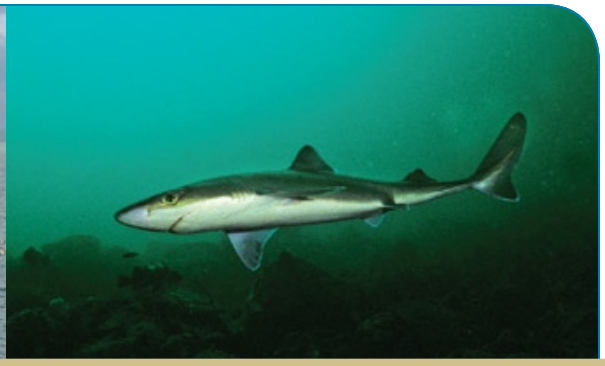




LENFEST OCEAN PROGRAM

RESEARCH SERIES

JUNE 2011

Accounting for predation mortality is important for accurate fisheries management targets

AN ECOSYSTEM PERSPECTIVE FOR FISHERIES MANAGEMENT

A SUMMARY OF NEW SCIENTIFIC ANALYSES:

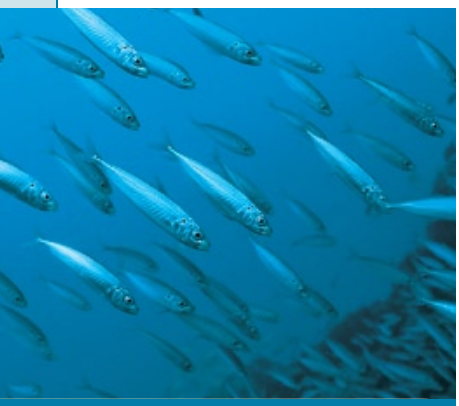
Tyrrell, M.C., J.S. Link and H. Moustahfid. 2011. The importance of including predation in fish population models: implications for biological reference points. *Fisheries Research* 108:1–8.

Moustahfid, H., M.C. Tyrrell and J.S. Link. 2009. Accounting explicitly for predation mortality in surplus production models: an approach to longfin inshore squid. *North American Journal of Fisheries Management* 29 (6): 1555–1566.

FOR SEVERAL DECADES, scientists have recommended a more holistic approach for fisheries management. A key recommendation is to include ecological processes, such as predator-prey relationships, in fisheries stock assessment models. Incorporating ecological interactions in stock assessment models, however, is still relatively uncommon.

A group of researchers from Woods Hole, Drs. Tyrrell, Link and Moustahfid, reviewed options for incorporating realistic estimates of predation mortality into stock assessments. They concluded that traditional, single-species population models generally underestimate the effects of predation on target species when predation is assumed to be low and constant rather than variable as predator and other prey populations change. The researchers found that including predation leads to more accurate estimates of total population size and more conservative biological reference points, or stock-specific benchmarks. The authors recommend adopting some of the existing methods they reviewed in order to incorporate ecological interactions into stock assessments. This *Lenfest Ocean Program Research Series* report is a summary of the scientists' analysis.

INCLUDING ECOLOGICAL INTERACTIONS IN FISH POPULATION MODELS



FORAGE SPECIES

These studies focused on "forage" species, which include many commercially-valuable fish, such as sardines, anchovy and menhaden. These species are a particularly useful example of the importance of including predation in population assessments because they straddle the middle of the food web, often feeding on plants and small animals and serving as crucial prey for valuable fish such as tuna and salmon as well as wildlife such as seabirds and marine mammals.

Fisheries stock assessment models evaluate how certain characteristics of a population, such as natural mortality (e.g., deaths from disease, senescence or predation), fishing mortality or reproductive rates, affect stock size over time. Some outputs of these models are biological reference points (BRPs) that can be used to gauge the status of specific stocks. For example, F_{msy} is a BRP that indicates the fishing rate that produces the biomass needed to sustain maximum sustainable yield (MSY; i.e., the largest average catch that can be sustained under current conditions without affecting the reproductive health of a stock). Traditional population assessments generally focus on estimating BRPs for a single target species and assume constant and low natural mortality even though significant or variable predation rates could influence the abundance of target stocks.

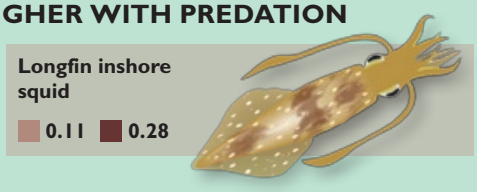
In a recent study, Dr. Tyrrell and her colleagues assessed the impact of ecological interactions on BRPs by reviewing fisheries population models that explicitly account for predation (Tyrrell et al. 2011). The researchers showed that predation mortality (rather than disease or age, for example) often makes up the largest part of the natural mortality rate and can be highly variable (Figure 1). Therefore, both multispecies models or modified single species models that include predation as an additional "fishing fleet" may lead to more accurate estimates of stock abundance because they capture the dynamic and variable predator-prey relationship.

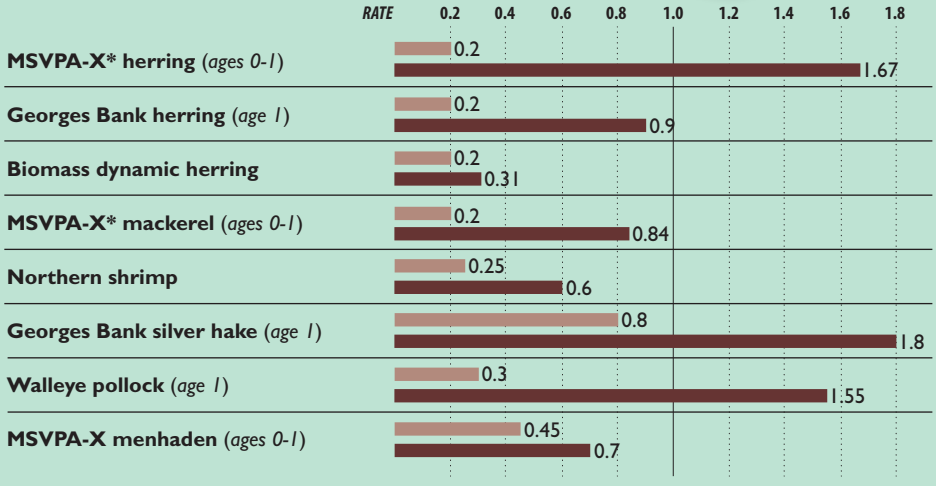
In a separate study, the scientists demonstrated the feasibility of including ecological interactions in stock assessments using longfin inshore squid *(Loligo pealeii)*, a commercially and ecologically important forage species along the U.S. Atlantic coastline, as an example (Moustahfid et al. 2009) (see Figure 2). The authors showed that it was possible to develop new BRPs (e.g., maximum usable production rather than MSY) that account for both predation and fishing mortality, and that these BRPs more likely reflect ecological realities for target stocks.

FIGURE 1: INCLUDING REALISTIC PREDATION IN MORTALITY ESTIMATES

NATURAL MORTALITY RATES HIGHER WITH PREDATION

Average annual estimates of natural mortality using either traditional stock assessment or models that explicitly include predation



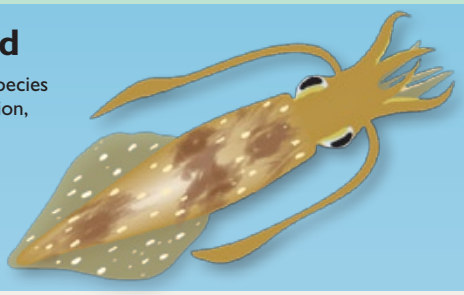


*Multispecies Virtual Population Analsysis-Extended **Age-Structured Assessment Program model
Note: The data considered in this graphic are from different studies that used data from different years.

FIGURE 2: INCLUDING PREDATION MORTALITY IN STOCK ASSESSMENTS

CASE STUDY: Longfin inshore squid

Moustahfid et al. (2009) used the longfin inshore squid fishery, a forage species found in the northwest Atlantic Ocean, to show how to estimate predation, include it in a stock assessment and the implications of doing so.

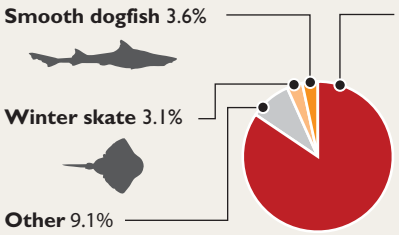


ESTIMATING PREDATION MORTALITY

The scientists estimated squid consumption by predators using fish stomach contents collected in trawl surveys and estimates of predator abundance.

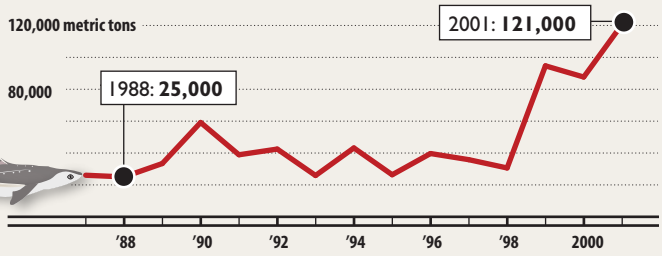
WHAT IS EATING LONGFIN INSHORE SQUID?

Of 867,000 metric tons consumed by the top 15 predators in the northwest Atlantic Ocean from 1987-2001



CONSUMPTION VARIES SEASONALLY AND ANNUALLY

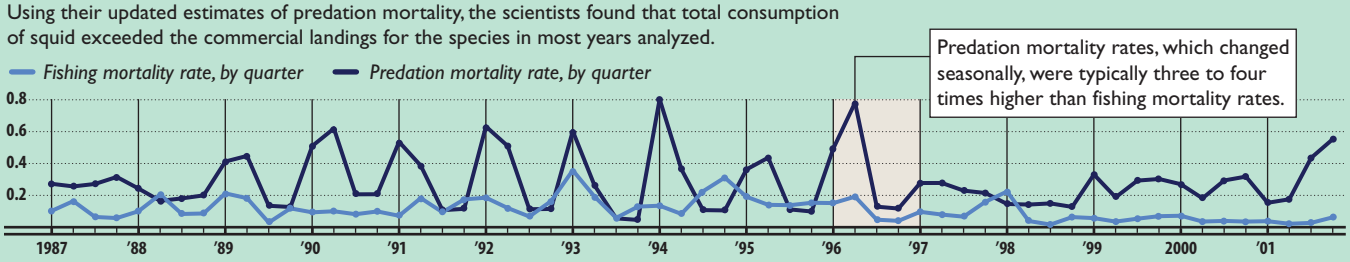
For spiny dogfish, in the northwest Atlantic Ocean from 1987-2001, in metric tons



Note: Illustrations not to scale.

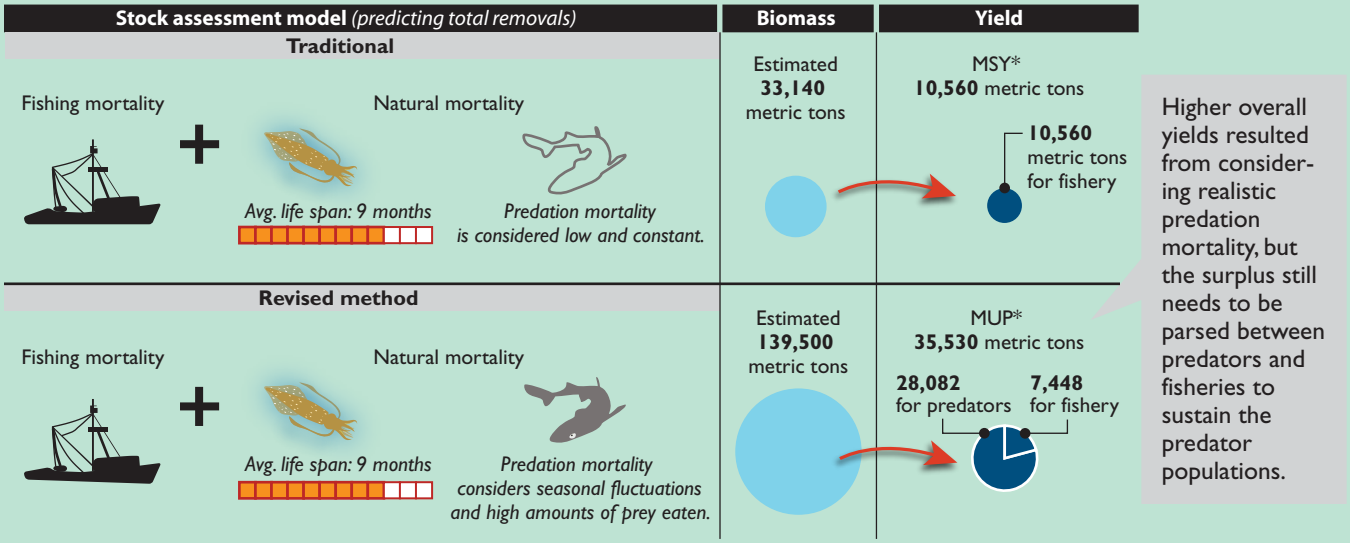
COMPARING PREDATION MORTALITY TO FISHING MORTALITY

Using their updated estimates of predation mortality, the scientists found that total consumption of squid exceeded the commercial landings for the species in most years analyzed.



INCLUDING PREDATION MORTALITY ESTIMATES IN STOCK ASSESSMENTS

To incorporate predation mortality into a stock assessment model, the authors treated predation consumption data as a second fishing fleet (i.e., predation plus fishing equals total removals), following a similar approach that was done by Overholtz et al. (2008).



Higher overall yields resulted from considering realistic predation mortality, but the surplus still needs to be parsed between predators and fisheries to sustain the predator populations.

*Maximum sustainable yield, or MSY, only considers fishing mortality. Maximum usable production, or MUP, is analogous to MSY but includes predator removals and can be divided between fishery yield and predation demand using a partitioning approach described in Overholtz et al. 2008.

CITATION: Moustahfid, H., M.C. Tyrrell and J.S. Link. 2009. Accounting explicitly for predation mortality in surplus production models: an approach to longfin inshore squid. *North American Journal of Fisheries Management* 29 (6): 1555-1566; Overholtz, W.J., L.D. Jacobson and J.S. Link. 2008. An ecosystem approach for assessment advice and biological reference points for the Gulf of Maine-Georges Bank Atlantic herring complex. *North American Journal of Fisheries Management* 28(1): 247-257.

MANAGEMENT IMPLICATIONS

These studies show that it is feasible to incorporate realistic estimates of ecological interactions, such as predation, in stock assessments. This research also demonstrates the importance of reflecting ecological realities in fishery management targets, such as biological reference points. Although the authors found that including predation in stock assessment models led to higher overall yield, the yield to fisheries was lower. This is likely due to improved estimates of how much predators consumed and how much prey is needed to sustain predators. While using more realistic predation mortality in stock assessments may lead to more conservative management targets, these revised targets should also be more accurate and ultimately help to prevent biomass declines.

Efforts to rebuild fisheries and marine mammal populations are underway around the world. Many of the targets of these rebuilding efforts are predators found high in the food web. As the abundance of these predators increases, they are likely to consume more prey, including forage species. Thus, accurate predation rates will be essential to estimating recovery trajectories for both predators and their prey.

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