VERTICAL MOVEMENTS OF COD CHALLENGE ASSUMPTIONS OF ACOUSTIC-BASED BIOMASS ESTIMATES

by O. Heffernan[1], D. Righton[1] and K. Michalsen[2]

High-resolution data provide evidence that cod experience changes in buoyancy and orientation during rapid vertical movements, which could lead to underestimation of biomass in acoustic surveys.

Context and aims

Fish biomass is routinely estimated using acoustic techniques based on reference target strength, a measure of backscatter that assumes negligible variation in attitude and behaviour of fish. We used data storage tags (DSTs) to investigate vertical movement of cod in the North, Irish and Barents Seas and the implications for biomass estimation.

Methods/Results

Buoyancy

Laboratory and field studies have shown that cod maintain neutral buoyancy (NB) in mid-water by gas secretion into and resorption from the swimbladder[1,2]. We examined post-release descents of 10 DST-tagged cod with clear adaptation to increasing depth. During adaptation (several days), cod descended at a mean rate of 0.4-0.8m h^{-1}, consistent with maintaining NB at their upper depth range (Figure 1a). In the short-term, however, cod made routine rapid vertical movements (Figure 1b), in some cases up to 70 m in 10 minutes. These rates suggest that gas exchange from the swimbladder is not rapid enough to compensate for swift vertical movements. Cod are, thus, likely to experience changes in buoyancy during rapid vertical movements in mid-water.

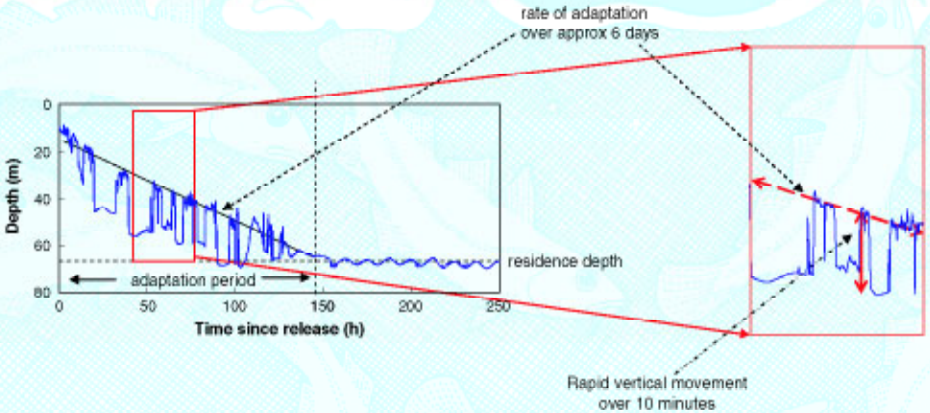

Figure 1: a) Postrelease depth profile of a cod in the North Sea. Depth was sampled at 10-minute intervals during adaptation i.e. the period of gradual decrease in mean depth from release until reaching a stable residence depth
b) Long-term and short-term rates of descent

Movement Rates

We used high frequency sampling (10-minute intervals) to estimate rates of ascent (Figure 2) and descent for 42 individual cod. Comparison to rates estimated at less frequent (30-, 60-, 120- and 240-minute) intervals showed that movement rates were underestimated at lower sampling frequencies due to the omission of short-term rapid movements, such as those regularly observed in the present study.

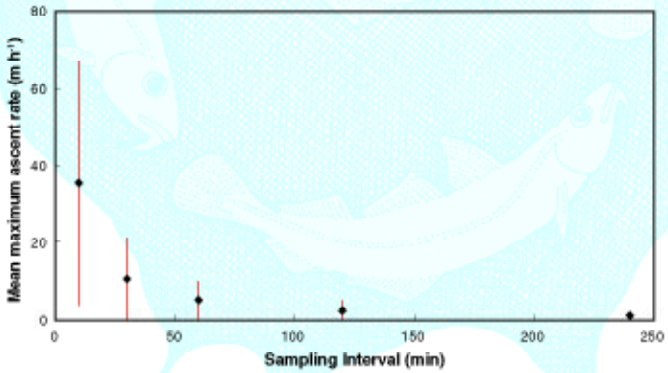

Figure 2: Relationship between sampling rate and estimate of ascent rate

Tilt Angle

Cod alter the angle of their body to move between depths. The proportion of time spent tilted was estimated for 10 individuals using an assumption of constant ground speed of 0.5 bodylengths s^{-1} (Figure 3a). Data sampled every 10 seconds showed that cod spent 50% of the time tilted by more than 5° (Figure 3b) and that orientation varied systematically with time of day (Figure 3c).

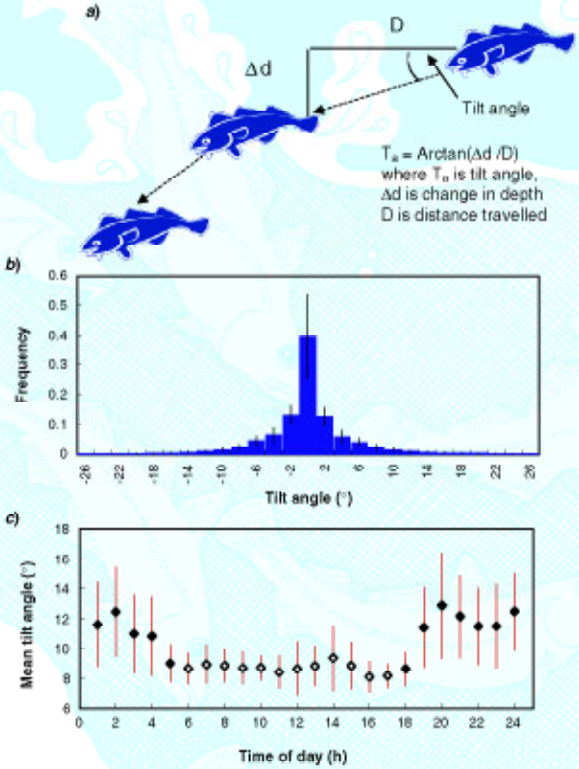

Figure 3: a) Simple calculation of tilt angle b) Tilt angle distributions sampled at 10 s intervals c) Variation in mean tilt angle with time of day

Conclusions

- Cod routinely make swift vertical movements causing alteration of buoyancy and tilt angle.
- High-frequency sampling is necessary to accurately quantify movement rates and to infer non-compliance of the swimbladder with NB.
- Systematic negative buoyancy and tilt of the body will reduce fish target strength and could cause considerable underestimation of biomass in acoustic surveys.

References

1. Harden-Jones, F. and P. Scholes, *Gas secretion and resorption in the swimbladder of the cod Gadus morhua*. Journal of Comparative Physiology B, 1985. **155**: p. 319-331.
2. Arnold, G.P. and M. Greer-Walker, *Vertical movements of cod (Gadus morhua L.) in the open sea and the hydrostatic function of the swimbladder*. ICES Journal of Marine Science, 1992. **49**: p. 357-372.

Acknowledgement

Background reproduced with kind permission of Simon Drew ©

[1]The Centre for Environment, Fisheries and Aquaculture Science (CEFAS), Lowestoft Laboratory, Pakefield Road, Lowestoft, Suffolk NR33 0HT, UK. E-mail: o.heffernan@cefas.co.uk http://www.cefas.co.uk
[2]Institute of Marine Research, Bergen, Norway http://www.imr.no