed-for-Quota Effort
(standard hp-days, potential 1970–72 = 100)

opment from smaller to larger vessels, combined with large vessel hps which have a relatively low productivity, results in standard effort which is lower than nominal effort. Measuring effort based on realized nominal hp-days since 1970 leads to a 36% over-estimation of fishing effort in 1995, compared to standardized effort.

An interesting way to look at aggregate standard fishing effort is to compare it to output. To this end, for each species, landings have been multiplied by average real prices over the period concerned. Thus, price changes are accounted for, while quantities per species are still weighted with average price differences that more or less represent scarcity. In this way, output is expressed in (theoretical) proceeds at a fixed price level. In figure 5, effort is shown together with output. In general, the curves follow each other, but in certain periods they diverge. It would be beneficial for those data to be compared with actual data on the development of fish stocks in the North Sea. However, as only a part of the North Sea fisheries is covered by the input of Dutch vessels, a large series of the data are missing. Moreover, the landings of the Dutch fleet represent various shares in the total landings (for instance, sole for about 75%, plaice about 35%, cod about 10%, *etc*.). Therefore, a quantitative confrontation of this data to data on stocks is not currently feasible.

Qualitatively, we can say that increasing effort (an investment boom) seemed to result in unchanged output during the mid 1970s. This could mean a temporary average decline in fish stocks. However, there is evidence that, during the investment boom, the fishermen continued fishing on traditional grounds. As aggregate North Sea stocks did not appear to decrease, this has been the case in that limited area. In the next investment boom, beginning about 1980, fishing grounds were extended. Only after 1986 do fish stocks seem to decline. This was certainly the case concerning roundfish. Gradually plaice stocks also tended to decrease; around 1990 landings are partly compensated by increasing sole stocks.

Time Series on Fishing Capacity

An insight into the development of aggregate fishing capacity evidently should be one of the bases for fishing fleet policies. Up to now, aggregate tonnage or engine power data have been used to get at capacity.[3] Based on the method described above to standardize effort, capacity data should also be standardized. Nominal engine power[4] in different horsepower groups should be indexed. However, in a case where the fleet is shifting toward even larger vessels, this is not sufficient. For obvious reasons bigger vessels are able to spend more days at sea than smaller ones, and even standardized fishing capacity should be corrected by the potential number of days at sea for each group.

The result of such a calculation is a time series on potential standard capacity. Potential numbers of days at sea for different groups were derived from “normal” average numbers of days at sea in periods when no catch limitations were valid. Also in this case the growth of nominal data from 1978 to 1995 surpassed that of standardized data by about 36%.

Having data on potential and realized effort at hand, one can show which part of the potential capacity is “used,” as has been done in figure 6. It is clear that fisheries management gradually succeeded in bringing down the number of days at sea of the fleet, initially by quota management, later supported by days-at-sea regulations.

To explain the extent of utilization of potential effort, an extra item is added; an estimate of the effort needed to fish the quota. Until 1989, fisheries management clearly did not fully succeed in keeping total effort in hand in several periods. However, after 1989, the gradually increasing effort needed to fish the quota encountered a shrinking fleet, resulting in an increased utilization of potential capacity in the 1990s. An important factor was an incorrect (too high) assessment of plaice stocks (one of the main species fished), resulting in the fleet’s inability to fish the quota. In recent years fisheries management began to reverse this error, resulting in a downward trend of effort needed to fish the quota. The decrease of total potential effort came to a halt, so that in 1995 potential effort was on the same level as the effort needed to fish the quota. Slowly increasing utilization of potential effort now led to a level of realized effort quite near that needed to fish quota.

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[3] These measures have been used by, for instance, the EU Multi-Annual Guidance Programmes (MAGPs) that try to govern fishing capacity in member states.

[4] “Nominal” refers to hp-days which are not adjusted using a yearly index.

It must be said that since 1993, a policy change involving Fisheries Producers' Organizations (FPOs) in the execution of quota management certainly has had its effects. Those FPOs were charged with the responsibility of managing their members' ITQs, at the same time granting them extra flexibility in mutual trade of (yearly slices of) ITQs. This resulted in the FPOs developing into some kind of clearing institutions, that may match yearly ITQs for several species of each individual vessel to the composition of its catches, which to a certain extent is unpredictable in a multi-species fishery. That development clearly contributed to a higher utilization of ITQs and of national quota.

Conclusions

In a multi-species fishery, fishing effort on an aggregate of all species has been the only reliable effort measure. In this report, an aggregate effort measurement for a specific fleet is developed, taking into account capacity of the fleet and the number of days at sea. In this measurement, the changes in the size and composition of the fleet over time is measured using engine power, by weighting the engine power of vessels of different sizes according to their economic productivity. Then, to find a relationship between fishing effort and productive output, using landings by species is not enough because catchability of the species varies over a wide range. Instead quantities of landings are weighted by using average prices. Thus, output is then a function of fishing effort and the availability of fish stocks.