ICES SGFARV REPORT 2008

ICES FISHERIES TECHNOLOGY COMMITTEE

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Report of the Study Group on Fish Avoidance to Research Vessels (SGFARV)

22-23 June 2008

Bergen, Norway

ICES International Council for the Exploration of the Sea

CIEM Conseil International pour l'Exploration de la Mer

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Executive summary

In the early 1980s fisheries acoustics began to be one of the most used survey methods for evaluation of fish populations. It had many advantages, but a preliminary condition was required to allow considering the data collected as representative of the populations: that fish was not avoiding the vessel. Pioneer works from Olsen *et al*. (1983a, b) described clearly the problem. A series of measurement on fish avoidance were performed and gave very variable results, from no avoidance to huge avoidance. The question was recognised as critical for the survival of the acoustic methods.

In 1995 a Cooperative Research Report (No. 209) titled "Underwater noise of research vessels: review and recommendations" was produced. This work was motivated by the observation that fish was usually strongly avoiding vessels, and particularly research vessels, which was a source of biases in most of the observations, surveys and experiments performed aboard these vessels. One obvious source of perturbation was the noise generated by these research vessels (e.g. Olsen *et al*., 1983). An important work was done, the noise of a series of RV was measured, studies of the hearing capacities of the most important surveyed fish was collected, and recommendations for building silent vessels, and published in CRR 209. Since this time several research vessels have been built following the CRR 209 specifications (e.g. RV "Scotia", RV "Thalassa", RV "G.O. Sars", etc.). It exists now a series of ships that are remarkably silent. It became interesting to evaluate how much surveys are improved by these new characteristics. Nevertheless the results of measurements remained rather variable, and some experiments demonstrated that "fish do not avoid [silent] research vessels (Fernandes *et al*., 2000; Nature vol 404:35–36, 2 March 2000); while other found that the avoidance was not significantly reduced (Ona *et al*., JASA, March 2007)

It clearly appears that fish avoidance is not a simple "linear" response of fish to noise, but obeys to more complex patterns. It is likely that the biological status of the fish as well as the environment and other stimuli (visual, chemical, sensitivity to pressure waves, etc.) interferes with "pure" sound stimuli. Moreover, it may be suspected that some other reactions, such as exploration behaviour or fish learning may interfere.

In order to document all these points, ICES committed the Fisheries Technology Committee through its two Working Groups (FAST: Fisheries Acoustics, Science and Technology; and FTFB: Fisheries Technology and Fish Behaviour) to organise a study group on this question.

The objectives of the study group are:

- What are the differences in the reactions of fish to a "noisy" and to a "silent" research vessel?
- What are the main acoustic factors influent on fish avoidance?
- More generally, what are the behavioural patterns allowing a fish to respond to an anthropological stimulus?
- What kind of recommendation should ICES give to scientists, manufacturers, ship builders etc. for improving the quality of in situ research?

1 Introduction

The Study Group on Fish Avoidance to Research Vessels (SGFARV) worked by correspondence during the period June 2007 – June 2008 and met in Bergen, Norway, from 22–23 June 2008.

A full list of participants to the SGFARV meeting in Bergen, Norway can be found in Annex 1.

1.1 2008 Terms of Reference for the Study Group

The recommendations to the Study Group for 2008 were:

The Study Group will explore when and why fish avoid research vessels:

a) elucidate and expand the list of the possible physical stimuli produced by research vessels (platform related stimuli - PRS) that could elicit avoidance reactions in survey-targeted species;

A report was written by Dick Wood on this theme and was presented at the SGFARV meeting in Bergen, and also presented to the WGFAST. It is available, on the SGFARV SharePoint site: http://groupnet.ices.dk/eg/eg2008/sgfarv2008/default.aspx

b) produce a literature review to improve our understanding of fish hearing and their reaction to sound stimuli;

A bibliographical list was produced representing more than 150 references so far. The list was distributed to the members through the Study Group's SharePoint site in order to add the references that are lacking. From this list and from the partial literature reviews already done by the Study Group members, the literature review will be continued under coordination of Nils Olav Handegard, Alex De Robertis and Julia Parrish

c) generate a list of recommended items to be monitored and measured on research vessels, wider than just noise related;

A preliminary list was done and presented in the document from D. Wood (see SharePoint site)

d) produce a review of methods for measuring avoidance to aid in the design and development of new methods to independently monitor fish reaction to PRS;

A list of methods was built from the literature review. To summarize, the methods are the following:

Statistical methods:

- Differences between day and night data; repetitions
- Differences in results from the same vessel in different areas
- Differences between data collected during spawning-non spawning periods; migration-non migration, etc.;
- Differences between results from different methodologies (acoustics vs. eggs & larvae, lidar, etc.

Methods aboard a ship:

- omnidirectional sonar (avoidance in front of the ship;
- multibeam sonar for avoidance measurement in situ;

- split-beam tilt angle variations and individual avoidance (tracking);
- experimental (e.g. changes in sound production)

Comparative methods (intercalibration):

- parallel transects, etc. (e.g. "G.O. Sars" vs. "F. Nansen", or O. Dyson vs. M. Freeman etc.)

Methods with external platforms:

- buoys and observatories (e.g. Olsen, Wilson, etc.)
- ROV & AUV. e.g. Scotia vs. AUV; measurements on trawls vs. ROV, etc.)
- Acoustic tagging on free individuals

Laboratory experiments:

- Reactions to sounds; learning; habituation; etc.

More details are presented in a PowerPoint file added to the SharePoint site.

e) design explicit experiments to further examine the causes of fish reactions to PRS;

Discussion was done on this topic and several propositions were presented. An analysis of these propositions will be made during 2008 and a preliminary report presented at the FTC meeting in Halifax, September, 2008.

f) produce an ICES Cooperative Research Report on fish response to anthropogenic sounds.

The structure of the ICES CRR was discussed during 2007–2008. The final structure for the CRR was agreed on the following basis:

TITLE

"Causes and consequences of fish reactions to fisheries research vessels"

The first year of the Study Group left open the possibility of a wider scope, including any kind of platform, any kind of stimulus (e.g. light, electromagnetism.;.) and any kind of reactions. After one year of exploration it was agreed to define more precisely the scope of the CRR, which is now related to research vessels and will mostly focus on "sound" stimuli (which includes infra-sounds to ultra-sounds, pressure waves, and any wave system produced by a research vessel. This does not mean that ancillary sources of stimuli will not be taken into consideration (e.g. differences between stimuli emitted by a vessel with or without trawling); the fish reaction will be analysed, i.e. wider than strict avoidance.

CONTENTS

Chapter 1: State of the art on the effect of noise reduced vessels on detection of fish (observation vs. assessment)[1]

- Succinct presentation of the problem (silent vessels vs. noisy)
- State-of-the-art (part of Dick Wood's document)
- The objective of the report (specific questions/issues this report will tackle)

Coordinators: Dick Wood & Julia Parrish

Chapter 2: (the signals a platform emits)

- fish abundance estimation w/ specific respect to fishery research vessels; and the cumulative effects of them
- Interactions between fish and platforms (natural & artificial, other sources of stimuli…)
- Characteristics of the stimulus (scaring vessel)
- Noise (sound field) (acoustic energy) = from ultra-sound to infra sound, low pressure static, gradients (respect to time, respect to distance)
- 3D directivity patterns
- repeated measurements to monitor performance
- Establish a list of the relevant parameters that more fully characterise the noise signature of a research vessel

Coordinators: Dick Wood & Ron Mitson

Chapter 3: The fish sensory physiology (signal perception: the signals a fish receives)

Signal perception

Full range of sensory capabilities of fish

- hearing capabilities (pressure, types of waves perceived and location of source, directivity capabilities)
- chemoreception
- Electromagnetic sensitivity
- Fish visual capabilities (related to Light generated by the vessel: bio-luminescence, light aboard, shadow of the hull, etc.)

Cyclic changes in sensitivity and physiological threshold capacities,

[1] *(note: presentation of the reasons why the SGFARV was created after the results of the first silent-not-quiet research vessels)*

Permanent and temporary threshold shifts

Coordinator: Chris Wilson

Chapter 4: The fish behaviour (from perception to reaction)

- Literature review of fish reactions (Species specific response: driven by age, by physiological characteristics, by spatial behaviour? (small pelagics, large pelagics, demersal),Definition of vessel-induced fish behaviour (defining the elements of avoidance pattern); the data that are affected by fish reaction to vessel, Adaptive response of fish (cascade of stimuli, learning, habituation, etc. threshold for response type: avoidance, fleeing, "nervousness", non linear effects, Species effect, Solitary vs. collective, Interference, etc.)
- Conceptual behavioural model/approach: ("Analyse the signal the same way the fish do" (filtering abilities) Behavioural modelling)
- Matrix of most influential factors

Coordinators: Nils Olav Handegard & Alex De Robertis

Chapter 5: Effects of fish reactions on measurements and assessments of fish

- Defining what is measured (list of variables that are likely to be affected by the vessel): TS, backscattering, fish movements, distribution (2D, 3D), aggregation structure, school types, morphology, etc.
- Effect of reactions on these measurements (abundance estimates, location of fish, …). What do we use these measurements for?
- Impacts of fish reactions on assessment models

Coordinators: Emma Jones and a fisheries biologist to be selected by E. Jones

Chapter 6: designing experimental to evaluate fish reactions

- Material/physical limitation and technical constraints
- Experimental design
- What to measure?
- How to measure it?

  How to calibrate behaviour?

  A list of possible experiments so far: AUV, buoys, towed body, intership, etc. PLUS the list of what has to be measured and how.
- Statistical requirements and limits including / from comparison of existing results (table?)

Coordinators: François Gerlotto and Erwan Josse

Chapter 7: Results / Recommendations

Table of thresholds and types of reactions

Coordinator: François Gerlotto

2 Resolutions for the next year

The SGFARV submitted to WGFAST the following recommendations for 2009:

The Study Group will work by correspondence on fish reactions to fisheries research vessels/platforms and meet in Ancona, Italy, 16–17 May 2009 to:

a) produce a review and develop recommendations for the ICES community on methods for the study of physical stimuli produced by fisheries research vessels (platform related stimuli - PRS) and evaluation of reactions by survey-targeted fish;

b) update the literature review on fish reactions and vessel produced stimuli;

c) design explicit experiments to further examine the causes of fish reactions to PRS;

d) review progress of the SG according to the time table below

e) review the draft of an ICES Cooperative Research Report on fish response to anthropogenic sounds that will be prepared during the year to be submitted to ICES in 2010.

Annex 1: List of participants

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Annex 2: SGFARV terms of reference for the next meeting

The **Study Group on Fish Avoidance to Research Vessels** [SGFARV] (Chair: Francois Gerlotto, France and Julia Parrish, USA) will meet in Ancona, Italy from 16–17 May 2009 to:

a) produce a review and develop recommendations for the ICES community on methods for the study of physical stimuli produced by fisheries research vessels (platform related stimuli - PRS) and evaluation of reactions by survey-targeted fish;

b) update the literature review on fish reactions and vessel produced stimuli;

c) design explicit experiments to further examine the causes of fish reactions to PRS;

d) review progress of the SG according to the time table below;

e) review the draft of an ICES Cooperative Research Report on fish response to anthropogenic sounds that will be prepared during the year to be submitted to ICES in 2010.

SGFARV will report by 22 May, 2009 to the attention of the Fisheries Technology Committee.

Supporting Information

Priority:	The current activities of this Group will lead ICES into issues related to the effect of noise reduction in research vessels on the fish behaviour. Consequently, these activities are considered to have a very high priority.
Scientific justification and relation to action plan:	Action Plan No: 1. Term of Reference a) Several countries are building or have recently built research vessels fulfilling the recommendations of CRR 209. So far the effect of these "silent" vessels to fish reaction is not completely documented and contradictory results have been published. A review of more recent work will define the the appropriate stimuli to measure and determine the need for experiments and measurements in order to produce sound recommendations for evaluating the effect of noise and related stimuli on abundance estimates. Term of Reference b) An important set of results and experiments, sometimes contradictory, have been published and a synthesis has to be done. It is important also to evaluate from the literature What are the main sources of stimuli a reseArch vessel is likely to produce. Term of reference c) some common measurement will be necessary to compare the effects of silent and noisy vessels, and between the new generation of silent vessels. Experiments will be designed in order to make these comparisons possible. Term of reference e) The result of the SG will be published in a cooperative Research Report. There is need to submit the draft of the CRR to the parent WG (WGFAST) during its annual meeting.
Resource requirements:	As the work will be done by e-mail and during the SGFARV meeting in 2009, no additional resource is required.
Participants:	The Group is normally attended by some 15-25 members and guests.
Secretariat facilities:	None.
Financial:	No financial implications.

Linkages to advisory committees:	At present, there are no obvious direct linkages with the advisory committees. In the near future some results on anthropogenic noise in the sea will be available to advisory committees for evaluating the level and effects of noise contamination in the ocean.
Linkages to other committees or groups:	There is a very close working relationship with all the groups of the Fisheries Technology Committee. It is also very relevant to the Working Group on Ecosystem Effects of Fisheries.
Linkages to other organizations:	The work of this group has implication on the construction of research vessels in the future.