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Vulnerability and availability of fish to trawls

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This series documents the scientific basis for stock assessments and fisheries management advice in New Zealand. It addresses the issues of the day in the current legislative context and in the time frames required. The documents it contains are not intended as definitive statements on the subjects addressed but rather as progress reports on ongoing investigations.

VULNERABILITY AND AVAILABILITY OF FISH TO TRAWLS

by M.P. Sissenwine

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Many MAFFish assessments are based on biomass estimates derived from trawl surveys. In order to estimate biomass from a trawl survey it is necessary to estimate, or assume, the fishing power of a standardized unit of trawl survey fishing effort. Fishing power is expressed as the catchability coefficient, q, which is the mean fraction of the population that is caught by a standard survey tow.

The catchability coefficient takes account of several factors:

$$q = \frac{rva}{A}$$

where r is the fraction of the population which is available to the survey gear (availability coefficient); v is the fraction of fish in the path of the trawl that are caught (vulnerability coefficient); a is the area sampled by a single tow; and A is the total survey area. Availability takes account of unavailable fish that are not within the survey area or in locations within the survey area that cannot be sampled (i.e., in the water column, untrawlable bottom). The area sampled is the product of the path width (w) swept by the trawl net and the distance towed (d); a = w.d. Either the distance between trawl doors or the distance between the trawl wings can be used as w. For the remainder of this paper, the subscripts w and d will be used to distinguish between wingspread and doorspread when specifying w, a, and v.

One advantage of using w_w is that it is a standard dimension which is given for trawl nets, whereas w_d is not. On the other hand, if w_w is used, it is possible that v_w will exceed 1 since some fish may be herded, by doors and warps, into the path between the wings. It is customary to use wingspread; i.e., w_w, v_w, and a_w.

In most cases, MAFFish estimates biomass by $1.6\bar{X}A/a_w$, where $\bar{X}$ is the mean catch per tow. This estimate is referred to as the "average of wingspread and doorspread estimates" (B_{wd}). In some cases, MAFFish is less conservative and uses $\bar{X}A/a_w$ which is referred to as a "wingspread estimate." (B_w). B_w and B_{wd} are based on the implicit assumption that rv_w equal 1.0 and 1.6 respectively. There are no scientific data to support these assumptions. It is worth considering a few estimates of rv_w that are based on data.

Edwards (1968) estimated v and rv_w for 27 species of the Northwest Atlantic. His estimates ranged from 10% to 90% for v_w, and 3.5% to 90% for rv. He based his estimates on submersible observations although his exact method is not described. Therefore, it is suspect.

Uzmann et al. (1977) compared biomass estimates made by submersible observations, camera sled, and otter trawl. There were a total of about 50 locations sampled, but not by all methods. Results in Uzmann et al. (1977) allow comparison between the submersible and the trawl for six demersal finfish species for 10 stations. If the estimates from the submersible are taken as the density of fish available to the net, then estimates of v_w are 9% for silver hake, 25% for goosefish, 14% for little skate, 14% for witch flounder, 3% for fourspot flounder, and 5.6% for Gulf Stream flounder. All of these estimates are for daylight sampling. Values of rv_w are probably lower ($r < 1.0$). Trawls are known to increase in fishing power at night for demersal species by a factor of up to 32 (see Sissenwine and Bowman 1978).

Clark and Brown (1977) calculated weighting factors (u) that could be applied to trawl survey catches to express them as absolute biomass. Weighting factors were calculated by dividing the survey catch per tow by biomass estimates from VPA that corresponded to the area surveyed. These weighting factors are actually the reciprocal of q. This means that $rv_w = Au/a_w$. For Georges Bank, $A = 53000 km^2$ and $a_w = 0.028$ km (based on wingspread) for the trawl surveys that were considered. Using these values, I have calculated rv_w for several species: 19% for haddock, 1.5% for silver hake, 12.3% for red hake, 32% for yellowtail flounder, 18% for cod (using a slightly different area than Georges Bank).

Collie and Sissenwine (1983) estimated the catchability coefficient (q) for bottom trawl surveys using a Modified De Lury method. Their estimates of q can be converted to estimates of rv_w by taking account of a_w and A. The resulting estimates of rv_w are 45% and 20% for Georges Bank haddock and yellowtail flounder, respectively; and 59% for southern New England yellowtail flounder. The difference in efficiency between areas for yellowtail flounder is noteworthy.

Most of the populations considered above are heavily fished ($F = 0.5$ to 1.2). This means that rv_w could not have been underestimated by much. If rv_w were significantly higher, it would mean that biomass estimates would be significantly lower than the catch (which is theoretically possible, but unlikely).

Of course, vulnerability to trawl gear depends on many factors. All of the estimates above apply to trawls which are not particularly efficient. Nevertheless, these results should help to put MAFFish's frequent assumption of 160% for rv in perspective.

There are a lot more data available that await analysis, in particular, numerous stock assessments that include both biomass estimates from VPAs and trawl survey catch-per-tow data. These assessments could be used to estimate rv, although it would be necessary to determine A and a for the trawl surveys. These values are not given in most assessments, but they should be available from the institutions that conduct the surveys. ICES, NAFO, CAFSAC, and several US National Marine Fisheries Service Laboratories are potential sources of stock assessments.

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