

OGP JIP E&P Sound and Marine Life.

Summary of workshop: Methods and technologies for studies of fish behaviour.

This report is a summary of the workshop that was held at Thon Hotel Maritim, Stavanger Norway, April 19 – 20, 2009 as part of the OGP JIP Sound and Marine Life project on Fish Behaviour.

Associated with the report are the presentation slides presented at the workshop, and available as a separate file.

The list of participants is given in Appendix A, and the proposed agenda for the workshop is in Appendix B.

This report gives a brief outline of the presentation and discussion at the workshop. However, due to the complexity of the topic, no firm conclusions can be given. However, it is recommended that the JIP develop the outcome of the discussions further, for design of possible studies of fish behaviour as a reaction to E&P sounds.

Sunday, April 19, 2009

Opening remarks – *Nina-Elise Brevik Jacobsen.*

- Nina-Elise Brevik Jacobsen, StatoilHydro, opened the workshop with a 1-minute silence for Pat O'Brian, leader of the Project Support Group for Fish Behaviour, who died suddenly on Easter Weekend from a heart attack. Pat should have chaired the workshop, and his insight and dedication to the topic will certainly be missed during the days ahead.
- Nina welcomed the participants to Stavanger, and was especially happy that so many had been able to attend a Sunday / Monday meeting.

OGP JIP E&P Sound and Marine life overview – *John Young*

- John Young gave a short review of the OGP JIP on E&P Sound and Marine Life. He stated that even if the focus of the JIP was on Marine Mammals, two clear messages had risen over the years, namely “Don't forget the fish” and “Don't forget the turtles”.
- John pointed out that the new measurements of E&P sound sources will determine a broader frequency range than earlier measurements. This will be important for impact assessments of E&P Sound on Marine Life.

OGP JIP E&P Sound and Marine life objectives – Roger Gentry

- Roger Gentry pointed out that the objectives of the JIP are to address research that may reduce regulatory uncertainty by providing scientific data. Fishery problems – both biological and impact on commercial fishing – have been identified as important problems.
- The workshop will review past studies and learn what new things can be done.
- The Acoustical Society of America has a Working Group that is drafting fish noise exposure criteria, similar to the “Southall criteria” for marine mammals. Of the workshop participants, Tony Hawkins, Tom Carlson, Svein Løkkeborg and Roger Gentry are members of the Working Group.

Presentation of studies on Fish Behaviour.

Presentation FB1

Fish Behaviour and Sound Disturbance - Tom Carlson

- Stated that studies of fish behaviour are difficult – many species and many factors may influence the results.
- Best way to look at the problem is from a case study approach.
- Reviewed the project reported in 1992 by W.H. Pearson et. al. (also in Skalski et al):
 - The background for the study was a dispute between seismic surveys and fishermen in the St. Barbara channel. Rockfish fishermen contended that their livelihood was diminished when seismic surveys operated in the area.
 - A Panel was set up to perform a study and to give an answer to solve the dispute. Walt Pearson, an educator on fish behaviour, was leader of the panel.
 - The key to the fish problem is learning the “rules of behaviour” for fish, which can take decades
 - The fishermen in the area used vertical long lines.
 - Salmonids react to velocity of water flow more than the sound pressure.
 - Fish momentarily disturbed, such as C-start behaviour, is probably of minor consequence.
 - Fish do not habituate to C-start reactions, but habituation is observed from sound sources that cause avoidance. But avoidance is difficult to determine.
 - The study results were acceptable to both MMS and the fishermen. As a result some compensation was paid for loss of catches.
 - Studies are often missing the link between exposure and behaviour.
 - At received levels above 186 dB there was a loss of catch, and the fishermen were compensated
 - The study was accepted as a success
 - Hook and line and trap fisheries are easier to study than trawl
 - Time effects – we do not know. Duration was not persistent over weeks. Survey timing is important – not to coincide with peak fisheries.

Comment: Was video recording used in the study?

- Response:* No video recording was used, all observations were by human observers of the echo sounder equipment used.
- Comment:* How portable are the results to other locations and species?
- Response:* Results can be considered valid for rockfish, not necessarily valid for other species.
- Comment:* How can the results be transferred to science? Can the study techniques be used to determine CPUE?
- Response:* Since the variations – location and species – are so large it is difficult to make standard rules for interpretation of results.
- Comment:* It should be stressed that various species, locations and seasons will give specific results.

Presentation FB2

Scottish Studies - Tony Hawkins

- Reviewed the study “Effects of seismic air guns on marine fish, by Wardle et.al. (2001)
 - The study showed behavioural reactions – but how long these lasted or how significant they were is difficult to determine.
 - Previous studies had shown responses of pelagic whiting to an air gun. The fish dived in response to firing, but habituated over time.
 - Wardle used a telemetry system on cod, pollock and saithe, with spaced hydrophone receivers and pingers implanted into the stomach of the fish. The fish could then be positioned to an accuracy of a metre or so. Their movements were examined in detail before any air gun sounds were presented.
 - Time-lapse video recording was made of untagged gadoids, gobies, flatfish, and wrasse.
 - The airgun used in the Scottish study was the Triple-G gun
 - A significant behavioural reaction was shown when the research vessel arrived at the test location. the regular movements of the fish were disrupted.
 - The fish disappeared completely when a seal appeared at the location
 - Summary of the results:
 - Some fish showed a C-start reaction. This is an involuntary reaction – not necessarily leading to avoidance behaviour.
 - When the airguns were at the sea bed, the cloud of air bubbles made the fish react more severely.
 - The last two slides in the presentation were prepared during the discussions of the ASA group on noise criteria for fish. Dose response curves are difficult to prepare. Some behavioural reactions are more significant than others. Ideally the overt responses must be considered as input to a PCAD model.
- Comment:* The Wardle study showed how fish reacted when a survey started up – not necessarily what will happen in an open / deep water long-lasting survey

- Response:* The fish were specialized on feeding in the area – therefore they stayed
- Comment:* Easy to understand – fish reacted to the vessel coming in, but not necessarily to the airguns
- Response:* Vessel may well mask other sound used for detecting prey.
- Comment:* Do we have any indication on how much disruption to feeding can be tolerated?
- Response:* Would guess that for fish one week disruption is not serious.

Presentation FB3a

Acquatic telemetry at NINA, Norway - Bengt Finstad

- A short review of NINA (Norwegian Institute of Nature Research), Trondheim, Norway, and their projects in aquatic telemetry.
 - Showed that NINA has performed telemetry studies in many countries, in addition to several in Norway.
 - They have worked on several species of fish, but main work on Atlantic Salmonids.

Presentation FB3b

Synopsis of post-smolt migration studies in Norway - Bengt Finstad

- Presented results from telemetry studies in 3 Norwegian fiords, and showed how these studies could be used to monitor environmental impact factors.
 - Fish (hatchery-reared Atlantic salmon and wild anadromous brown trout) used in telemetry studies are often held in tanks before tag implant.
 - They are also kept in the tanks after implant to ensure that fish have recovered before release.
 - Most studies use VR2 receivers (Vemco), and the data is retrieved from fixed receivers.
 - Manual tracking can be done to follow individual fish. This is best done in fiords due to the limits on detection range.
 - The tags operate at a frequency of 69 kHz, and detection range varies from 200–400 m dependent on tags.
 - Fish may detect the signal from the tags – but they have not reacted.
 - Hatchery reared fish have different fins – even if body conditions are better
 - Not really difference in swimming speed between hatchery reared fish and wild ones
 - Fish are swimming twice as long as the net progression out of the fiord
 - Showed that some fish will travel considerable distance, but only to return back to the starting point.
 - Smolt that shows “abnormal behaviour” may have been eaten by larger fish.
 - “bl” used in some of the figures means “body length”.

Comment: How is depth recorded?

Response: Depth transducers can be part of the tag, and the information recorded by the receivers.

Comment: Is position of the fish determined by triangulation, which involves many problems?

Response: Position is only determined by tracking single fishes.

Comment: The accuracy of fish detection is dependent on the detector arrays. If better detection is required, then more receivers are needed.

Comment: If only 3 gram extra weight is added to the fish, then this may change the depth at which neutrally buoyancy is achieved.

Presentation FB4

Scaring effects in fish by offshore seismic explorations - John Dalen

- Presentations by IMR cover more than 20 years experience in studies of seismic surveys impact on fish and fisheries.
- They have also tested acoustic tagging to follow individual fish in the Barents Sea. 12 cod were tagged in 1976. After a week away from the release area, they could detect 5 of the fish on return to the area.
- The 1984-85 studies were the first studies to analyse fish behaviour on fishing and feeding grounds in relation to an ongoing seismic operation, as well as on direct damage on exposing younger life stages from eggs to fry (110 days) under controlled conditions. The studies were reported in 1985 (IMR reports) and 1987 (symposium).
- The 1984 studies are more complete, and reported in 1985 and 1987.
 - The fish distribution and acoustic fish abundance were mapped prior to and during the seismic operations.
 - The seismic vessel – Malene Østervold operated by Geco – used a super wide airgun array (4752 cu.in.).
 - The fishery research vessel produced too much noise for the seismic operation when working rather close to the seismic vessel to study fish behaviour by horizontal looking sonar.
 - There was a break in the seismic operation of 6 days. This was used to map the fish distribution following the seismic survey.
 - Pelagic fish moved out of the seismic operations area, and the abundance of demersal fish was also reduced. But some of the reduction may be caused by fish moving closer to the bottom and therefore not seen on the echo sounder

Comment: Vessels will scare fish. How did this impact the study?

Response: From related work on herring during winter, it was found that the fish move out ca. 100 m and go 20 – 30 m deeper when exposed to vessel noise.

Comment: Was the study done when there were commercial fisheries?

Response: June does not have significant fisheries in the area.

Comment: Water depth?

Response: Varied between 200 – 300 m.

Comment: Does the school get denser or does the fish move away?

Response: Both reactions are typical for schooling fish – here they moved away. The dominating species, blue whiting, does not generally school much. The echo sounder looks down with a 7.5 deg. beam and is therefore less suitable for tracking of schooling fish.

Comment: Need to look at the technology used. In a broad sense, the integration technique is using windowing and squaring to determine the echo strength of fish in the area.

Response: The fish echo integration technology and related applications for scientific use are well established and used in several countries around the world.

Presentation FB5

Effects of Seismic Air Gun Sound on Commercial Catch Rates - Svein Løkkeborg

- The presentation covered two studies performed in 1991 - 1992, and reported in 1993 and 1996:
 - Analysis of catch reports of cod, saithe and shrimps from 4 fishing areas offshore Norway in relation to nearby seismic surveys (Fisken og Havet no. 4, 1993, and ICS mar. Sci. Symp., 196, 1993).
 - A controlled experiment at Nordkappbanken offshore Norway (in the Barents Sea) studying catches of cod and haddock (Fisken og Havet no. 9, 1993 and Engås et al, Can. J. Fish. Aquat. Sci. **53**, 1996).
- The analysis of catch reports showed
 - Very low levels of cod by-catch in shrimp trawlers.
 - A three-fold increase of cod by-catch in saithe trawlers.
 - 55 – 80 % reduction of long line catches
- It should be noted that the seismic survey adjacent to the long line fishing vessels performed a site investigation (site-survey), where the seismic sound source was significantly smaller than what is normally used for exploration surveys.
- The controlled experiment showed reduction in both catch rates and measures of acoustic abundance during and after the seismic survey.
 - 70% reduction in cod and haddock trawl catches
 - 70 % reduction in haddock catches on long line
 - 45% reduction in cod catches on long line

Comment: How did other fishing vessels in the area impact the results?

Response: There had been a significant number of vessels fishing in the area before the start of the experiment, and the remaining vessels were asked to leave the area not to impact the results.

Comment: The statistical analyses are important in order to get full understanding of the results.

Comment: How did the fact that the fish were not feeding in the area impact the analysis?

Response: The observation was that there was more small cod than large, which may indicate that the large cod move faster. The combination of both trawl and long line should give a better estimate of the conditions in the area. "If you assume that fish stop feeding under the influence of seismic sounds, the trawls should still catch them".

Comment: Can sound stimulus cause non-feeding fish to move?

Comment: Fish are nomadic animals and will follow their evolutionary instincts.

Comment: Can changes in depth account for the reduction in acoustic abundance?

Comment: Several decades of experience from the area show that large fish move out from the coast after spawning during March - May, while smaller ones are "all over the place" most of the year.

Response: The results are only relevant for that area and that year.

A discussion of acoustic abundance measurements gave the following remarks:

- The scientific echo sounder uses a narrow beam, and may therefore not give an accurate representation of the total volume of fish in the area.
- The strength of the received sonar echo will vary, and therefore the results may be inaccurate.
- Various fishing gear work in different situations, and the limitations are not always taken into account.
- The survey design may influence the observed results.
- Trawling to evaluate fish species, size and condition are always done to support the acoustic abundance surveys.
- Fisheries management is always based on different techniques, and not just only one.

Comment: In the 1993 report there is day-by-day analyses of catch rates two days before and two days after start of the seismic survey. Is it possible to extend such an analysis to the full period?

Response: Yes, but the change in abundance happened so quickly that it was not necessary to perform the analysis.

Comment: The sound pressure from the seismic source at 18 nautical miles must be close to the ambient background noise?

Comment: The presented study should be seen as a pilot study, and as such it is fairly complete. Based on the experience from this survey it should be possible to make improvements in layout and data analysis.

Presentation FB6

Acoustic mapping of pelagic fish distribution and density in relation to a seismic exploration area off the Norwegian west coast - *John Dalen*

- The presentation covered a study at Ringhornet Dome in the Norwegian Sea in connection with a seismic survey performed by PGS in 1999.
- The study is published two times, in 2002 (symposium) and 2004 (Slotte et al., Fisheries Research 67, 2004).
- Important aspects of the survey are:
 - Concern that the seismic survey may impact the migration of post-spawning herring heading westward from the spawning areas at the Norwegian coast. The study involved herring, blue whiting, and mesopelagic fishes.
 - The migration directions and feeding areas of the herring was important for determining national quotas in the Norwegian Sea (for Norway related to herring abundance in the Norwegian Exclusive Economic Zone (EEZ)).
 - If the estimated herring abundance exceeded 225 000 tons in a defined area including Ringhorne Dome PGS had to delay their survey. The estimated abundance was found to be below that level.
 - Herring stock 1998 map showed an example of a typical abundance distribution.
 - The weather condition during the first part of the survey was bad.
 - There was not a clear conclusion that the seismic survey had an impact on total fish abundance
 - Statistical analysis may indicate some impact on fish distribution in Survey 1 & 2, not in Survey 3.

- Changes in depth of fish may resemble the findings of Chapman and Hawkins (1969).
- The survey does not indicate that the seismic survey has an immediate scaring effect on the fish in the study area.

Comment: If the study covered migrating fish, why would you expect to see a difference?

Response: Based on previous experience, some avoidance effects should be expected.

Comment: With the large breaks in the seismic survey, is there a pattern to the area distribution of the fish?

Response: Most of the herring is coming from the east. Echo abundance figures show all transects in each survey in relation to the location of the actual seismic lines.

Comment: Any time you have a process involving time the density may be misleading. When you are analysing a migratory process, then time can be very important. This should be considered for future studies.

General discussions

What did we learn from these studies?

- The subsequent discussion covered a number of issues, ranging from survey design parameters to the possible impact on commercial fisheries.
- With regards to survey design the participants highlighted the following criteria:
 - The study must have control of the seismic vessel, not just operate in the vicinity of a seismic survey as a study of opportunity.
 - There needs to be a good description of the background conditions, such as other vessel noises, fish activity (feeding, spawning, migrating etc.)
 - Measurement of the exposure signal rather than the signal at the source is very important.
 - Although it is possible to do some studies on fish behaviour in a fiord, it may be difficult to extrapolate the results to open waters.
 - Fish in cages may react very different from free-swimming fish, and therefore give rise to false interpretations.
- Cooperation with commercial fishermen is probably the largest problem for the industry.
 - Fish in different situations will react differently. Therefore it is difficult to make general rules for fish behaviour.
 - If fishermen feel that they are excluded from an area, they will focus on their own opinions and not necessarily listen to the scientists. It is their business that is most important to them.
 - Is there an answer to the questions: where, when and how can we do seismic operations and cooperate with fishermen?
 - Periods when no seismic operations are allowed may be one solution, as used in Norway. But lack of knowledge may in many areas make the selection of periods quite difficult.
 - Even if compensation to fishermen for loss of access to an area could be used in some cases, the participants did not find this to be a generally acceptable solution.
 - A fisherman's beliefs are often based on his own experience and those of other fishermen and not on science. Therefore the communication issue is extremely

important.

- A risk analysis approach should be adopted, allowing for a safe zone to be determined for each activity. We should distinguish between different categories of fish reaction, such as
 - Startle responses
 - Behavioural changes
 - Avoidance reactions

The overall significance of these reactions should be assessed in order to determine the impact that a given seismic survey may have on its surroundings.

- Regulator requirements are probably most important for studies on fish behaviour. This will be discussed tomorrow.
- The summary of the days presentations and discussion gave some valuable comments:
 - The fish ear consists of a system of accelerometers – not all fish detect sound pressure and those that do use particle acceleration to determine sound direction. Therefore the right measurements are important, i.e. measurements of the kinetic components of the sound. Seismic sources at the surface generate shear waves at the sea bottom. The impact of this on fish close to the seabed is a big unknown.
 - The presentations and discussions have been very interesting. To an oil company this has both medium and long-term interest. With operations in many parts of the world, and in very different conditions, we need to have information to give to both regulators and local fishermen. How can we operate and still protect nearby fish farms? What received decibel levels are acceptable for a safe zone?
 - The Norwegian fishermen claim an 18 nautical miles safe zone – what can we do to document a necessary distance better?
 - Somewhere something is wrong! Is it sound propagation, is it effect, or is it response in the fish. If we find the answers to the questions, future survey designs can be much better. These are important topics, and regulatory bodies have a role to play and should be involved with project planning.
 - Have discussed technical issues that must be solved. Secondly, it is important to have the answer in areas where the industry is working. Third is a regulator requirement – any study we plan should be referred to regulators for comments.
 - We need a multidisciplinary approach, and knowing airgun signal is important. Differences between fiords and for instance the Barents Sea may give valuable data
 - Fish behaviour can be studied in fiords or labs, but for the big issue one has to go out in the open waters and study commercial species.

End of day 1.

Monday, April 20, 2009

Presentation of studies on Regulator Requirements.

Presentation RR1

E&P Sound and Fish: Authorities' requirements as seen from the Norwegian Petroleum Directorate – Jan Stenløkk

- The situation in Norway has been very difficult in recent years, particular with regards to the NPD seismic surveys offshore Lofoten and Vesterålen. (2007 – 2009).
- The presentation gave an overview of the legislation in Norway, and the authorities involved in the permitting of seismic surveys. It was pointed out that the NPD could stop seismic activities.
- The requirement is that there should be cooperation between fishermen, fishermen's organisations and the oil industry. Focus is on seismic noise and its impact on commercial fisheries, especially on fish avoidance and related distance from the source
- The challenges in Norway are many, and the "hottest" are:
 - Increased use of the area at sea – area conflict between seismic operations and commercial fisheries.
 - If it takes even months before the fish return – what impact will this have on the oil industry operations?
 - The effective distance to fish interference is discussed and is the big issue.
 - Can modelling of sound propagation be one part of the answer?
- Better co-existence between oil industry and commercial fisheries is a key requirement from the government, but so far it has been difficult to get the parties to agree on a way forward.
- The NPD seismic survey in 2009 will be monitored by controlled fishing operations and acoustic abundance measurements performed by IMR. This study will be discussed later in the workshop.
- The 2008 impact study was limited to analysis of fishing vessels' logbooks and catch reports. A report is due in June 2009.

Comment: How much information can be derived from the 2007 / 2008 studies of catch reports and logbooks?

Response: The catch reports are not as proper as wanted and expected; therefore there are significant problems with the analysis. The main fisheries are on cod, mackerel, herring and saithe.

Comment: Reports from fishermen during 2008 was that the seismic scared away the food for saithe, i.e. herring and norway pout. Therefore question may be - should we study saithe catches or herring distributions?

Presentation RR2

Regulation of seismic surveys in Brazilian waters - Cristiano Vilar do

- Brazilian oil industry is quite recent. In 1997/98 the continental shelf was opened for international oil companies. Before then, Petrobras had a monopoly and acted as a self-regulator.

- Brazil has two main bodies for regulating the oil and gas industry:
 - ANP – handles bidding rounds like NPD or MMS
 - IBAMA – handles all environmental regulationsCompanies need licences from both organisations for seismic surveys.

- Seismic surveys are regulated in 3 classes, based on water depth in the survey area. Permitting for surveys in Class 1 – water depth less than 50 m - takes one year or more and involves public hearings, while permitting in Class 3 - deep waters – normally takes 2 months.

- Commercial fisheries in Brazil have characteristics that are important in the regulation of seismic surveys:
 - 50% of the fisheries are artisanal, and not as effective as in many other countries.
 - Even if there are organizations, most cases are influenced by local politics. This makes it very difficult.
 - Very low income. Basically subsistence fishing. One-week loss of access can mean a lot.
 - Many fishermen do not have radio, echo sounder or GPS.
 - Now starting to get better knowledge about fishing grounds.
 - Some artisan fishermen are now semi-industrial.
 - The conflict is asymmetrical, so IBAMA has to play a role.

- EIA for the seismic surveys must specifically address possible impact on fisheries. If basic data is not known, then the oil company must talk to local fishermen for info.
 - Companies use “mental maps” to find out where fishing occurs. But every time the grounds get bigger and bigger, for local fishermen have seen the possibility for compensation.
 - Social communication involves warning signs at ports where fishermen go out.
 - Fisheries professionals are not fishermen – but “academics” who know the local situation. Must speak Portuguese.
 - A seismic survey may have up to 4 support vessels.
 - The seismic boat has right of way
 - Some times the seismic crew help the fishermen to move gear and then put them back
 - Support vessels are normally small fishing vessels.
 - Today compensation for loss of fishing gear is not really a problem. The local seismic representative will handle this directly.

- Compensation to fishermen started in 2003, but the objectives are now changed.
 - Earlier compensation was directly to fishermen
 - Today, the scheme is based on participation and the objective is to help fishing communities get better organized and improve the infrastructure. This may have increased the cost of compensation, but the conflicts are much less.
 - IBAMA oversees the process but tries not to be part of the monetary discussion. The cost is agreed between the oil company and the local communities.

- No significant change in catch rate is ever detected. Youngsters in the communities keep records – they are often sons of fishermen.

Comment: So the scheme is paying for access, not really for damage.

Comment: Is the story over after the survey, or do fishermen complain later?

Response: Fishermen always complain. Therefore IBAMA is there to mediate the conflict. The current system has been in place for the last 2-3- years.

- A study was done in 2004 – just after a massive fish mortality in the area. A report (Universidade Federal Do Parana /GIA, June 2004, in English) concluded that seismic surveys cause no short-term mortality, but startle responses were observed when the seismic vessel was close to the fish cages (only the 5 nearest shots).

Comment: In shallow water and at relatively close range, particle velocity is probably more important than pressure.

- Petrobras is planning seismic surveys in 2010, and IBAMA is preparing new studies on impact of the surveys in marine life. International organizations are invited to participate in these studies.
- The main issue in Brazil is the use of space. There is agreement that seismic does not cause mortality, and the behavioural impact is contested. Fish may leave the fishing ground, but still be available for fishing even if the fishermen have to go farther for catches. So the case is really a socio-economic problem, and this is where IBAMA has a role as mediator. Based on previous experience they are now developing a new system for environmental considerations of licenses.

Comment: Is the question the mere presence of ships or the ship footprint. What about OBC?

Response: Even if the vessels have less footprint – in OBC the fishermen are kept outside the survey area

Comment: Is it possible for foreign researchers to participate in Brazilian studies.

Response: This should not be a problem, but they have to partner with local universities to ensure knowledge transfer.

Comment: IMR is already engaged in studies in Brazil in cooperation with local universities and an international oil company.

Presentation RR3

Brief overview of ESRF SEIFish Proposal - David Taylor

- Canada does not have compensation for loss of access. But there are schemes for loss of gear. A fundamental rule is that it is illegal for seismic operations to move or interfere with fishing gear.
- ESRF (Environmental Studies Research Funds) established in 1983 to have studies to support regulatory decisions
 - Funding based on lease acreage

- Board is directly responsible to two ministers. Money does not go into government funds but is kept separate within the Federal budgeting system but expenditures of funds are governed by same administrative rules as all Federal expenditures.
- East coast concerns are
 - o Seismic
 - o Sea birds
 - o Waste
 - o Air emissions
 - o Socio-economic
- Canada has rules for seismic operations with regards to marine mammals, but there are no specific rules with regard to fish.
 - The work authorization is the main regulation for oil company operations
 - EIA is required for every operation. In this, impact on fisheries should also be considered.
 - There is a requirement for fishery liaison representative on seismic vessels in addition to marine mammal observers.
 - In Newfoundland and Labrador - OneOcean is established as a forum for interaction between oil and fisheries (www.oneocean.ca). The organization is funded by the oil companies with support from government. In Nova Scotia the CNSOPB has a fisheries liaison committee that addresses fisheries matters.
 - A workshop in Halifax in 2000 outlined the first concept of studies on fish behaviour.
 - Lobster has gained importance as a commercial fishery after the cod collapse.
 - A study on seismic impact on lobster indicated a change in feeding post exposure to seismic sound energy (c.f. Payne, J.F., Andrews, C.A., Fancey, L.L., Cook, A.L., and Christian, J.R. 2007. Pilot study on the effect of seismic air gun noise on lobster (*Homarus americanus*). Can. Tech. Rep. Fish. Aquat. Sci. 2712: v + 46.)
- The SEIFish project was designed to answer “how far does the fish move”.
 - The initial project we budgeted at \$ 8 mill, using 731 receivers and up to 450 simultaneously tagged fish using tags with accelerometers.
 - Pilot study in 2007 showed 400 - 800 meter detection range. 25 – 33% of the fish in the test stayed within 10 km for 1 ½ month
 - Son of SEIFish has reduced number of receivers and tagged fish, and cost is brought down to between 1.7 and 2.2 mill. USD.
 - Project is currently cancelled. No new partners have been identified.
 - ESRF is still very interested in the problem, and will pursue new possibilities.

Comment: Does the SEIFISH study have to be done in Canada?

Response: There is no direct requirement for ESRF work to be done in Canada, but fishermen and regulators are asking for “local” information. If study is done in Norway then it would be regarded with interest and it would likely be asked – can you repeat this in Canada?

Comment: Has the study been out for Request for Proposals (RFP)?

Response: ERSF is working with local institutions. If a revised project is considered, then it may be broken up into sub-projects that can be RFP’ed.

Comment: A Request for Proposal may give new ideas that can improve the project.

Presentation RR4

Effects of Seismic Shooting on Longline and Gillnet Fisheries – Svein Løkkeborg.

- The IMR will study the effects on fisheries in relation to the NPD operated seismic survey offshore Lofoten and Vesterålen in 2009. Details of the survey are:
 - Two vessels using gillnets and two vessels using long lines will start fishing 10 – 12 days before the seismic survey starts, during the seismic survey and for 12 days(or more) after the seismic survey.
 - The main fisheries in the area are cod, haddock and saithe.
 - Seismic will last for 6 weeks
 - R/V Håkon Mosby will do acoustic abundance and fish distribution studies before start of seismic and for a total of 17 days.
 - Use acoustic “lander/buoy”; a split beam echo sounder that can be mounted to look up from the bottom or down from the surface. The Plankton lander echo sounder use a frequency of 200 kHz, and the Fish lander echo sounder has a frequency of 38 kHz.
 - Sound recording will be done with a number of sensors in the area.

Comment: Question is generally claimed, “Seismic will change the distribution of fish in a local area”. Acoustic measurements may give input to a “dose response for fish”. How could you determine a dose response? Do we have the tools? Can displacement after 2 days be compared with the one after 4 days? We need to standardize dose response for fish.

Comment: We often say seismic, but should be more specific such as 2D, 3D or site survey. In 3D defined area the vessel will work for 2 –3 weeks. 2D use longer lines and longer time between adjacent lines.

Response: The NPD project may give some indication about dose response, since there will be fishing during the full seismic survey.

Comment: Dose response measurements are dependent on the algorithm. A larger group should address this topic.

Comment: The use of landers/buoys may give important information at fixed points. These will give time as the main parameter.

Response: The survey will only use two landers – one upward looking and one looking downwards. In addition acoustic data will be recorded at the research vessel, and the acoustic data will be supported by trawl data. Spatial sampling may be a problem, but the trawl samples should yield additional data to give information about the fish species and fish distribution in the area.

If the Engås et al study had been performed today, longer periods before and after the seismic survey would be used. The use of control groups in such surveys are difficult, since the distance from the survey area must be so large that local variation may influence the results and make the control invalid.

Comment: The statistical design of the survey is very important. If a large area is to be investigated, then concentrating the work in a small area may give biased results. It is better to work in several subsets of the area for statistical analysis.

Comment: Calculation of dose responses may be difficult when the source is moving. Working the inverse – locating the vessel based on acoustic measurements – may give more information.

Response: In previous surveys acoustic measurements were taken by use of buoys at single points, the location of which was advised by statisticians. The same concept will be used this year.

Comment: Acoustic sound measurements at fixed points are cheap, and may give input to calculation of the dose response. But it is important to have a good control of the processing and analysis of the data.

Comment: Sound propagation can be modelled, but only with limitation, so actual measurements are preferred.

A discussion on how to measure dose response took place. In summary, there seemed to be agreement that a combination of acoustic measurements and catch data (e.g. CPUE) could be used to improve the analysis of the data. Ideally, several vessels should be available for acoustic measurements; however, if only one vessel can be used it should concentrate on subsections of the area rather than give a space sampling of the whole area.

Concluding discussion: What are the questions?

- There will be a different set of questions for different types of fish. A possible matrix of combinations of species, habitats and sensitivities was proposed by Tony Hawkins and is presented in Appendix C.
- The questions that were tabled during the discussion are the following:
 - Is it possible to categorise fish species into sensitivity groups?
 - Do fish move off the fishing ground during a seismic survey, and if so how can we assess this: where, how far and how long?
 - Is it possible to categorise the response into levels of reaction: possible long term behavioural effects and biological significance?
 - What are the reactions from the individual “resident” fish and “migrating” fish?
 - What is the change in the ability to catch the fish for individual fishermen and/or the fleet?
 - Is it possible to predict the responses?
 - Define scenarios; moving away, swim closer to the seabed, denser shoals.
 - What is the effect of shallow water seismic on spawning migration, migration area?
 - Why do we want to know?
 - How do we inform regulators?
 - How do we answer the question: How far and for how long time do reactions take place?
 - How do we do baseline studies?
 - What is the value of acoustic mapping before, during and after a seismic survey?
 - Shallow bank study of pelagic fish, complete acoustic mapping and fishing before and after introducing to seismic. Look into not only distribution but also availability for catching.
- The discussion about fishermen’s concern highlighted the following points:
 - We need to focus on projects that address the fishermen’s concerns and those that can improve their cooperation with the oil industry.
 - The behavioural impact of seismic surveys is seems to guide the fish in a direction that is most unfavourable to the fishermen. Can we learn more about the directional reactions of fish in relation to seismic sounds?
 - Concerns were raised over impacts during spawning periods. However, this may not be a real problem because regulators can ensure that seismic surveys are not allowed in sensitive areas and periods.

- It was pointed out that fish in spawning areas may be less sensitive to sound impact, but they are not without sensitivity.
 - The most important issue is the relationship with fishermen. They are not always concerned with science; therefore CPUE is a critical factor.
 - Studies should be designed on a scientific basis, but when we have the results it is important to communicate these in terms and language that fishermen understand.
- The discussion about regulator's concern highlighted the following points:
 - Some regulators have stated that they are not concerned if the fish move 2 km away from a seismic survey, but they are concerned over 22 km. And how long does it take before fishing returns to normal?
 - The Skalski et. al. 1992 study is a good basis for analysis of impact. But can we extrapolate the results to other species in other areas?

Concluding discussion: What can the JIP do in the near future?

- The possibility of cooperation with the NPD in their analysis of impact from the seismic surveys offshore Lofoten and Vesterålen was discussed extensively. It was concluded that it is too late for any extension of the work in 2009, but there will possibly be further seismic surveys in 2010, and then further studies may be possible.
- If more studies are considered, it is important to use proper geostatistical models for the fieldwork and data analysis. Planning of a 2010 survey should start as soon as possible in order to take all parameters into account.
- The use of control groups in open water studies may present significant problems, due to the necessary distance from the actual survey area and the quickly changing environmental conditions. "A control, if poorly done, does not add value. It may even make things worse".
- John Dalen, IMR, presented some project ideas that they had developed for the coming years. The list is given in Appendix D.

Concluding summary from the workshop participants:

- Very helpful event. We have a real problem in coming up with a scheme that can be useful, but need to work with the regulator issue and better cooperation with fisheries.
- Participation in the workshop has been very interesting, and I need time to digest a lot of useful info. It has contributed to our internal discussions, and look forward to possible future partnership in studies of fish behaviour.
- Very interesting info from the workshop that will be useful in daily work. The review of projects useful, and look forward to the results of this years NPD survey.
- Interesting workshop. Look forward to further developments of the new statistical approach that was suggested during the discussion.

- The background information is very important, and should be a key factor in new surveys. Impact on common fisheries may be significant.
- There may be interest in 2010 with NPD support. It is possible to plug in models and estimate reactions
- Telemetry techniques may often come as an increase in budgets. But often the alternatives are really more expensive. Use of telemetry can give valuable information in studies of fish behaviour.
- After the workshop in Halifax 2005 we have followed the JIP and noted that there has not been any effort on fish behaviour. Very happy that this is now in the plans, and look forward to possible project in 2010.
- Good discussion and apparent similar problems to our own. The perspective on previous studies important.
- It was especially interesting to review studies. Communication with fishermen more important.
- Appreciate time for discussion of this year's survey. But the major concern is continuity. Since Engås et. al. not much has happened, and there is a need for more gradual work.
- Learned a lot. We should give more considerations of testing with fish in cages. Also, the reports of regulator issues were very valuable, for the North Sea rules are now applied worldwide. Reef problems should be considered, for it is relevant for many seismic operations. Alternative sources will also be interesting. The use of telemetry was a new discovery.
- The workshop was challenging and important. Thanks to the participants for helping to find the way forward. Also thanks to the regulators. Ideas of grouping concepts may be a way forward
- A very good workshop – and thanks to all for being here on a Sunday.

At the end Roger Gentry informed that the next “Nyborg meeting” will be in Cork, Ireland in August 2010.

Appendix A: List of participants:

FISH BEHAVIOUR WORKSHOP - E&P SOUND AND MARINE LIFE
STAVANGER, 19th & 20th April 2009

List of Participants

Attendance List

Name	Company	Email address
John Young	ExxonMobil, Chairman	john.v.young@exxonmobil.com
Rodger Melton	ExxonMobil	rodger.melton@exxonmobil.com
Cristiano Vilardo Nunes Guimaraes	Invited Guest	Cristiano.Guimaraes@ibama.gov.br
Tom Carlson	Invited Guest	probiosound@gmail.com
John Dalen	Invited Guest	john.dalen@imr.no
Bengt Finstad	Invited Guest	Bengt.Finstad@nina.no
Tony Hawkins	Invited Guest	a.hawkins@btconnect.com
Dagfinn Lilleng	Invited Guest	Dagfinn.Lilleng@fiskeridir.no
Svein Løkkeborg	Invited Guest	svein.loekkeborg@imr.no
Finn Økland	Invited Guest	Finn.Okland@nina.no
Jan Stenløkk (Monday only)	Invited Guest	Jan.Stenlokk@npd.no
David Taylor	Invited Guest	dtaylor@nflid.com
Nina Elise-Jacobsen	StatoilHydro	nebj@statoilhydro.com
Lars Petter Myhre	StatoilHydro	lmyh@statoilhydro.com
Jürgen Weissenberger	StatoilHydro	JURW@statoilhydro.com
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Claude Artzt	Total	Claude.ARTZT@total.com
Roger Gentry	OGP	roger.gentry@ogp.org.uk

Appendix B: Planned workshop agenda:

OGP JIP E&P Sound and Marine Life.

Methods and technologies for studies of fish behaviour.

to be held at Thon Hotel Maritim, Stavanger Norway
April 19 – 20, 2009

Workshop agenda:

Sunday, April 19, 2009:

- | | | |
|-------|---|---------------------------------|
| 09:00 | Opening, safety moment and introduction of participants | Nina Jacobsen |
| 09:10 | Review of the OGP JIP on E&P Sound and Marine Life | John Young |
| 09:15 | Objectives for the meeting, and planning of deliverables | Roger Gentry |
| 09:30 | Presentations of earlier studies on fish behaviour: | |
| | - Studies in US | Tom Carlson |
| | - Studies at FRS Marine Laboratory, Scotland | Tony Hawkins |
| 10:30 | <i>Break</i> | |
| 10:45 | Presentations continue | |
| | - Studies at NINA, Norway | Bengt Finstad |
| | - Studies at IMR, Norway | John Dalen /
Svein Løkkeborg |
| 12:15 | <i>Lunch</i> | |
| 13:30 | Discussion of earlier studies, with emphasis on: | All |
| | - Which kinds of behaviour should we be looking at? | |
| | - What changes in behaviour are we looking for? | |
| | - Which kinds of behavioural reactions are likely to have most significance? | |
| | - What implications would the changes in behaviour have for fish populations? | |
| | - What significance does this have for the fishing industry? | |
| 14:30 | <i>Break</i> | |
| 15:00 | Discussion continue | |
| 16:30 | Summary of Day 1 | |
| 17:00 | Closure | |

Monday, April 20, 2009:

08:30 Opening and safety moment

08:45 Introduction by regulators with respect to their concerns over E&P Sound and fish and discussion of regulators requirements.

- Norway Jan Stenløkk
- Brazil Christiano Guimaraes
- Canada David Taylor

10:30 *Break*

11:00
different methods of study;
their advantages and their limitations

Consideration of
All

- Sonar studies
- Tagging studies
- TV observations
- Changes in catches
- Physiological changes

12:15 *Lunch*

13:00 Discussion on future priorities: All

- Which species categories are most important in terms of possible impact?
- Are there any species whose behaviour is especially amenable to study?
- Are there any geographical locations especially suitable for observations and experiments?
- Are there any improvements to technology required?

14:30 *Break*

15:00 Outline of documentation from the workshop / scope for possible “white paper” on fish behaviour

16:30 Summary and Conclusion

17:00 Closure

The agenda should be very flexible, but the participants should ensure that the key topics of the meeting are discussed thoroughly and that the final documentation can be used as a guide for future studies

Appendix C: Matrix of important fish species and sensitivities to E&P sound (proposed by Tony Hawkins as a basis for further discussion):

TYPE OF FISH						
Fish with gas bladder connected to ear		Herring Sprat Shad	Weakfish Deep-sea-cod	Squirrel-fish	Catfish Carp Goldfish	Dace Minnow
Fish with gas bladder close to ear			Cod Haddock Saithe	Red Snapper		
Fish with gas bladder distant from ear	Dorado	Horse Mackerel	Spot	Wrasse	Sand-smelt	Salmon Eel
Fish with no gas bladder	Sharks	Mackerel	Plaice Sole		Flounder	
Fish eggs & larvae	Dorado larvae	Herring larvae	Cod larvae	Red Snapper larvae	Catfish larvae	Salmon eggs
HABITAT	Large Pelagic	Small Pelagic	Demersal	Reef	Shallow/ Estuary	In River

Appendix D: John Dalen's list of project ideas for 2009:

NORWAY: SOME PROJECT "PROPOSALS / IDEAS" - by 2009

Titles

Influence from seismic activities on fish in concentrated spawning migrations and on the spawning fields

Scaring effects in pelagic fish from seismic activities

Scaring effects in fish species without swim bladder

Impacts from seismic activities on behavior and catch rates of sand eel

Impacts from seismic activities on behavior and catch rates of selected demersal fish species

Regeneration and weakening of spawning processes at the spawning fields

For how long time does the effects of behavior alterations last?

Sound masking in fish and disturbances of sound communication and navigation from seismic activities

Impacts from seismic activities on survival and behavior of important zooplankton species

John Dalen/20 April 2009