III ii Application of fish behaviour knowledge for improved assessment and fisheries

ICES mar. Sci. Symp., 196: 190–195. 1993

Consequences of fish behaviour for stock assessment

Pierre Fréon, François Gerlotto, and Olé Arve Misund

Fréon, P., Gerlotto, F., and Misund, O. A. 1993. Consequences of fish behaviour for stock assessment. – ICES mar. Sci. Symp., 196: 190–195.

The influence of fish behaviour on the most common stock assessment methods is reviewed. Fish behaviour may be divided into four major groups: habitat selection, aggregation pattern, avoidance reactions, and learning. Examples of temperate and tropical species are presented.

Pierre Fréon, François Gerlotto, and Ole Arve Misund: ORSTOM, BP 5045, 34032 Montpellier Cedex, France.

Introduction

Indirect stock assessment techniques have improved considerably through the development of population dynamics, and the use of computers and adequate statistics have increased their precision. Direct stock assessment methods such as fisheries acoustics are still improving, largely because of benefits from technological progress.

Although fish behaviour is not directly represented

metres below the surface to a small distance off the bottom (Mitson, 1983). Several economically important species such as cod (*Gadus morhua*) and walleye pollock (*Theragra chalcogramma*) live semipelagically, and in such cases a combination of acoustic and trawl surveys is applied (Godø, 1990; Wespestad and Megrey, 1990). A substantial difficulty for this approach is that semipelagic species sometimes choose to live mostly demersally or pelagically (Godø, 1990). Similarly, species usually living pelagically, such as herring (*Clupea harengus*), may

Table 1. Relative importance of four behavioural patterns on four categories of stock assessment approach.

Behavioural pattern	Stock assessment method			
	Cohort analysis, VPA, etc.	Surplus production models	Trawl survey	Acoustic survey
Habitat Choice				
Short term	0	0	+ or −	++ or −−
Diurnal	0	0*	++ or −−	++ or −−
Seasonal	0	0*	++ or −−	+ or −
Yearly	+ or −	+++ or −−−	++ or −−	0
Aggregation	0	+++ or −−−	++ or −−	++ or −−
Avoidance	0	0	−−−	−−
Learning	−(?)	−(?)	−(?)	0

0 = no influence of behaviour.
+, ++, +++ = increasing risk of over-estimation.
−, −−, −−− = increasing risk of under-estimation.
* except if interannual changes in the fishing pattern are not taken into account.
(?) importance not clearly assessed.

Data gathered by trawl surveys generally also provide a high variability (Ulltang, 1977) which may partially result from horizontal or vertical displacement of the biomass. Repeated trawling at the same place may suggest varying influence of factors such as temperature (Rijavec, 1971), internal waves (Caverivière, 1982), and light intensity. Flatfishes may take advantage of tidal currents for horizontal migration by moving up in the

may affect the swimbladder volume, especially in physostomatous fish, and may have an impact on target strength (Blaxter and Batty, 1990).

Seasonal variation

Surveys are usually conducted during the same time of year to avoid bias arising from seasonal variation in fish

schools (Pitcher, 1983) These behaviour patterns have a significant influence on sampling.

Density distribution

The aggregative behaviour of fish induces a large dispersion and skewness in the distribution function of echo integration data. This is especially evident when the fish

Norwegian fjord, Toresen (1991) fitted equations to correct the fish density estimates for extinction. A solution to correct for extinction in aggregations with varying density is proposed by Foote (1990).

Catchability

Changes in stock abundance of pelagic species often occur without noticeable changes in catchability or with

us japonicus) avoids most when well fed and swimming in schools, less when shoaling and feeding, and even less

and Huse, 1983). Pyanov (1992) argues that "one-trial learning" may exist because tagged fish were not caught

Blaxter, J. H. S., and Hunter, J. R. 1982. The biology of clupeoid fishes. Adv. mar. Biol., 20: 1–223.

Boély, T., and Fréon, P. 1979. Les ressources pélagiques côtières. *In* Les ressources halieutiques dans l'Atlantique Centre-Est. lère partie: les ressources du Golfe de Guinée, de l'Angola à la Mauritanie, pp. 12–78. Ed. by J. P. Troadec and S. Garcia. FAO Tech. Pap. 180.

Buerkle, U., and Stephenson, R. L. 1990. Herring school dynamics and its impact on acoustic abundance estimation. *In* Proceedings of the International Herring Symposium, Anchorage, Alaska, USA, October 23–25, 1990, pp. 185–208. Alaska Sea Grant College Program, University of Alaska, Fairbanks, Alaska. 672 pp.

Caverivière, A. 1982. Les espèces démersales du plateau continental ivoirien: biologie et exploitation. Thèse doc. état

Kemmerer, A. J. 1980. Environmental preferences and behaviour patterns of gulf menhaden (*Brevoortia patronus*) inferred from fishing and remotely sensed data. *In* Fish behaviour and its use in the capture and culture of fishes, pp. 345–370. Ed. by J. E. Bardach, J. J. Magnuson, R. C. May and J. M. Reinhart. ICLARM Conference Proceedings, Manila. 512 pp.

Lévénez, J. J., Gerlotto, F., and Petit, D. 1990. Reaction of tropical coastal pelagic species to artificial lighting and implications for the assessment of abundance by echo integration. Rapp. P.-v. Réun. Cons. int. Explor. Mer, 189: 128–134.

Lévy, P. 1925. Calcul des probabilités. Gauthier-Villars, Paris.

MacLennan, D. N., 1990. Acoustical measurement of fish abundance. J. Acoust. Soc. Am., 87: 1–15.

MacLennan, D. N., and Simmonds, E. J. 1992. Fisheries

Acoustics, Seattle, Washington, USA, 22–26 June, 1987. 12 pp.
Toresen, R. 1991. Absorption of acoustic energy in dense herring schools studied by the attenuation in the bottom echo signal. Fish. Res., 10: 317–327.
Traynor, J. J., and Williamson, N. J. 1983. Target strength measurements of walleye pollock (*Theragra chalcogramma*)
Ulltang, O. 1977. Mesure de l'abondance des stocks par d'autres méthodes que le recours aux données commerciales de capture et d'effort. FAO Fish. Tech. Pap., T176. 25 pp.
Vilhjálmsson, H., Reynisson, P., Hamre, J., and Røttingen, I. 1983. Acoustic abundance estimation of the Icelandic stock of capelin 1978–1982. FAO Fish. Rep., 300: 208–216.
Wespestad, V. G., and Megrey, B. A. 1999. Assessment of