Kinetic Energy and Selection in Trammel Nets[a]

JÜRGEN SAEGER
c/o ICLARM
MC P.O. Box 1501
Makati, Metro Manila
Philippines

Introduction

Trammel nets as discussed here consist of three sheets of meshing, of which the two outer ones have large meshes, while the central sheet has very small meshes. Fishes are caught as they push the material of one of the outer sheets through a mesh of the central sheet, thus forming a "bag" which retains them (Fig. 1).

To form this bag, a fish must perform *work*, which appears in the form of kinetic *energy*. The fish will be caught inside a bag only if kinetic energy is higher than the work needed to shape the netting material into a bag.

The work is related to the swimming speed. Concerning this, Bainbridge (1961) suggested that the swimming speed of fish is a function of their muscle mass, which is also a function of the length of the fish. This has generally been expressed as

$$v = \alpha * l \ (\mathrm{sec}^{-1}\ \mathrm{m}) \qquad \ldots 1)$$

where alpha is a species-specific index with dimension sec^{-1} and l is the length of the fish. Fulton (1903) concluded that in flatfishes $2\ (\mathrm{sec}^{-1}) \leq \alpha \leq 3\ (\mathrm{sec}^{-1})$, while Harden-Jones (1968) gave for cod, herring and salmon, ranging from 10 to 100 cm, a value of $\alpha \approx 3\ (\mathrm{sec}^{-1})$.

Note that α as used here refers to sustained swimming and not to "burst" swimming (see Sambilay, this issue of Fishbyte), since fish caught in trammel nets are not assumed to have been "bursting" into it.

From the mass and swimming speed of a fish, one can compute the work that it performs. Expressed as kinetic energy (E_{kin}), this equals,

$$E_{kin} = \bullet\ mv^2 \qquad \ldots 2)$$

or

$$E_{kin} = \bullet\ m(\alpha\, l)^2 \qquad \ldots 3)$$

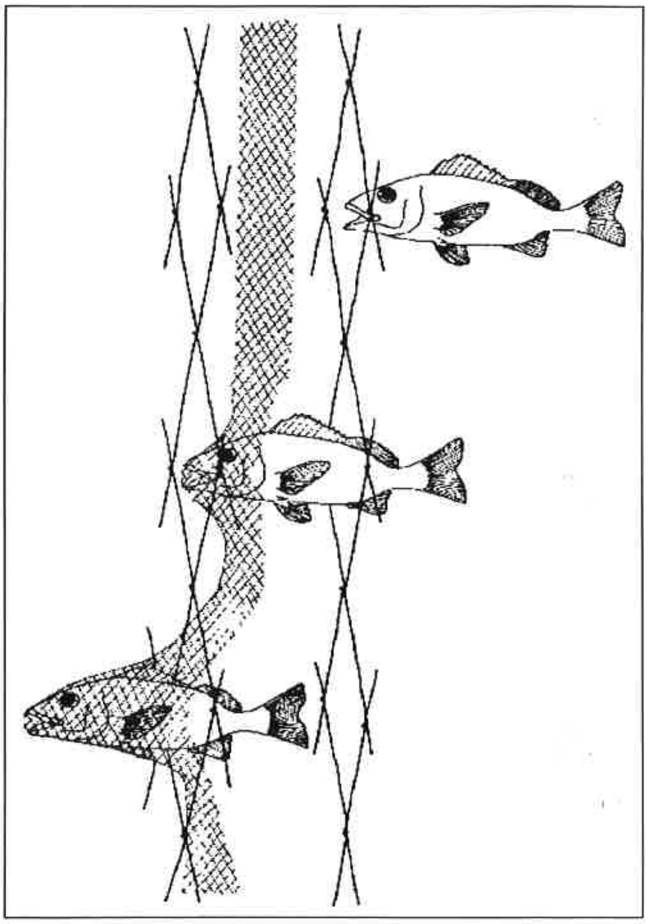

Fig. 1. Mode of operation of a trammel net. Note how fish push into the central, narrow meshed wall of the net, thus forming a bag which retains them (adapted form von Brandt 1972).

Volume can be assumed proportional to mass (not to weight as we normally say disregarding the force of gravity as we need to do here). We have,

$$m = q\, l^3 \qquad \ldots 4)$$

where q is a constant (the condition factor) and m the mass. Combining (3) and (4) we have

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[a]Editor's note: This was translated and edited (with the author's approval and assistance from V. Christensen, ICLARM) from an unpublished doctoral thesis entitled "Der Befischungszustand der Flunderpopulation in der Kieler Bucht" Math. Nat. Wiss. Fakultät, Christian-Albrechts Universität zu Kiel, submitted in 1974. This is meant to provide an answer (partial) to the many queries I have received concerning the selective behavior of trammel nets. Readers are invited to develop this further.

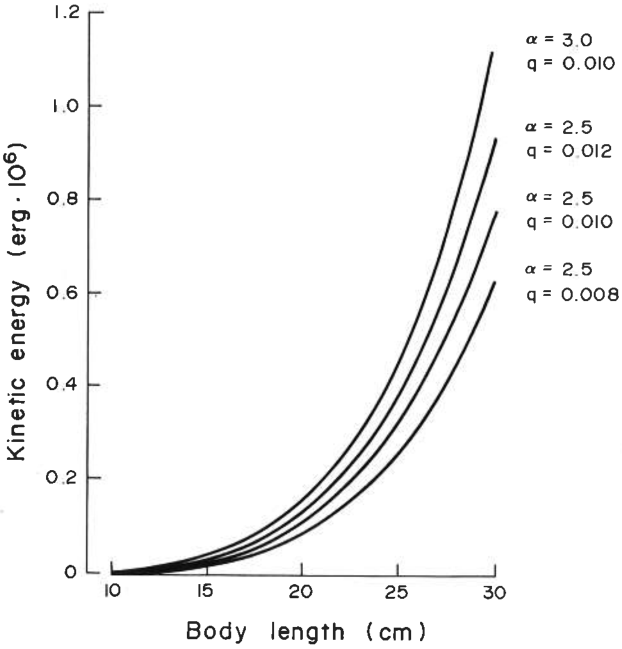

Fig. 2. Kinetic energy of fishes with various swimming speeds (α=body length·sec^{-1}) and condition factors (q), plotted as a function of body length.

$$\begin{aligned} E_{kin} &= \tfrac{1}{2} q\, l^3 \alpha^2 l^2 \\ &= \tfrac{1}{2} q\, \alpha^2 l^5 \\ &= ß\, l^5 \end{aligned} \qquad \text{...5)}$$

where ß is a species-specific constant. The unit for work (E_{kin}) is Newton meter or Joule, where 1 Nm = 1J = 1m^2 kg sec^{-2} = 10^{-7} erg.

Equation (5), when used with α as defined above and CGS units, leads to kinetic energy being expressed in erg. The increase of work with length is shown in Fig. 2 for various values of α and q.

Equation (5) suggests that selection depends, in trammel nets, very strongly on fish length; a certain size must be reached before a fish can extend enough kinetic energy to form a bag. Small fish may not be caught by a trammel net even when they are large enough to be retained by its outer meshes. This suggests that with regard to this gear, fish size — in small fish at least — may be more important than mesh size.

References

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News on ECOPATH II*

The ECOPATH — which some 'old' readers may remember from J. Polovina's articles in Fishbyte (Aug. 1984, Apr. 1986) — is a model for construction and parametrization of ecosystem models. Based on readily available population data (biomass, mortality, food consumption and diet composition) the model balances the flows in the system, and calculates various parameters for characterization of the system.

Polovina's original version of the ECOPATH model was most welcome at ICLARM where the need for readily available methods for assessing multispecies tropical stocks was clear. Therefore the work with ECOPATH was continued, and a test version of an improved model — the ECOPATH II — was ready and first applied in 1987 (Pauly et al.)

More recently the Ecopath II efforts has developed into a project at ICLARM — thanks to funding from DANIDA. The project has been operative since early 1990 and the results are beginning to show. Let's mention the development and release of the ECOPATH II Package in May 1990 (ICLARM Software 6), and the subsequent use of it on a large number of ecosystems. Most notably is a poster theme session at the Statutory Meeting in October 1990 of the International Council for the Exploration of the Seas of Aquatic Ecosystems where steady state models of some 35 systems originating from all over the world (Antarctica, Brunei, California, China, The Caribbean, France, Georges Bank, India, Israel, Lake Victoria, Malawi, Mexico, Mozambique, the Netherlands, the North Sea, Peru, the Philippines, Sierra Leone, Tanganyika, the United Kingdom, Venezuela, the Wadden Sea and Zimbabwe) were presented.

Practically all of the contributions at the theme session had one thing in common: they used the ECOPATH II package as a means for turning readily available population data into a balanced ecosystem model. Only few of the participants (which were mainly NTFS members) had any previous experience with ecosystem modelling - but they had data and a system to describe and perhaps manage.

The proceedings from the theme session are presently being edited to appear in the ICLARM Conference Proceedings Series (Christensen, V., and D. Pauly. In press. Trophic Models of Aquatic Ecosystems. ICLARM Conference Proceedings 26.)

Since the ICES Session, the ECOPATH II project has focused on a new and much improved version of the ECOPATH II Software. We are getting nearer the release, and expect to be able to distribute it as Version 1.1 in April 1991. Those who have been waiting for the new version will hopefully have patience with us.

NTFS members with interests in further information on the ECOPATH II are encouraged to contact us.

More news in the next Fishbyte: A description of the new version of Ecopath II, and notes on the incorporation of a multispecies length cohort analysis in ECOPATH II.

References

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*Item contributed by Villy Christensen