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Agenda Item 5.1.: **Bycatch Issues.**
Other research related to by-catch

EPIC - Elimination of Harbour Porpoise Incidental Catches
Project no. DG XIV 97/0006. Final Report for the period 1 June 1998 - 31 July 2000

Submitted by: **Denmark**

ASCOBANS

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EPIC – Elimination of Harbour Porpoise Incidental Catches

Project no DG XIV 97/0006

FINAL REPORT

For the period 1 June 1998 –31 July 2000

A summary document for ASCOBANS, 2-5 April 2001

prepared by
[1]Christina Lockyer, [2]Mats Amundin, [3]Genevieve Desportes and [4]Dave Goodson

[1] **Danish Institute for Fisheries Research, Charlottenlund, Denmark**
[2] **Kolmårdens Djurpark, Kolmården, Sweden**
[3] **Fjord and Belt Centre, Kerteminde, Denmark**
[4] **Loughborough University, Loughborogh, United Kingdom**

PROJECT DESCRIPTION

1. OBJECTIVES

To eliminate by-catches of harbour porpoises in set gillnets, by a logical sequential integration of:
1) recording and analysing behaviour of harbour porpoises in controlled (enclosed) conditions, in relation to foraging, reaction to obstacles presented and acoustic stimuli;
2) recording and analysing behaviour of harbour porpoises in semi-controlled conditions in the wild, in terms of reaction to acoustic stimuli and other potential deterrent devices;
3) technical improvement of deterrent devices, signal processing, relevant analysis and engineering on the basis of new data and current research;
4) providing a report of by-catch rate for the harbour porpoise population(s) at risk in set gillnet fisheries in Danish waters through monitoring schemes, and of population structure and diet through biological sampling of by-catches;
5) a results database and bibliography of by-catch publications for dissemination via internet or on CD-ROM.

2. DESCRIPTION OF WORK (as approved for funding)

Task 1 Investigate porpoise foraging behaviour
Objective 1
Sub-task 1.1 Study acoustic behaviour relating to porpoise foraging i.e. fish detection, interception and capture and compare with dolphin echo-location behaviour

Task 2 Investigate porpoise behavioural response to deterrent stimuli
Objectives 1, 2
Sub-task 2.1 Investigate deterrent sound characteristics that induce an avoidance response in harbour porpoises, e.g. spectral characteristics, waveform, pulse duration, intensity, repetition rate, etc.
Sub-task 2.2 Investigate how porpoises respond to an interactive type deterrent (an acoustically-triggered deterrent) in the presence of fish prey
Sub-task 2.3 Test masking porpoise sonar echoes in order to create "no-foraging" zones.
Sub-task 2.4 Investigate the distance at which an acoustic deterrent may be effective.

Task 3 Develop efficient deterrents
Objective 3
Sub-task 3.1 Develop electro-acoustically efficient, ecologically acceptable, long-life, "interactive" and "beacon mode" active acoustic devices. Explore other, cost effective porpoise deterrents for application in bottom set gillnet fisheries.

Task 7 Porpoise by-catch monitoring and biological sampling
Objective 4
Sub-task 7.1 Estimation of by-catch rates in the Danish fishery.
Sub-task 7.2 Collect and analyse biological samples, and data from porpoise by-catches in Danish fisheries.
Sub-task 7.3 Establish a database on by-catch data.

Task 8 Dissemination of information on cetacean by-catch mitigation research
Objective 5
Sub-task 8.1 Prepare a database of publications relating to cetacean by-catch mitigation research and set up an electronic access to this information via internet or CD-ROM.
Sub-task 8.2 Prepare multi-lingual material for the fishing industry (video or multimedia material) that can illustrate the best methods of mitigation to apply in specific fisheries.
Sub-task 8.3 Evaluate and report the feedback received from the fishing industry during this project as to the acceptability of the mitigation methods proposed.

Researchers and co-workers responsible for Tasks and Sub-tasks:

Task 1:
Genevieve Desportes, Fjord and Belt Centre
Sub-task 1.1:
- **Genevieve Desportes, Fjord and Belt Centre**
- Mats Amundin, Kolmårdens Djurpark
- Dave Goodson, Loughborough University

Task 2:
Mats Amundin, Kolmårdens Djurpark
Sub-task 2.1:
- **Mats Amundin, Kolmårdens Djurpark**
- Genevieve Desportes, Fjord and Belt Centre
- Dave Goodson, Loughborough University
- Jonas Teilmann, University of Southern Denmark

Sub-task 2.2:
- **Mats Amundin, Kolmårdens Djurpark**
- Genevieve Desportes, Fjord and Belt Centre
- Dave Goodson, Loughborough University

Sub-task 2.3:
- **Mats Amundin, Kolmårdens Djurpark**
- Genevieve Desportes, Fjord and Belt Centre
- Dave Goodson, Loughborough University

Sub-task 2.4:
- **Finn Larsen, Danish Institute for Fisheries Research**
- Nette Levermann, University of Copenhagen
- Morten Madsen, University of Copenhagen
- Genevieve Desportes, Fjord and Belt Centre
- Dave Goodson, Loughborough University

Task 3:
Dave Goodson, Loughborough University
Sub-task 3.1:
- **Dave Goodson, Loughborough University**
- Finn Larsen, Danish Institute for Fisheries Research

Task 7:
Christina Lockyer, Danish Institute for Fisheries Research
Sub-task 7.1:
- **Christina Lockyer, Danish Institute for Fisheries Research**
- Genevieve Desportes, Fjord and Belt Centre
- Heidi Andreasen, Danish Institute for Fisheries Research

Sub-task 7.2:
- **Christina Lockyer, Danish Institute for Fisheries Research**
- Genevieve Desportes, Fjord and Belt Centre
- Heidi Andreasen, Danish Institute for Fisheries Research
- Steven Benjamins, Danish Institute for Fisheries Research

Sub-task 7.3:

Christina Lockyer, Danish Institute for Fisheries Research
Heidi Andreasen, Danish Institute for Fisheries Research
Steven Benjamins, Danish Institute for Fisheries Research
Genevieve Desportes, Fjord and Belt Centre

Task 8:
Christina Lockyer, Danish Institute for Fisheries Research

Sub-task 8.1:

Christina Lockyer, Danish Institute for Fisheries Research
Jette Jensen, *formerly of* Danish Institute for Fisheries Research
Steven Benjamins, Danish Institute for Fisheries Research
Heidi Andreasen, Danish Institute for Fisheries Research
Mats Amundin, Kolmårdens Djurpark
Genevieve Desportes, Fjord and Belt Centre
Dave Goodson, Loughborough University

Sub-task 8.2:

Christina Lockyer, Danish Institute for Fisheries Research
Mats Amundin, Kolmårdens Djurpark
Genevieve Desportes, Fjord and Belt Centre
Dave Goodson, Loughborough University
Finn Larsen, Danish Institute for Fisheries Research
Steven Benjamins, Danish Institute for Fisheries Research
Heidi Andreasen, Danish Institute for Fisheries Research

Sub-task 8.3:

Christina Lockyer, Danish Institute for Fisheries Research
Finn Larsen, Danish Institute for Fisheries Research
Dave Goodson, Loughborough University

EXECUTIVE SUMMARY

- The project addresses methods for mitigation of bycatches of harbour porpoises in bottom-set gillnets, and is called EPIC - Elimination of Porpoise Incidental Catches.
- The area of study has focussed on the North Sea and Inner Danish waters. Nevertheless, results should be applicable to other areas and different situations.
- The objective of the project is to eliminate by-catches of harbour porpoises in set gillnets, by a logical sequential integration of:
    1) recording and analysing behaviour of harbour porpoises in controlled (enclosed) conditions, in relation to foraging, reaction to obstacles presented and acoustic stimuli;
    2) recording and analysing behaviour of harbour porpoises in semi-controlled conditions in the wild, in terms of reaction to acoustic stimuli and other potential deterrent devices;
    3) technical improvement of deterrent devices, signal processing, relevant analysis and engineering on the basis of new data and current research;
    4) providing a report of by-catch rate for the harbour porpoise population(s) at risk in set gillnet fisheries in Danish waters through monitoring schemes, and of population structure and diet through biological sampling of by-catches;
    5) a results database and bibliography of by-catch publications for dissemination via internet or on CD-ROM.
- The period of study has been June 1998 - May 2000 inclusive, but has actually included data from the period 1995 - May 2000 inclusive, and experimental fieldwork and study from June 1998 through July 2000.
- The project, lead by the Danish Institute for Fisheries Research (DFU), has included partners: the Fjord and Belt Centre (FBC), Denmark, Kolmårdens Djurpark (KD), Sweden and Loughborough University (LU), UK, and has also benefited directly from help and input by the University of Southern Denmark (USD), the Zoological Museum, University of Copenhagen, and Alpha Film Production, Denmark.
- The original project included study aspects to be conducted in both captivity and the wild, followed up by field trials. Due to budgetary constraints, the final approved EU-funded project has focussed on captive studies at FBC, with opportunistic study in the coastal waters of Denmark.
- Results from the captive work have been very positive and encouraging, but nevertheless, the next step must be field trials.
- EPIC has built on experiments from BYCARE (EU FAIR contract CT05-0523) which from the harbour porpoise perspective, focussed primarily on by-catch rate estimation, fisheries implicated in by-catches, essential porpoise biology, population parameters and population structure, and (in the case of Denmark) an extensive field trial in the Danish cod bottom-set gillnet fishery in September - October 1997 testing the efficacy of acoustic deterrents ("pingers") in reducing by-catches. In EPIC, the primary goals have been to explore in more depth the basic foraging and acoustic behaviours of porpoises in order to better understand why "pingers" <u>are</u> effective, and where, when and how porpoises feed, so that by-catch mitigation can be improved. The research has gone hand in hand with technological improvements on "pinger" design, incorporating and applying new knowledge on porpoises.
- Captive work has been undertaken at FBC where the holding pool is a semi-natural enclosure ultimately separated from the adjacent fjord in Kerteminde only by nets at opposite ends. This has provided both advantages and disadvantages. The former offer near-natural habitat with exposure of the porpoises to tide, natural seawater, climate, local fauna and flora and environmental noise and activities e.g. fishing boats. The latter have centred mainly on problems associated with inclement and unpredictable weather conditions (as normally experienced in the

field) which frequently limit the research, but also must include problems with water visibility and difficulties in viewing all parts of the enclosure. Nevertheless, FBC has proved to be an excellent environment for the study, with laboratory and animal training facilities for conducting all experiments on site.

- During the EPIC experimental periods, two porpoises were available, a male, Eigil, and a female, Freja. Both were in early maturity and aged ca 3 yr initially. During the experimental period, a third porpoise, a female, Nuka, was acquired. She was a juvenile of less than a year when she joined the other animals. Unfortunately she died later in February 2000, less than one year after acquisition, from an infection.
- The foraging studies (Task 1) have shown clearly that a significant component of feeding behaviour is the head-down vertical feeding on the seabed - "bottom-grubbing", especially in the young. Observations showed that preoccupation with bottom-grubbing and catching prey made at least one of the animals insensitive to surrounding threats, indicating that bottom entanglement in nets would be very likely unless the animal was alerted to the threat.
- The studies also indicated that whilst echo-location was important in foraging, sight was probably also important although this could not be tested directly within the timeframe available. However, the porpoises were sometimes observed to "miss" fish situated almost directly below them when echo-locating, if the fish was laying on a stone. The porpoise may be unable to distinguish between certain fish and background if echoes from the former are weak compared to the background.
- Examination of stomachs of by-caught and stranded porpoises in the North Sea and Inner Danish waters corroborated the likelihood of bottom-feeding, from the high incidence of bottom-dwelling prey species (Sub-task 7.2).
- It was concluded that passive means of enhancing the acoustic (or even visual) reflectivity of nets would not alone be sufficient to prevent entanglement, as the porpoises did not regularly echo-locate ahead: and, even when they were aware of obstacles in the environment, they did not necessarily pay attention to them while busy hunting prey.
- The results reaffirmed our belief that, for the present, porpoises must be exposed to an acoustic alerting device to make them interrupt their activity and be made aware of the environment. This can have the consequence of encouraging them to explore the environment by echo-locating ahead (as in trial use of interactive "pingers" - Sub-task 2.2) or by beacon-mode acoustic deterrents that may simply encourage the porpoises to leave the area away from the sound source (Sub-task 2.1).
- We conclude that passive enhancement of net "visibility" acoustically may be useful only when backed up by and armed with acoustic alerting devices.
- The beacon-mode acoustic deterrents (based on LU's PICE99™ - AQUAmark100™) with multi-signal random emissions (11 different sounds) proved to be significantly effective - even after persistent exposure over time, thus indicating no compelling evidence for habituation.
- The physiological monitoring of the female porpoise using a dorsal fin pack fitted with electrodes and capable of recording swimming speed, dive depth and heart rate, indicated heart rate changes (a stress indicator) during "pinger" test phases, and all animals moved away from the sound source during test phases.
- However, post-test recovery was always very rapid, indicating that once the source of stress (sound emission) was removed, the porpoises resumed former activities. This has important implications in the field, where porpoises could be expected to move back into areas once "pingered" fishery operations had finished.
- Five sound types in all were tested: 1) square wave sweep (squeep), 2) square wave tone, 3) chirp - all broad band in the range 20-160 kHz depending on the signal type, and 4) dolphin-like (centred at 70 kHz) and 5) porpoise-like clicks (centred at 140 kHz). The most aversive were all

non-click sounds, and chirps elicited stronger physiological reactions in the female (carrying the dorsal fin pack fitted with electrodes and capable of recording swimming speed, dive depth and heart rate).

- Diminishing the duration (256 msec., 128 msec. to 64 msec.) of the signal emission had no significant diminishing of the aversiveness of the "pinger", so that this factor could be exploited to prolong battery life in pinger manufacture and to increase the variety of signals.
- In the captive situation it was not possible to see how far the porpoises could be displaced from the deterrent sound source because of the limits of the enclosure, although field experiments using pound-nets off the coast offered a chance to investigate this. The deterrent sound was emitted at decreasing distances from the pound-net where two porpoises swam freely, starting at ca 600 m distance (previously reported as the possible limit of effectiveness of PICE™ - Goodson *et al.,* 1997a) down to 148 m. (Sub-task 2.4). The porpoises moved to the side of the net furthest from the sound source at all times suggesting aversion, except during exposure at 148 m. The reason for this latter result is unclear, but could be confusion / panic of the animals in trying to locate an exit. The respiratory rate increased slightly - consistent with stress, but not significantly, as the distance from the sound source was reduced. The results did not contradict the previously reported findings that pingers may be effective from 125 - 130 m and even up to 600 m. Presently "pingers" are placed at up to 200 m centres on nets, but this could possibly be increased. More experimental fieldwork is required on this important aspect of "pinger" deployment, and we have no new recommendations.
- The interactive "pinger" where the porpoises themselves triggered the device acoustically, indicated a very promising method of acoustic deterrent deployment that could minimise general acoustic emissions from "pingers" into the environment, and further delay possible habituation, although only limited testing was possible. The porpoises responded very cautiously to the powerful "echo" returned from the transducer, and kept away from it during the test period. The recovery was slower than with the beacon-mode "pinger", but was still rather quick. They refrained from investigating the transducer at close distance with their sonar, as they did when the beacon-mode was used. Preliminary tests with 70 kHz dolphin like click trains were done, in order to study the possibility to entice the porpoises to investigate the transducer with their sonar. This is a necessity for the concept to be effective. Further tests are required to evaluate this aspect.
- A further very limited trial (because of inclement weather) was carried out of a different use of sound designed to mask the echo-location frequencies (100-150 kHz range) that would inhibit foraging, creating an "acoustic fog". The sound was a band-passed white noise. During test noise exposure, the porpoises tended to stop bottom-grubbing and move away. Recovery afterwards was rapid.
- This method could be very effective by creating temporary "exclusion zones" while fishing operations were taking place. The system however, requires heavy-duty continuous power supply - unsuited to long nets and long soak times, and could only be suitable for discrete operations e.g. wreck sites, or in other fishery operations e.g. trawling where the ship would be able to continuously supply power. This method definitely merits future investigation but even so, is not yet ready for field trial as more technological design is required.
- One obvious possible flaw in these methods could arise as the result of failure of a sound source in a string so that an apparently safe corridor would open up for the porpoises, but in reality increase the risk of entanglement. However, until we know the effective distance required between devices allowing for failure, this event could jeopardise any by-catch mitigation system relying on acoustic emissions.
- The acoustic deterrent "pinger" design currently incorporating input from EPIC is theAQUAmark100™ (Task 3, ANNEX 1) with the full specification:

Frequency	A variety of complex broad band chirps between 20kHz and 80kHz with harmonics extending to 160 kHz.
Signal Strength	Peaks at 145dB re 1µPa @ 1m, typical. Remains constant over lifetime.
Signal Duration	300ms typical
Signal Interval	Pseudo-random between 5 and 30s typical
Dimensions	140 mm (5.5 inches) long x 56 mm (2.2 inches) maximum diameter
Weight in water	110 g (4 oz)
Attachment	Single point attachment through mounting hole, or by placement in bait bags, or similar
Spacing	200 m maximum recommended
Maximum depth	200 m
Shelf life	4 years (battery manufacturer's recommendation)
Battery life	1 to 2 years with continuous immersion, dependent on temperature. Up to 4 years in typical fishery with seasonal or discontinuous deployment as devices switch off when not in water.

This also incorporates advice and feedback from industry on practical useage (Task 8.3).

- The continued monitoring of porpoise by-catch onboard the Danish gillnet fleet (Sub-task 7.1) has not produced new information since Vinther's (1999) estimate of 6,785 (c.v. 0.12) per year in the Danish North Sea fleet, because of changes in discards observer deployment. Results however, confirm that porpoise by-catch is not a significant product of the flatfish gillnet operations.
- The "drop-out" / loss rate of porpoises from gillnets during hauling is estimated at 5-12 % in the Danish fleet but could be far higher as elsewhere, in which case by-catch estimates could be under-estimated. It is likely that "drop-out" rates will not be accurately determined unless dedicated cetacean by-catch observers are placed on vessels, at least for a set period.
- By-catch recovery, augmented by strandings recovered in Danish waters, has enabled a continued updating of the biological database first started under BYCARE. This database (Sub-task 7.3) now holds 1966 records, from between 1834 and 2000, with full biological information, including digital photographs in most cases, from dissections of porpoises between 1996-2000 inclusive.
- Biological investigations (Sub-task 7.2) reaffirm that it is the young juveniles that are predominantly the victims of by-catches - mainly in the first / second year, perhaps after separation from the mother after weaning.
- Age studies (sub-task 7.2) reveal that potential life-span may be ca 24 yr, and that the female can remain fecund all through life with a potential for calf production annually. However, life expectancy mostly does not exceed 10 yr.
- A disturbing but as yet unexplained persistence in sex-ratio imbalance has been found with up to 1.5 males : 1 female. This exists in both by-catches and strandings. A segregation by area and / or time is suggested but not verified.
- Porpoise stomach analyses reveal a catholic diet, with some differences between areas, but bottom-dwelling prey species comprise a significant part of the diet in all areas (Sub-task 7.2).
- A reference database on publications and other literature on marine mammal by-catch-related and harbour porpoise topics has been established on PAPYRUS version 7 (D.Goldman, Research Software Design, USA), a DOS-based library software system (Sub-task 8.1). On this subject alone (ANNEX 2), there are currently 1383 references. Hard copies of at least a third are located at DFU. Abstracts, where feasible, are also included on the database along with sources to obtain unpublished literature where possible. Earlier versions have already been made available to other international organisations e.g. IWC, NAMMCO, and will be made available to ASCOBANS and others requiring it, including other EU-funded projects.

- A film of ca 21 min. duration, designed as an instructional video (in English and Danish - eventually also Swedish) has been compiled (Sub-task 8.2) showing the current international agreements and legislation concerning cetacean by-catches, the problems besetting the fisheries, the current scale of by-catch, research supporting adopted mitigation measures, and practical implementation of mitigation measures and future prospects. Copies of the film have been distributed to the competent authorities in Denmark, UK and Sweden, as well as Belgium and the Netherlands, and have been presented to the ASCOBANS 3rd Meeting of Parties, held in Bristol, UK, July 2000. Copies of the film have also been given to the Danish Fisheries Association immediately prior to the implementation of the Danish regulations regarding use of "pingers" in gillnet operations on wrecks 1st August - 31st October 2000. Requests for copies of the film have been made by many organisations and institutions.
- Continuous feedback - both formal and informal between scientists, fishermen and governmental authorities at national and international levels, has taken place (Task 3 and Sub-task 8.3) enabling the improvement of the "pinger" design and its attachment in different national fisheries.