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Treatment of Zero Catches in CPUE Analysis

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Abstract

Trawl catches are commonly used in indicators of catch per unit effort (CPUE) measures, not least as trend indicators of the health of fish stocks. Most importantly, declining CPUEs conventionally indicate a decline in the underlying biomass of the stock that is being targeted. Conventionally, CPUE measures are for trawl fisheries using conventional extensive trawling, i.e. the trawl is deployed on the seafloor then towed for periods up to five or six hours but three hours, or shorter periods, are more common. The assumption is that the trawl, when standardized for tow distance captures a fixed fraction of the stock, usually according to the relation



TREATMENT OF ZERO-CATCH OBSERVATIONS IN CPUE ANALYSIS OF TOW RESULTS

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1. INTRODUCTION

Trawl catches are commonly used in indicators of catch per unit effort (CPUE) measures, not least as trend indicators of the health of fish stocks. Most importantly, declining CPUEs conventionally indicate a decline in the underlying biomass of the stock that is being targeted. Conventionally, CPUE measures are for trawl fisheries using conventional extensive trawling, i.e. the trawl is deployed on the seafloor then towed for periods up to five or six hours but three hours, or shorter periods, are more common. The assumption is that the trawl, when standardized for tow distance captures a fixed fraction of the stock, usually according to the relation

Where,

q = the catchability coefficient, i.e. that fraction of the stock that is taken by one unit of fishing effort

f = fishing effort, measures in the same units as for q

B = biomass of the species/stock in question.

So, twice the effort would imply twice the catch.

The validity of this model becomes highly problematic in the case of aimed benthic-pelagic trawling. In this type of fishing, the gear is not deployed until the skipper has located a fish aggregation that he believes he can capture. The trawl is deployed, then assisted by acoustic techniques, the trawl is positioned on the fish and the skipper attempts to 'bag' the aggregation by towing on the aggregation. This may require pursuing the aggregation along the sea floor and down the bottom slope as the fish sound in response to the approaching trawl.

If the bridge officer has not correctly positioned the trawl – up to two kilometres behind the vessel, or has not anticipated exactly how the fish will flee, then no fish will be caught, although a fish aggregation was evidently present or the bridge officer would have not deployed the trawl.

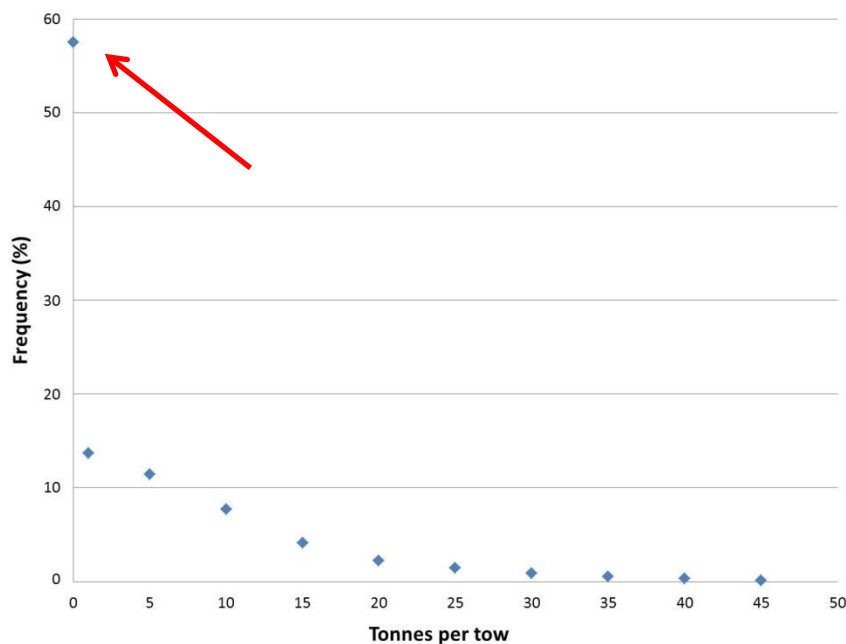
There has been discussion on how to treat recordings of zero catches in subsequent analysis of trawl tow data. Conventionally, when spatial ecological sampling data is found to have large numbers of zero observations, then the data can be transformed, e.g. by a log-transformation, to get a normal or at less-skewed distribution of catch results that are amenable to conventional methods of analysis.

Alternatively, a distribution model may be used that has additional parameters that explicitly account for the 'added' zeroes. But, is either of these methods appropriate in our case?

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Frequency of alfonsino catch rates, F.V. Will Watch, 1997–2011

Note: n = 7 186. Source: modified from Patchell (2012).



SAMPLING CONSIDERATIONS

In conventional spatial ecology sampling, e.g. using a quadrat thrown over the shoulder in the area of interest, if there are no items of the type that is of interest, a zero is the appropriate measure to record in regard to its abundance. But if for instance, in a beach survey of burrowing bivalves (think pipis), the quadrat landed on a rock, while no bivalves would be recorded, i.e. zero would be seen: clearly the sampling method had failed, which was why no bivalves were observed and the sample should be repeated.

The same analogy applies with tows in aimed trawling when there is no catch, i.e. a zero result. It is not that there are no fish – the bridge officer would not have shot the net if there were none, but rather that the items to be sampled, e.g. orange roughy or alfonsino, have avoided the sampling gear, in this case the trawl. In these cases the appropriate action is not to include the zero records as valid indicators of the abundance of fish, but rather to discard them as the result of a failed or flawed attempt at sampling. That is, the equivalent to throwing the sampling quadrat onto a rock.

FURTHER CONSIDERATIONS

Given this interpretation, it becomes apparent that difficulties will exist in the interpretation of catch data from aimed trawling. It is not possible for an analyst to know if the catch that has been recorded when there is a non-zero catch, represents the entire fish aggregation that the gear was set, or if the catch represent an unknown fraction of the targeted fish aggregation. I.e. if less than 100% of the targeted fish aggregation was caught, what was the actual fraction? 80%? 40%? 20%? There is no way of knowing – all that can be said is that the trawl caught up to 100% of the fish aggregation but it could have been (much) less. Thus, the abundance indicator may equal what was observed or it could underestimate the amount of fish that were present. Certainly it may be a major source of error.

Perhaps bridge officers have an idea as to what fraction of a fish aggregation they have targeted that they caught, or at least can provide an estimate? I don't know the answer to this question but it might be posed to them. If they can provide an estimate, then the record of a tow catch, for the purpose of analyses, might be increased using this estimate in an attempt to reduce the error, which will be present if the data are then used for estimating stock abundance.

DISCUSSION

If catch data from aimed trawling is to be used to make inferences at stock abundance, then at the first level of analysis zero-catch tows should not be considered. However, a question that might be asked is whether there is a relation between the number of zero catches and the abundance of the targeted fish stocks? For example, if reduced abundance results in smaller aggregations, might they be more successful in avoiding a trawl? Of the fish aggregation in its entirety more amenable to capture? I believe that the operations data exists that could enable this question to be investigated.

Clearly, using tow catch results from aimed trawling may lead to highly erroneous conclusions about the state of the stock and in my view, without a robust method for correcting for the errors I note above, using such data should either be discouraged or if undertaken, data analysts should be acutely aware of the possible errors.

It is of interest that Clark (NIWA, New Zealand) has undertaken a number of CPUE analyses of deepwater fisheries. However in one report (Clark 1996), a random trawl design was used, not aimed trawling, so the concern raised here would not apply. Clark *et al.* (2010) go on to note "The use of CPUE as an index of vulnerable biomass has been considered undesirable for orange roughy, but has nevertheless continued to be used (Ministry of Fisheries 2009). CPUE has been used where other information on biomass trends is unreliable or unavailable. Using CPUE as a biomass index for orange roughy is undesirable for several reasons, including the following:

1. Orange roughy form predictable aggregations ...The fishery prefers to target these aggregations, where large catches can be taken in a short time. When fishing on large spawning plumes, gear saturation may take place, or the bridge officer may limit the catches, e.g., to avoid net damage. The catch rates from a large aggregation can be maintained, even though the overall size of the aggregation may be declining. Under these circumstances, catch rates will be biased, and not related to biomass. Nevertheless, commercial catch rates of orange roughy in the spawning plumes in the Chatham Rise Spawning Box did (eventually) decline substantially as the resource was fished down and/or orange roughy changed their behaviour and location of aggregation.
2. Areas have been fished and apparently depleted sequentially (Clark 1999, Anderson & Dunn 2008) so that catch rates are maintained by moving from one area to another, giving the overall appearance of a stable catch rate. When this takes place, neither local nor overall catch rates are likely to be proportional to total stock biomass.

It may be that CPUE indices reflect trends in local biomass, but it is less certain that they index total biomass. These authors note that the use of CPUE as an index of vulnerable biomass has been considered undesirable for orange roughy, but has nevertheless continued to be used. CPUE has been used where other information on biomass trends is unreliable or unavailable.

Clark *et al.* (2010) make no distinction as to when the fishing that they analysed was aimed-trawling or conventional bottom trawling and it is possible that both types of fishing were confounded in the one analysis. If this were the case, then poor results with unknown error should be expected.

LITERATURE CITED

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