

## FISH SOUND, A FUTURE TOOL FOR SELECTIVITY

Soldal, A.V.<sup>1</sup>, Midling, K.Ø.<sup>2</sup>, Fosseidengen, J.E.<sup>1</sup>, Svellingen, I.<sup>1</sup> and Øvredal, J.T.<sup>1</sup>.

- 1) Institute of Marine Research, P.O.Box 1870 Nordnes, Bergen, N-5817, NORWAY  
[Aud.Soldal@imr.no](mailto:Aud.Soldal@imr.no)
- 2) Norwegian Institute of Fisheries and Aquaculture Ltd. N-9291, Tromsø, NORWAY.  
[Kjell.Midling@fiskforsk.norut.no](mailto:Kjell.Midling@fiskforsk.norut.no)

### ABSTRACT

The paper describes a project aimed at utilising biological sounds from marine fish to develop more species and size selective fishing methods. During the first year of the project biological sounds have been recorded from cod (*Gadus morhua*), haddock (*Melanogrammus aeglefinus*) and tusk (*Brosme brosme*) in natural environment using a remotely controlled sound and video recording unit. The sound production of net-penned cod has been studied in order to gather information on diurnal and seasonal variations, as well as size and age dependence in frequency and characteristics of fish sounds. The recorded sequences of fish sounds will subsequently be replayed to the same species and/or predatory and prey species to study the effect on fish behaviour. Observed attractive and repulsive behavioural responses of fish will be utilised at a later stage to improve selectivity in existing passive fishing methods.

### 1. INTRODUCTION

Responsible fishing has been given increased attention during the last decades (1). Today many of the world's major fish stocks have been exploited beyond their profitable level, and some of them are out of safe limits or at the point of collapse (2). The amount of bycatch and discarding of unwanted sizes and species is tremendous (3). A number of methods and technologies have been implemented in order to improve selectivity (4), like minimum mesh sizes, sorting grids and escape panels (5). Though improved selectivity of fishing gears often involves utilization of behavioural differences of fish, these methods only to a small extent affect the behaviour of the fish *per se*.

To attract or repulse fish, both light and sound are used in commercial fishery. Tuna is attracted to the fishing vessel by spraying water at the surface, the sound mimicking the sound of schooling prey, emission of white-noise can attract squid (6) and mackerel, herring and sprat can be concentrated prior to seining by using light to attract their prey (7). Emission of low-frequent sound are used to keep fish away from water-inlets in hydropower plants (8; 9). In sea ranching with conditioned fish, sound has proved to be an efficient stimulus (10; 11).

A number of fish species have the ability to produce sounds, among them several members of the gadoid family (12; 13). These sounds are produced by contracting muscles attached to the gas-bladder (drumming muscles). The sounds have various purposes: competition for food, defending territory and courting. The three species examined so far in this project are all vocal and have well developed drumming muscles. Though obviously serving communication purposes these sounds have so far not been used to affect the behaviour for fishing, neither to increase the catches nor to make the fishing more selective. The project described in this paper, which is still in an early stage, is planned to run through three phases:

1. To collect and analyse biological sounds produced by marine species in different social contexts.
2. To study the effect of replayed biological sounds on fish behaviour.
3. To develop selective fishing methods based on behavioural responses to biological sounds.

So far, the work has been focused on phase one, and we are just at the point of beginning at phase two.

## 2. MATERIALS AND METHODS

Recordings of sounds produced by fish were done both with cabled hydrophones from fish (cod) kept in net-cages at an aquaculture research station and in field by using a remotely operated audio and video unit (cod, tusk and haddock). Fig. 1 illustrates the experimental design that allows wireless observation and recording of fish behaviour and sound up to 1 nautical mile from the fish. Usually fish were lured to the recording unit by bait attached to the rig.

Brüel & Kjaer hydrophones with (type 8104) and without (type 8106) preamplifier Brüel & Kjaer amplifier (type 2635) for hydrophone 8104 Brüel & Kjaer 2-channels voltage supply (type 5935) for hydrophone 8106 Brüel & Kjaer real time analyser, 2 channels (type 2144) Sony DAT recorders TCD-D8, TCD-D10 and TCD-D100 Avisoft-SasLab Pro, sound analysis software for windows-pc Osprey SIT low light underwater camera
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*Table 1. List of equipment applied in the project*

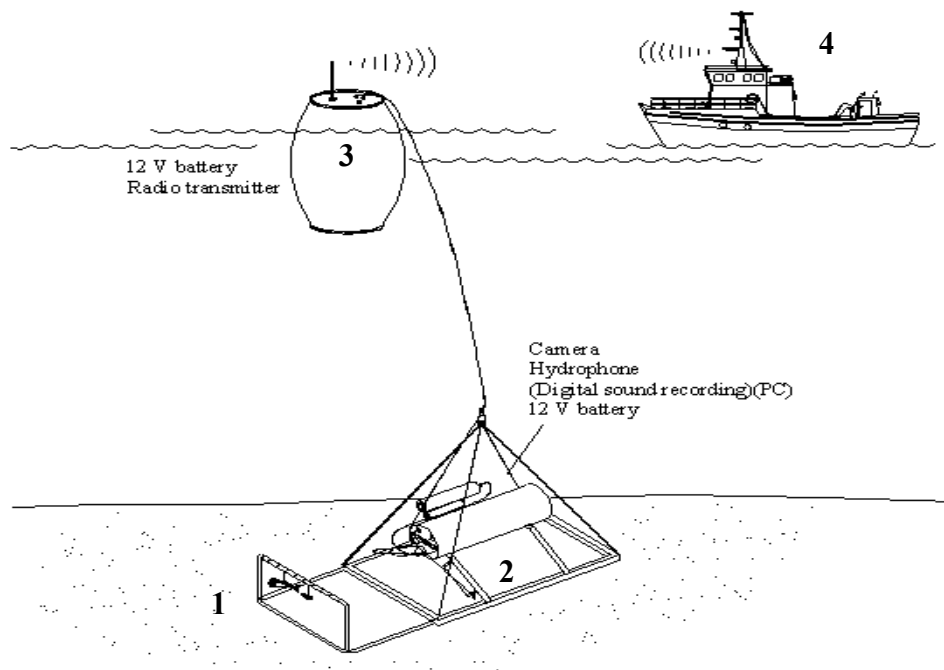


Figure 1. The experimental set-up for remote recording consists of a rig with attached bait (1), a waterproof cylinder containing instruments (2), a waterproof barrel with two radio-transmitters (3) and a research vessel where signals are received and processed (4).

### 3. RESULTS

Field recordings of sounds from wild living fish were done successfully from three different species: Cod, haddock and tusk. The three species showed distinct sound characteristics as shown in Figs. 2 to 4. The fish were lured to the recording unit by attractants released from a bait attached to the rig. The sounds produced were mainly related to feeding behaviour. Aggressive behaviour while competing for or defending the bait was also seen, particularly among tusk.

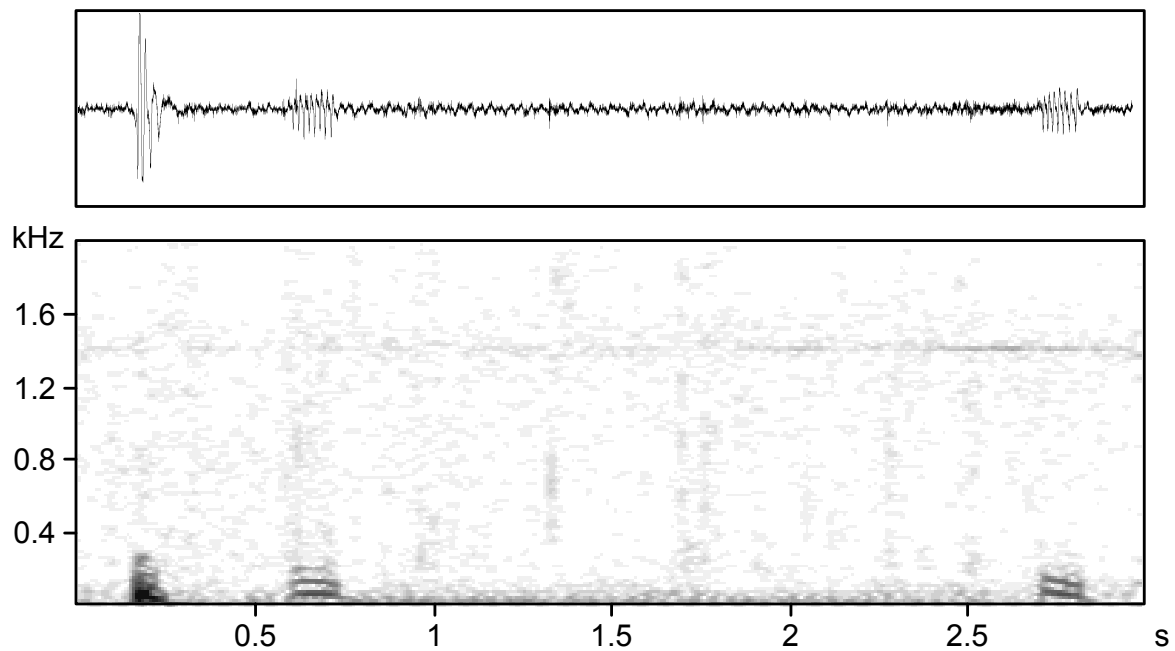
Cod made short “grunts” typically consisting of series of 6 to 12 low frequency pulses (Fig. 2 and 5). These grunts seemed to be rather similar in structure independent of the behaviour of the individual fish during sound emission, geographical area, season, etc. In addition to the “grunts”, cod were also heard to make a shorter sound (“bop”), often preceding a grunt.

Haddock sounds always consisted of short “knocks” (Fig. 3). Detailed examination of the sound pressure waveform showed that each knock was built of two short low-frequency pulses (Fig. 5). While shoaling around the bait and occasionally nipping it, the knocks were infrequent and irregular. During aggression identical “knocks” were repeated at shorter time intervals in series of different length, the intensity being proportional to the level of aggression.

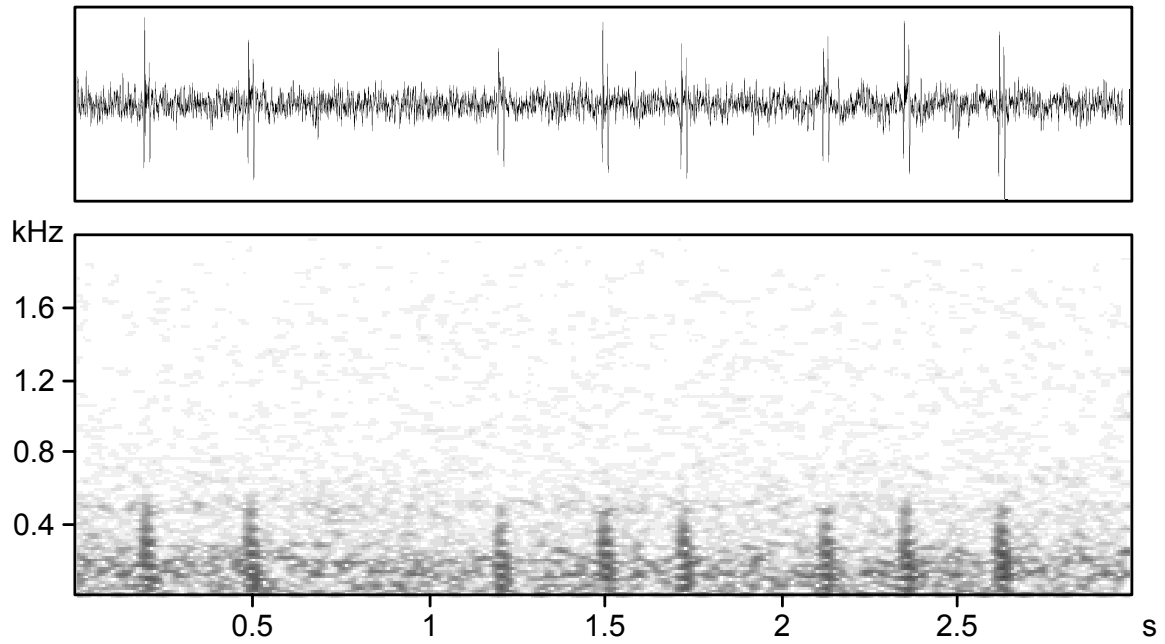
Sound recordings were only done during aggressive behaviour from tusk. This species was found to be highly vocal. The aggressive sound, recorded during defence of bait that was attacked by a co-specific of smaller size, consisted of a long series of short pulses of low frequency (Fig. 4) repeated at short intervals (approximately 20 pulses per second, Fig. 5).

The diurnal and seasonal vocal activity of cod kept in netpens at an aquaculture plant was also measured as part of the project, as well as the development of sound characteristics of cod relative to age and body growth. These data are not yet fully analysed.

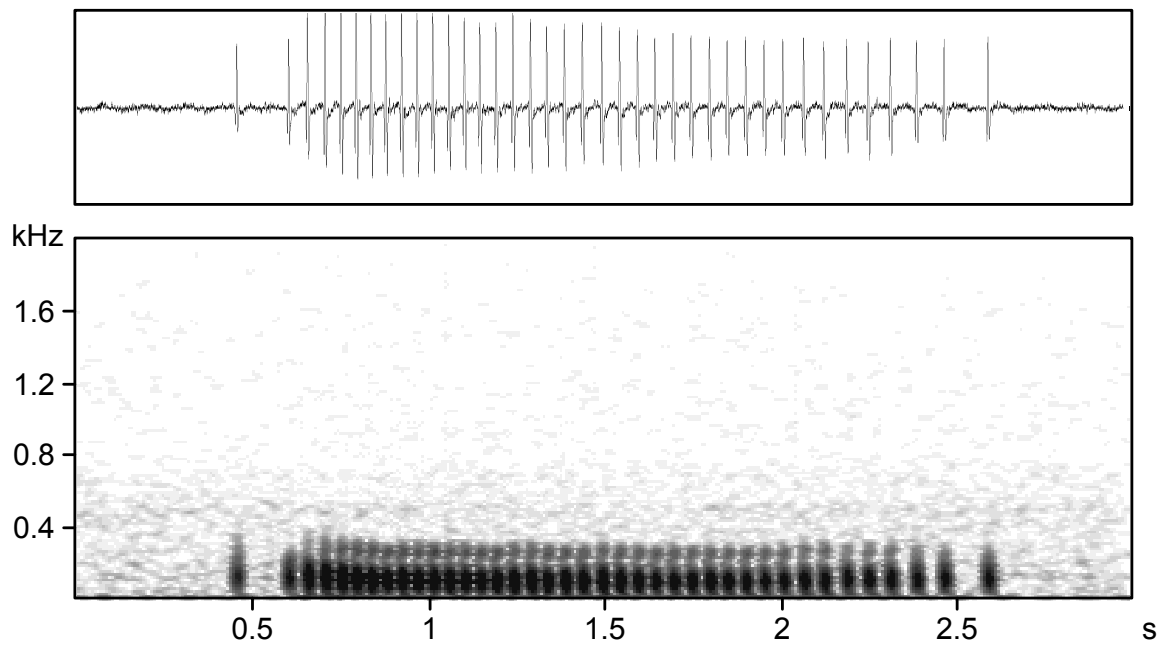
The sounds recorded in phase one of the project will next be used as basis for playback experiments starting this summer. Sound sequences will be replayed to fish of the same and other species kept in net pens in the sea as well as to wild living fish. During replay of sound, the fish behaviour will be monitored using a UV camera. Observed attractive and repulsive behavioural responses of fish will be utilised at a later stage to improve selectivity in existing passive fishing methods.



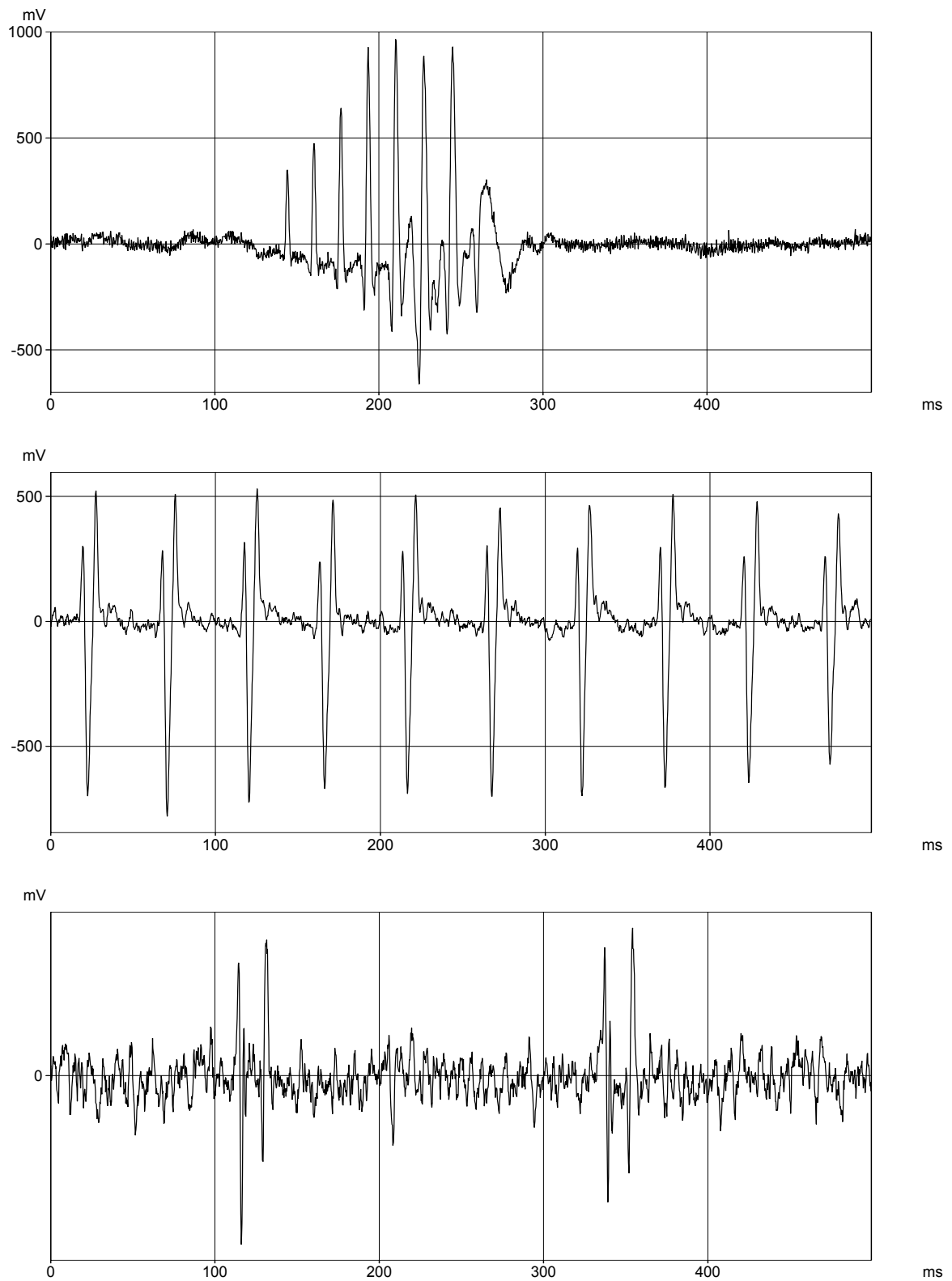
*Fig. 2. Envelope curve (top) and spectrogram (below) of two cod (*Gadus morhua*) “grunts” preceded by a “bop”. (FFT length 256, Hamming window, Overlap 87.5).*



*Fig. 3. Envelope curve (top) and spectrogram (below) of a series of haddock (*Melanogrammus aeglefinus*) “knocks” produced during approaching a bait. (FFT length 256, Hamming window, Overlap 87.5).*



*Fig. 4 Envelope curve (top) and spectrogram (below) of sounds produced by tusk (*Brosme brosme*) during aggressive behaviour. (FFT length 256, Hamming window, Overlap 87.5).*



*Fig. 5. Detailed time structure of sounds from cod (top), tusk (middle) and haddock (below).*

#### 4. DISCUSSION

Technical regulations of fishing gear have to a certain extent improved the fleet selectivity. Unfortunately the effect on the discard rate has often proved to be limited. One reason is that improved selectivity has been met with an increased fishing effort. Even when technically successful the improved selectivity of a fishing gear may not help to improve the survival of undersized fish and non-target species. The fish that have encountered a fishing gear may be fatally hurt during the catch process e.g. by hitting the net panels or being squeezed through the meshes of a trawl (14; 15). In longlining the fish may become injured while escaping the hook (16). Several of the most commonly used fishing gear may have a serious impact on the environment (17). Active fishing methods like bottom trawling may seriously damage the bottom substratum and benthos, while passive gears like longlines and gillnets often have unwanted bycatch of mammals and birds.

Future development of fishing gears and methods should focus on minimising the unwanted side effects of the present fishing technologies. This paper deals with the possibilities of improving fishing gear selectivity by using the fish's own language as a stimuli (attractant and/or repellent) in passive fishing gears like traps or pots. Sounds connected to sexual activity, feeding or prey may be used to attract fish towards passive gears. If these signals can prove to be species or size specific, this technology can lead to increased selectivity.

As a first step in the process of using fish sounds as a tool in fishing technology, sounds from three gadoid species, cod, haddock and tusk, was recorded and analysed. The sounds of cod and haddock were similar to those described by other authors (12; 13; 19). Although not earlier described in the literature, tusk showed to be a highly vocal species. Tusk is known to be a territorial species, defending a core area for shelter and a feeding area. It is reasonable to believe that sounds form part of the behavioural pattern used during territorial defence.

#### 5. ACKNOWLEDGEMENTS

The project was funded by the Norwegian Research Council.

#### REFERENCE

- (1) **Anon.**, *Code of Conduct for Responsible Fisheries*. FAO CCRF E, Sept. 1995.
- (2) **Alverson, D.L., Freeberg, M.H., Murawski, S.A., Pope, J.G.** A global assessment of fisheries bycatch and discards. *FAO Fisheries Technical Paper* 339, 233pp. 1994.
- (3) **Alverson, D.L.** Some observations on the science of bycatch. *Marine Technology Society Journal*, 33: 6-11, 1999.
- (4) **Mace, P.A.** Developing and sustaining world fisheries resources: the state of the science and management. In: Hancock, D.A., Smith, D.C., Grant, A., and Beumer, J.P. (eds.): *Developing and sustaining world fisheries resources. The state of science and management*. CSIRO, Collingwood (Australia), pp. 1-20, 1997.

- (5) **Isaksen, B., and Valdemarsen, J.W.** Bycatch reduction in trawls by utilizing behaviour differences. In Fernö, A. and Olsen, S. (eds.). *Marine fish behaviour in capture and abundance estimation*. Fishing News Books, pp. 69-81, 1994.
- (6) **Maniwa, Y.** Attraction of bony fish, fish and squid by sound. In: Shuijif, A. And Hawkins, A. D. (Ed.). *Sound reception in fish. Developments in aquaculture and fisheries science*. Elsevier Scientific Publishing Company, Amsterdam. Vol. 5: 271-283, 1976.
- (7) **Von Brandt, A.** *Fish catching methods of the world*. 3rd edition. ISBN 0 85238 125 5, 1984.
- (8) **Knudsen, F.R., Schreck, C.B., Knapp, S.M., Enger, P.S. and Sand, O.** Infrasound produces flight and avoidance responses in Pacific juvenile salmonids. *Journal of Fish Biology* 51: 824-829, 1997.
- (9) **Turnpenny, A.W.H., Tatcher, K.P., Wood, R. and Nedwell, J.R.** Fish guidance and protection at engineering facilities using underwater acoustics. *ICES Int. Symp. on Fisheries and Plankton Acoustics*, Aberdeen 12-16 June 1995.
- (10) **Fujiya, M., Skaguchi, S. And Fukuhara, O.** Training of fishes applied to ranching of red sea bream in Japan. In: Bardach, J.E., Magnuson, J.J., May, R.C. and Reinhart, J.M. (Ed.). *Fish behaviour and its use in the capture and culture of fishes*. ICLARM Conference Proceedings 5:200-209. Manila, Philippines. 1980.
- (11) **Midling, K.Ø., Kristiansen, T, Ona E., and Øiestad, V.** Fjord ranching with conditioned cod. *Count. Meet. Int. Count. Explor. Sea.* (F:29) 1-11, 1987.
- (12) **Hawkins, A.D., and Rasmussen, K.J.** The calls of gadoid fish. *J. mar. boil. Ass. U.K.* 58: 891-911, 1978.
- (13) **Hawkins, A.D.** Underwater sound and fish behaviour. In: Pitcher, T.J. (Ed.): *The Behaviour of Teleost Fishes*, 2nd Edition, pp. 129-169. Croom Helm. London, 1993.
- (14) **Soldal, A.V., Engås, A., and Isaksen, B.** Survival of gadoids that escape from a demersal trawl. *ICES Mar. Sci. Symp.*, 196:122-127, 1993
- (15) **Suuronen, P., Erikson, D., and Orrensalo, A.** Mortality of herring escaping from pelagic trawl codends. *Fisheries Research* 25: 305-321, 1996.
- (16) **Milliken, H., Farrington, M., Carr, A., and Lent, E.** Survival of Atlantic cod (*Gadus morhua*) in the Northwest Atlantic longline fishery. *MTS Journal* 33: 19-24, 1999.
- (17) **Thrush, S.F. et al.** Disturbance of the marine benthic habitat by commercial fishing: Impacts at the scale of the fishery. *Ecological Applications* 8: 866-879, 1998.
- (19) **Hawkins, A.D., and Amorim, C.P.** Spawning sounds of the male haddock, *Melanogrammus aeglefinus*. *Environmental Biology of Fishes*, in press, 2000.

