ECOSYSTEM SIZE SPECTRA AS INDICATOR FOR REGIONAL SEAS[1]

Maria Lourdes D. Palomares and Daniel Pauly
Sea Around Us *Project, Fisheries Centre, University of British Columbia*
2202 Main Mall, Vancouver BC V6T1Z4 Canada

ABSTRACT

The size-spectra of organisms are informative about the status of exploitation or 'stress' of marine ecosystems such as Regional Seas, but are very difficult to construct from observed data because of the extremely wide range of organisms to be considered (phytoplankton to whales). Here, a method is proposed which allows the construction of ecosystems' size-spectra from balanced trophic (Ecopath) models and growth parameters for each of the functional groups therein. An example pertaining to the South China Sea ecosystem is provided.

INTRODUCTION

Different ecosystems have characteristic size distributions of the organisms they contain. These distributions are usually represented as 'size-spectra', i.e., double logarithmic plots of the biomass of organisms of different sizes *vs*. their body weights (Kerr and Dickie, 2001). In practice, however, size-spectra covering the whole range of the different size domains (i.e., from phytoplankton to whales) in an ecosystem are difficult to produce. Thus, most empirically obtained size-spectra cover a narrow range of sizes, as obtained by, e.g., plankton nets or water samplers for phyto- and zooplankton or trawls for fish (Sheldon *et al*., 1972; Bianchi *et al*., 2000).

However, trophic spectra can be constructed from the relative biomasses of the various functional groups of Ecopath models of ecosystems. Thus, once a food web has been constructed and balanced with Ecopath, including biomasses that are mutually compatible over a certain period, at least (Christensen and Pauly, 1992), the biomasses of each functional group can be re-expressed as biomass by log size and then summed over all functional groups. Details are given below as well as an example with a brief discussion of potential applications to Regional Seas.

MATERIAL AND METHODS

The method to construct size-spectra from balanced Ecopath models, assuming steady-state, does the following (adapted from Pauly and Christensen, 2002, p. 221):

- uses the von Bertalanffy growth curves and the values of P/B (i.e., total mortality, Z; Allen, 1971) entered for each group in the model to re-express its biomass in terms of a size-age distribution;
- divides the biomass in each (log) weight class by the time, Δt, required for the organisms to grow out of that class (to obtain the average biomass present in each size class);
- adds the $B/\Delta t$ values by (log) class, irrespective of the groups to which they belong.

RESULTS AND DISCUSSION

Figure 1 presents two size-spectra, for different periods, constructed as described above. As might be seen, their slopes reflect the intensity of stress (due to fishing) exerted on the ecosystem, which here contains fewer large organisms than the earlier period. A number of other inferences can be drawn from such spectra as may be verified in the literature cited above. Important here is that given Ecopath models for all Regional Seas (and they exist, see Ahrens and Christensen, this volume), size spectra could be straightforwardly constructed for Regional Seas given the present availability of growth parameters for

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functional groups in all Regional Seas (Palomares and Pauly, 2008; Palomares and Pauly, 2009; see also www.fishbase.org and www.sealifebase.org).

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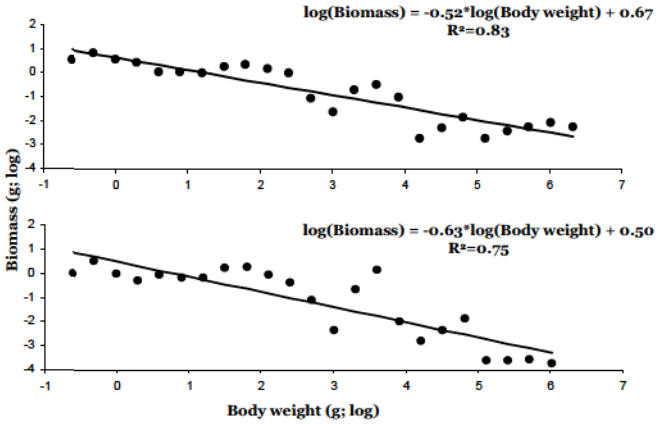

Figure 1. Size-spectra of functional groups of the northern South China Sea ecosystem based on published Ecopath models (see Cheung and Sumaila, 2008) for the period 1970s (upper graph) and 2000s (lower graph) showing a change in the size composition of functional groups (smaller sizes) in the latter period, thus inferring stress (due to fishing).

REFERENCES

Allen, R.R., 1971. Relation between production and biomass. *Journal of the Fisheries Research Board of Canada* 28, 1573-1581.

Bianchi, G., Gislason, H., Graham, K., Hill, L., Jin, X., Koranteng, K., Manickchand-Heileman, S., Payá, I., Sainsbury, K., Arreguin-Sánchez, F., Zwanenburg, K., 2000. Impact of fishing on size composition and diversity of demersal fish communities. *ICES Journal of Marine Science* 57, 558-571.

Cheung, W.W.L., Sumaila, U.R., 2008. Trade-offs between conservation and socio-economic objectives in managing a tropical marine ecosystem. *Ecological Economics* 66, 193-210.

Christensen, V., Pauly, D., 1992. The ECOPATH II - a software for balancing steady-state ecosystem models and calculating network characteristics. *Ecological Modelling* 61, 169-185.

Kerr, S.R., Dickie, L.M., 2001. *The Biomass Spectrum. A Predator-Prey Theory of Aquatic Production*. Columbia University Press, New York, 320 p.

Palomares, M.L.D., Pauly, D., Editors, 2008. Von Bertalanffy Growth Parameters of Non-fish Marine Organisms. Fisheries Centre Research Reports 16(10). Fisheries Centre, UBC, Vancouver, Canada.

Palomares, M.L.D., Pauly, D. 2009. The growth of jellyfishes. *Hydrobiologia* 616(1): 11-21.

Pauly, D., Christensen, V., 2002. Ecosystem Models. Chapter 10. *In:* Hart, P., Reynolds, J., (eds.), *Handbook of Fish and Fisheries*, pp. 211-227. Blackwell Publishing, Oxford, Volume 2.

Sheldon, R.W., Prackash, A., Sutcliffe, W.H., 1972. The size distribution of particles in the ocean. *Limnology and Oceanography* 17, 327-340.