Fitting observed fish trajectories to cathcability models

Nils Olav Handegard

Outline

- Introduction
  - Assessment of North East Atlantic Cod
  - Fish behaviour and sampling
- Methods and materials
  - Observing fish behaviour
  - Modelling fish trajectories
- Results
- Discussion

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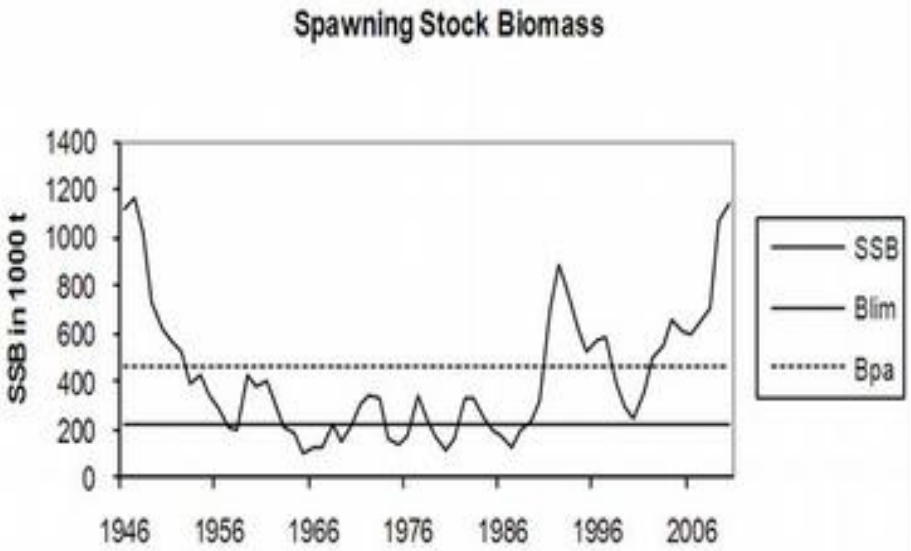
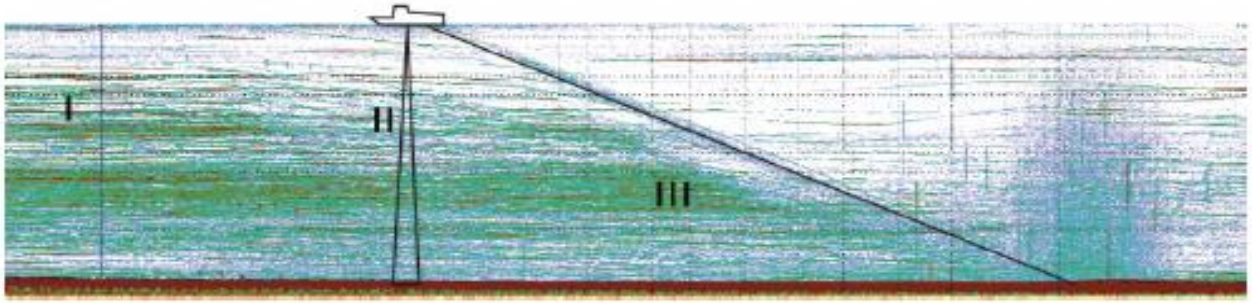
Assessment of North East Atlantic Cod



- Total allowable catch (2010) 607 000 tonnes
- Assessment based on
  - Fisheries dependent data (Catch statistics, catch sampling)
  - Fisheries independent data (Acoustic and trawl survey)

Fish behaviour and sampling



- The behaviour
  - I Behaviour before the arrival of the vessel
  - II Reaction close to the vessel
  - III Reaction to the gear
  - IV Selectivity to trawl (net, gear, mesh, etc)
- How does it affect the surveys?

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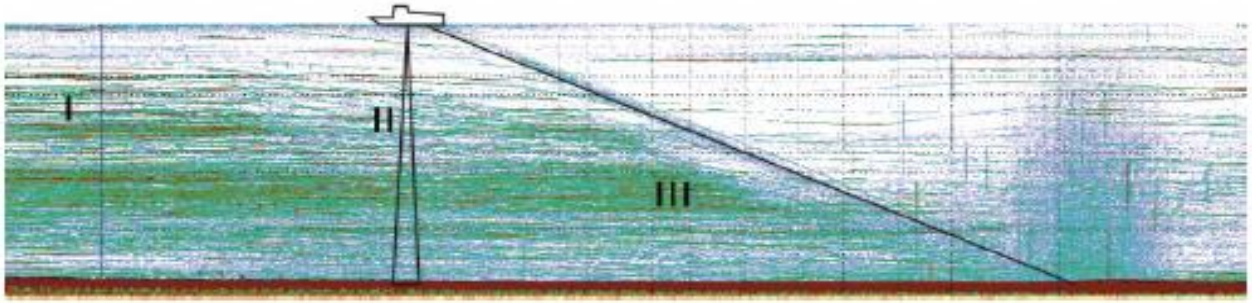
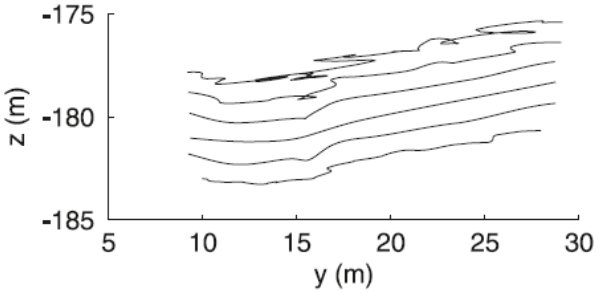
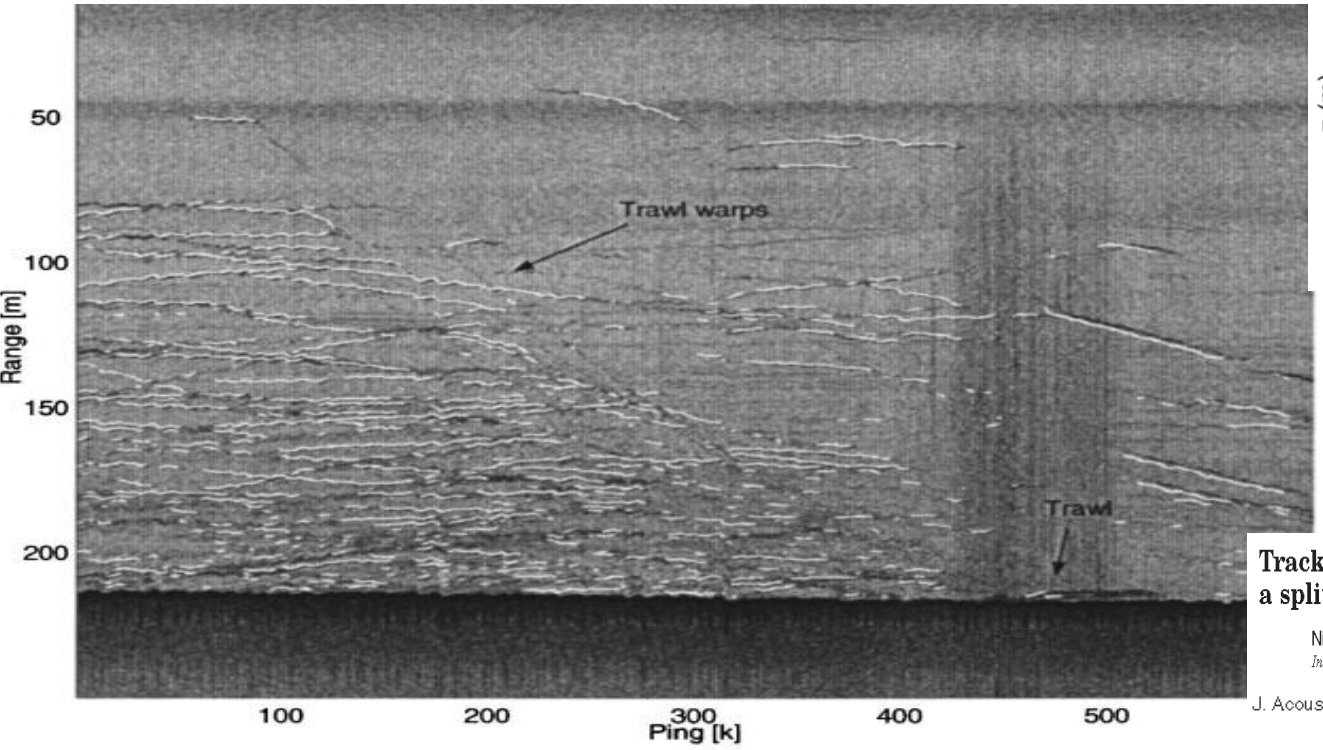
Observing fish behaviour



54 passings
23k tracks



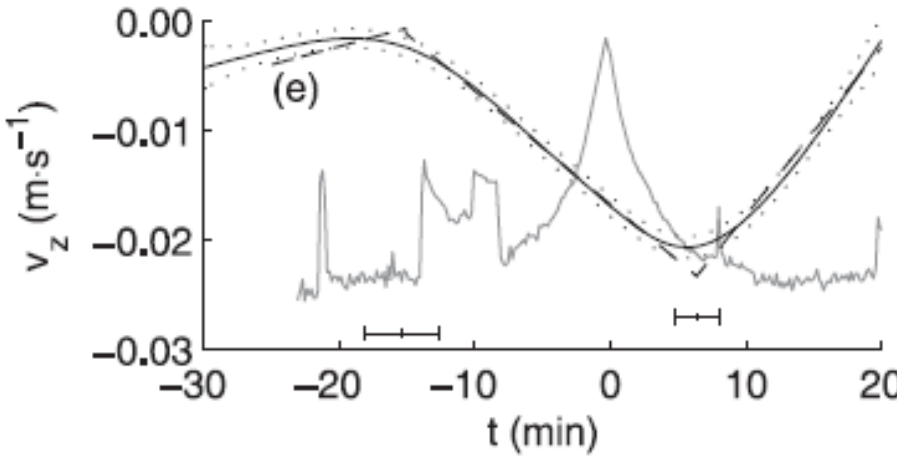


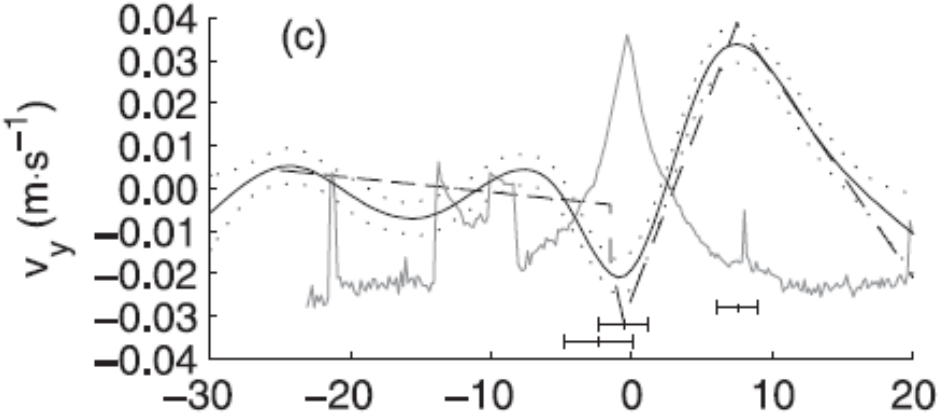
Tracking individual fish from a moving platform using a split-beam transducer

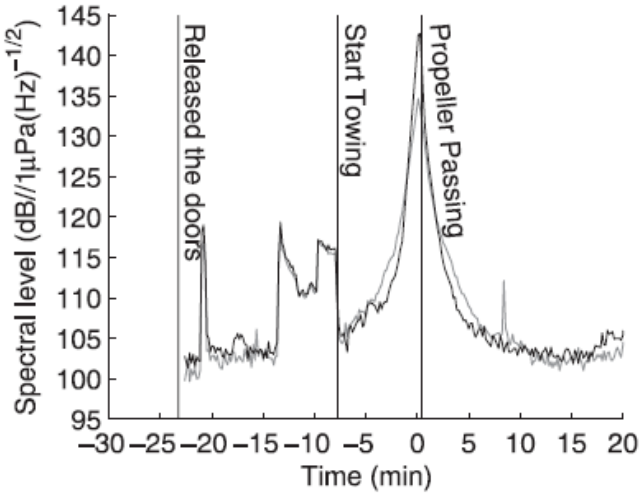
Nils Olav Handegard,[a)] Ruben Patel, and Vidar Hjellvik
Institute of Marine Research, P.O. Box 1870 Nordnes, N-5817 Bergen, Norway

J. Acoust. Soc. Am. **118** (4), October 2005

Observing fish behaviour





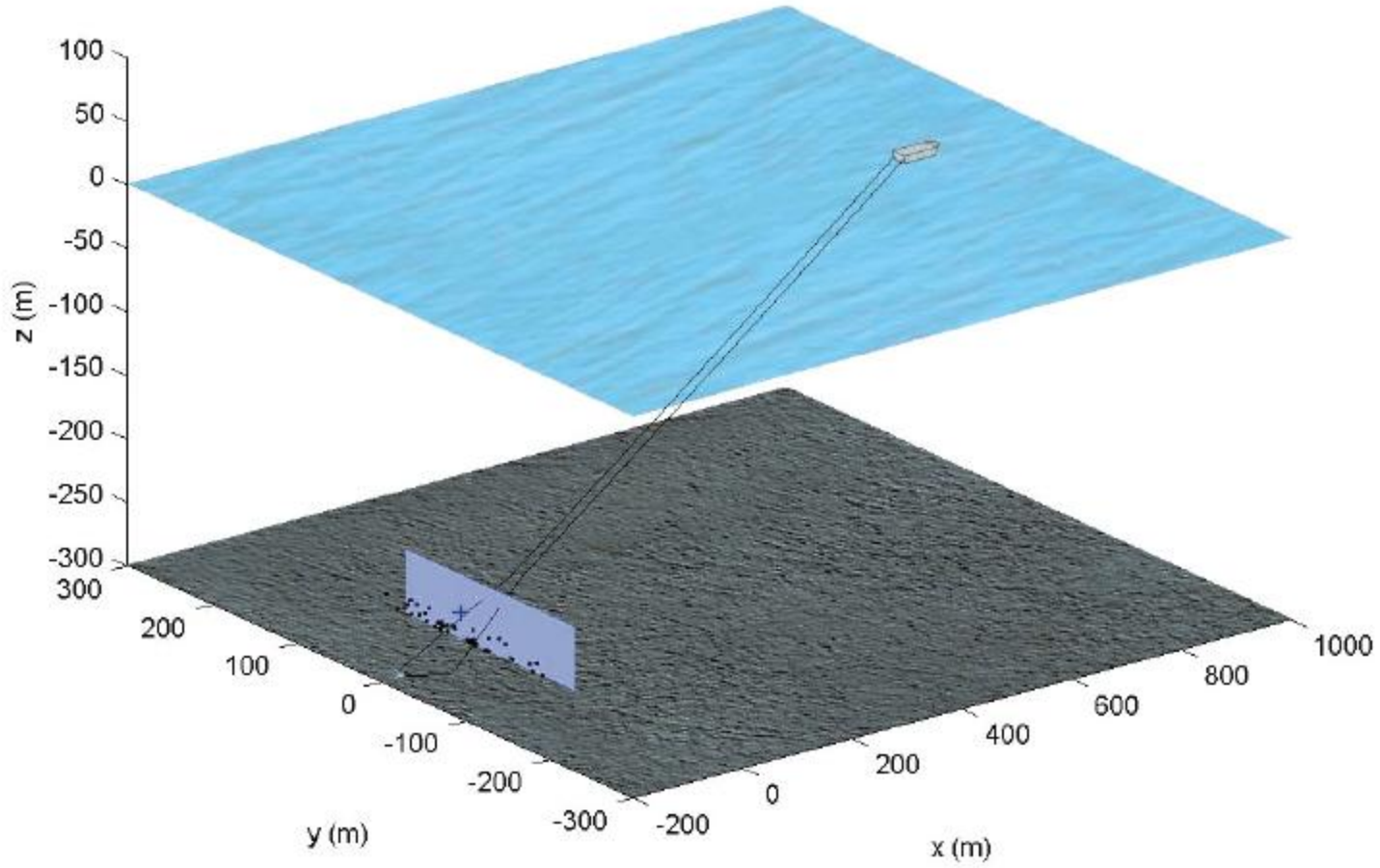


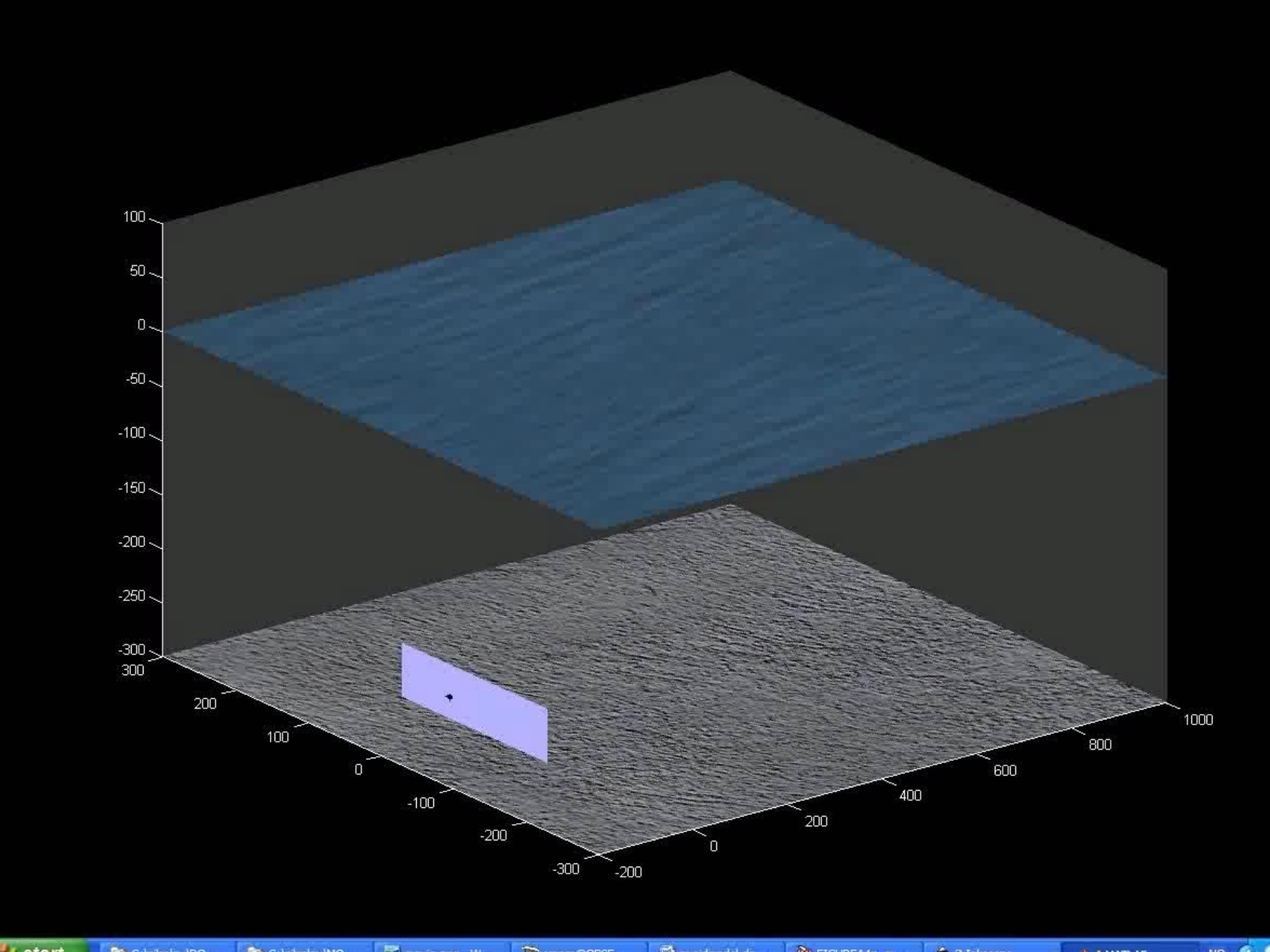
When fish meet a trawling vessel: examining the behaviour of gadoids using a free-floating buoy and acoustic split-beam tracking

Nils Olav Handegard and Dag Tjøstheim

Can. J. Fish. Aquat. Sci. 62: 2409–2422 (2005)

Modelling fish trajecories




100
50
0
-50
-100
-150
-200
-250
-300
300
200
100
0
-100
-200
-300
-200
0
200
400
600
800
1000

Modelling fish trajecories

Ohrnstein Uhlenbeck process

$$\frac{\mathrm{d}\boldsymbol{X}_t}{\mathrm{d}t} = \boldsymbol{U}_t + \boldsymbol{m}(z, t)$$

$$\mathrm{d}\boldsymbol{U}_t = -\mathbf{B}(z, t)\,\boldsymbol{U}_t\ \mathrm{d}t + \mathbf{S}(z, t)\ \mathrm{d}\boldsymbol{Z}(t)$$

m, B and S to be estimated from data.

Then trajectories can be simulated.

The sampling volume of trawl and acoustics: estimating availability probabilities from observations of tracked individual fish

Nils Olav Handegard and Dag Tjøstheim

Can. J. Fish. Aquat. Sci. **66**: 425–438 (2009)

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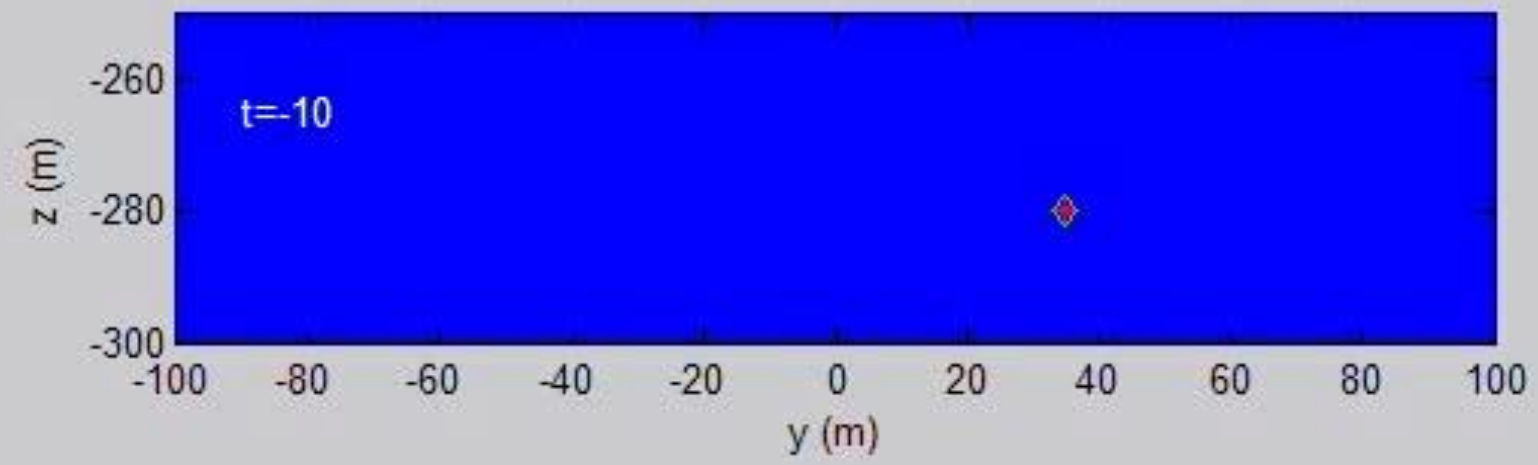
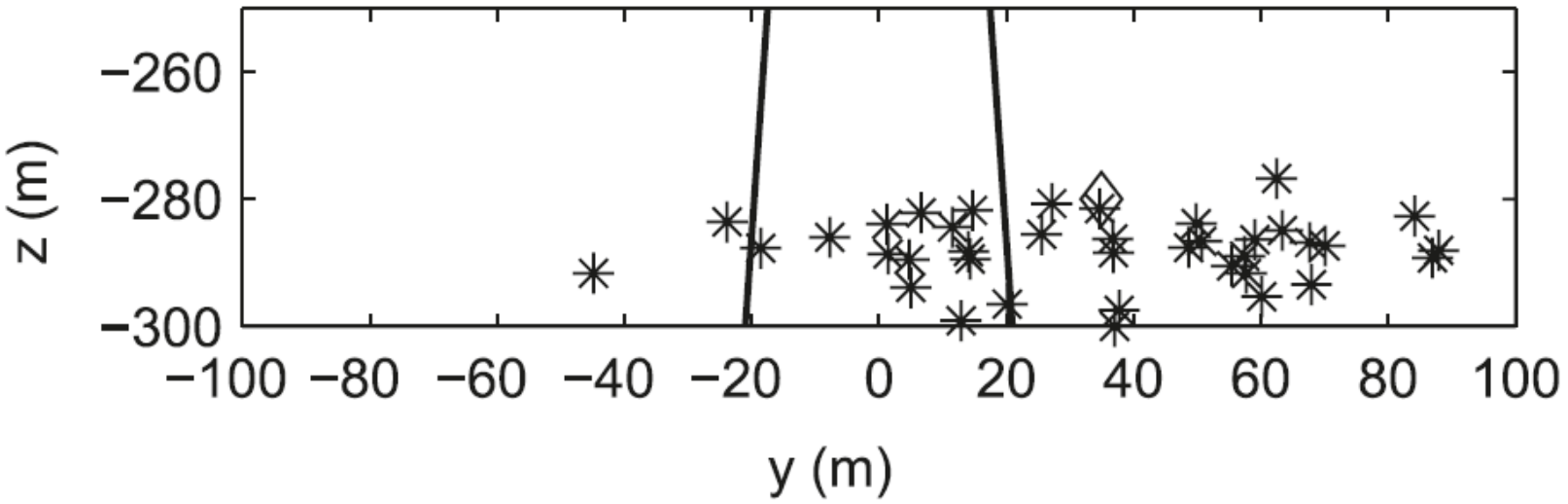
Results

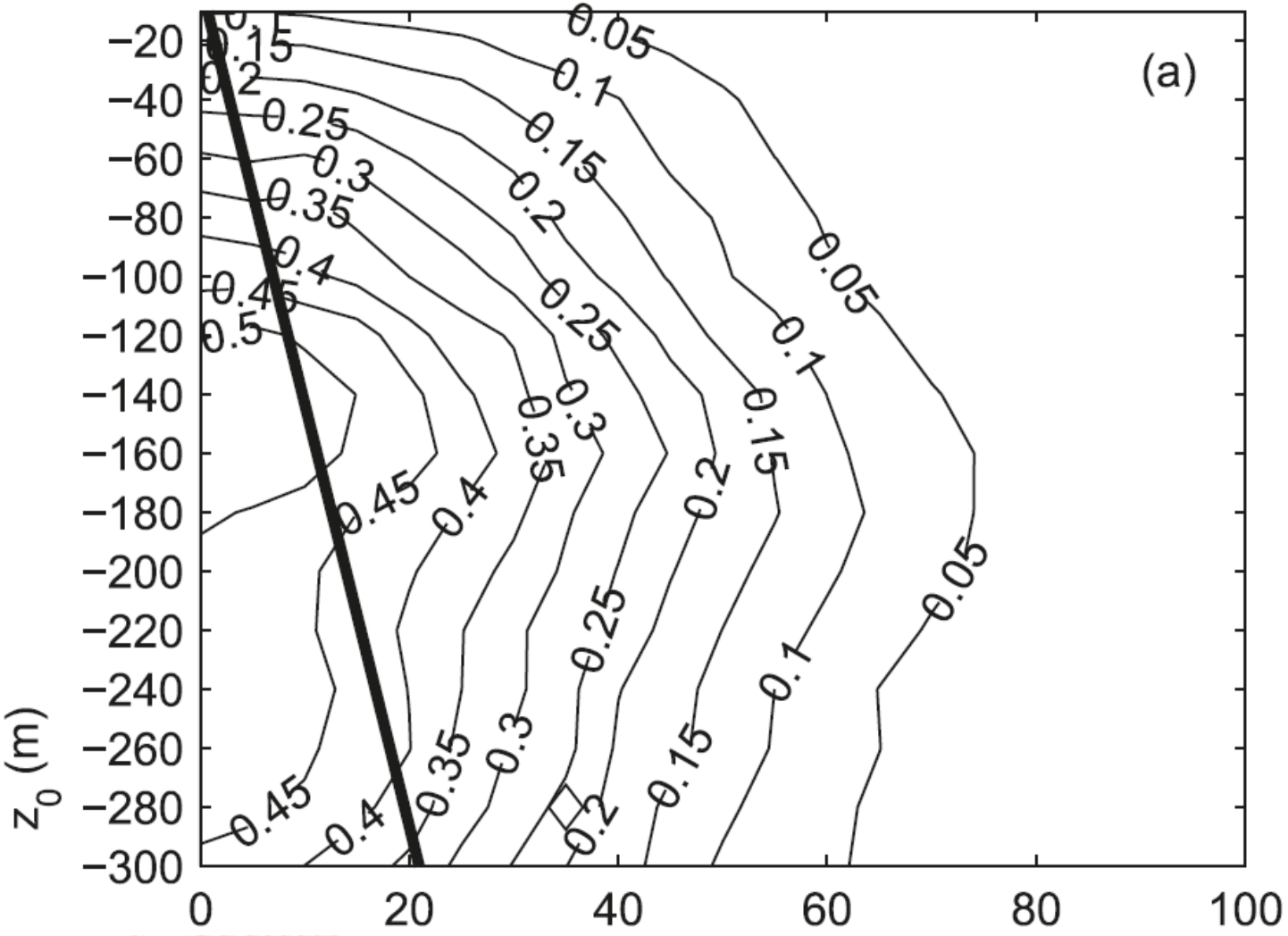


Results

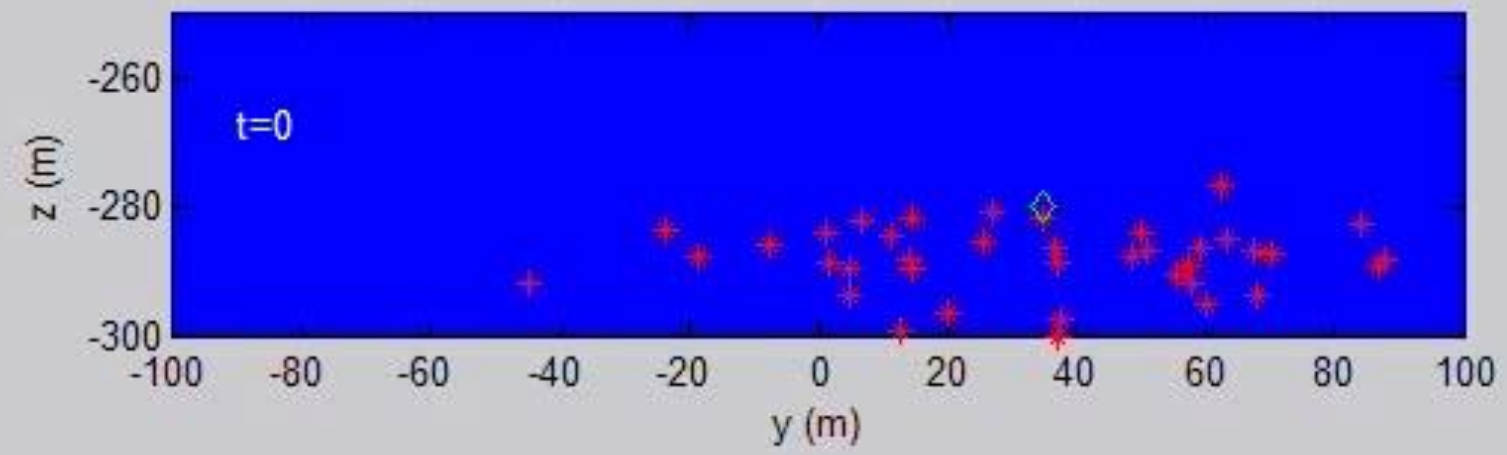


$$\widehat{P}\{E_{\mathrm{eb}} | \boldsymbol{X}_{t_0} = \boldsymbol{x}_0\} = 0.32$$

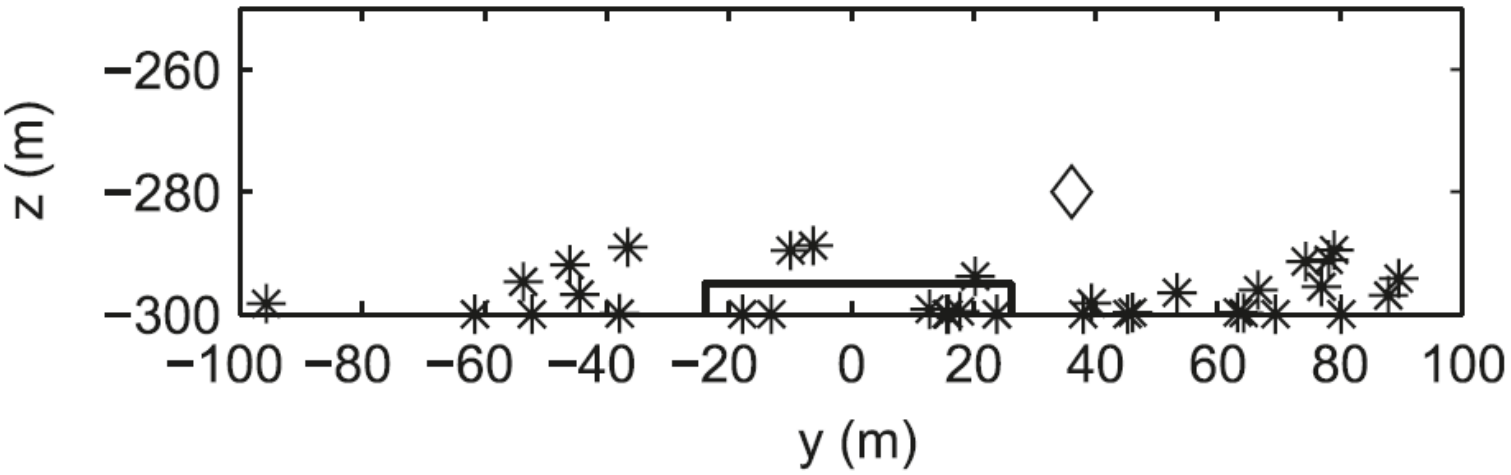
Results


(a)
z_0 (m)
−20
−40
−60
−80
−100
−120
−140
−160
−180
−200
−220
−240
−260
−280
−300
0
20
40
60
80
100
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
0.45
0.5

Results

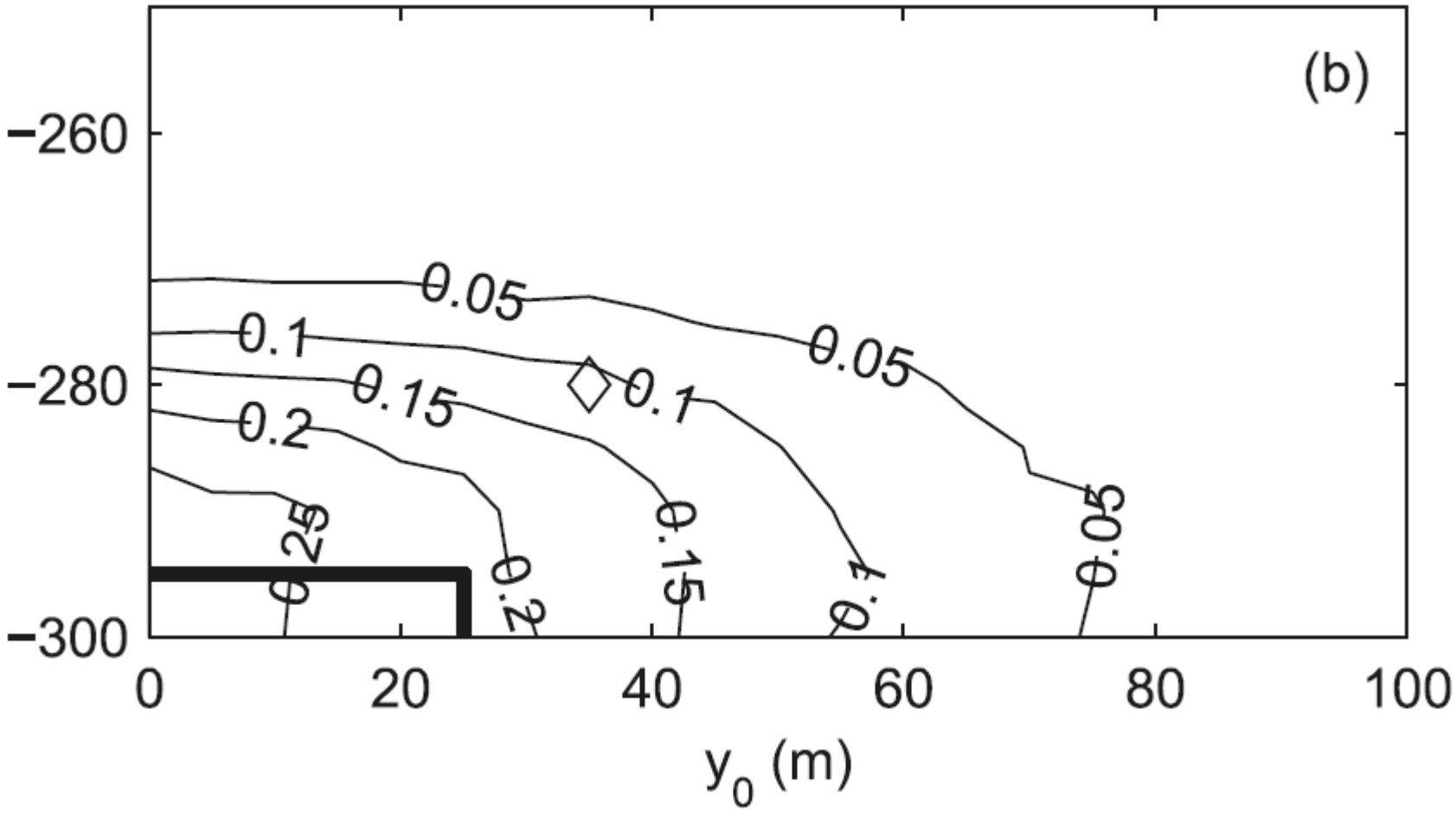


Results

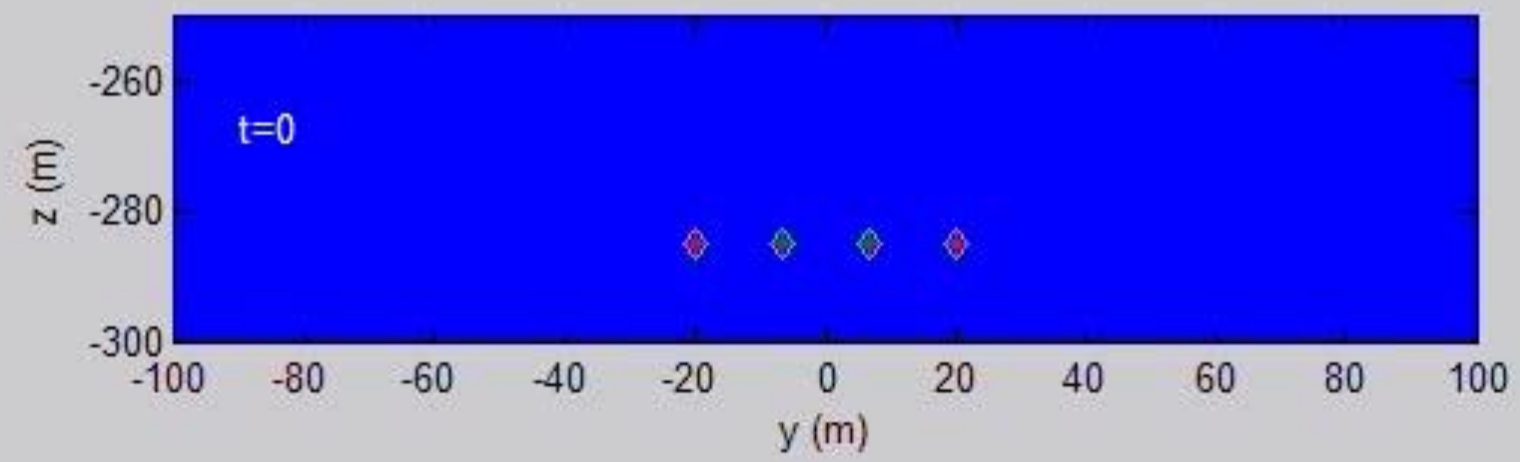


$$P\{E_{\mathrm{tr}} | \boldsymbol{X}_{t_0} = \boldsymbol{x}_0\} = 0.17$$

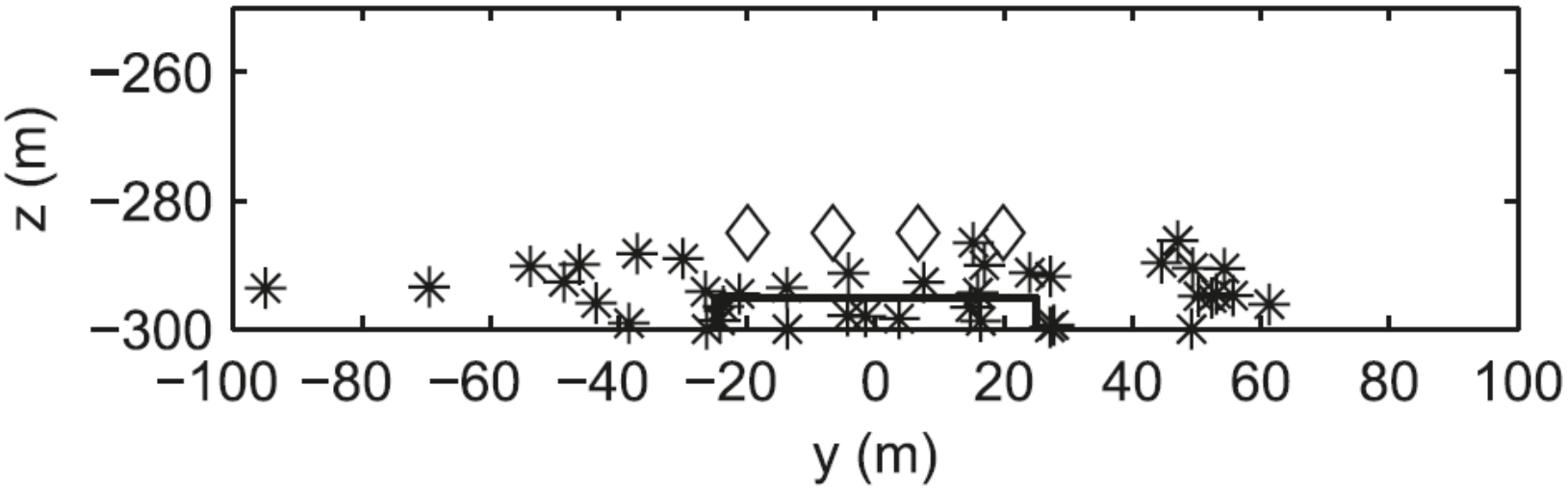
Results


(b)
−260
−280
−300
0
20
40
60
80
100
y_0 (m)
0.05
0.1
0.15
0.2
0.25
0.1
0.05
0.15
0.2
0.25
0.1
0.05

Results



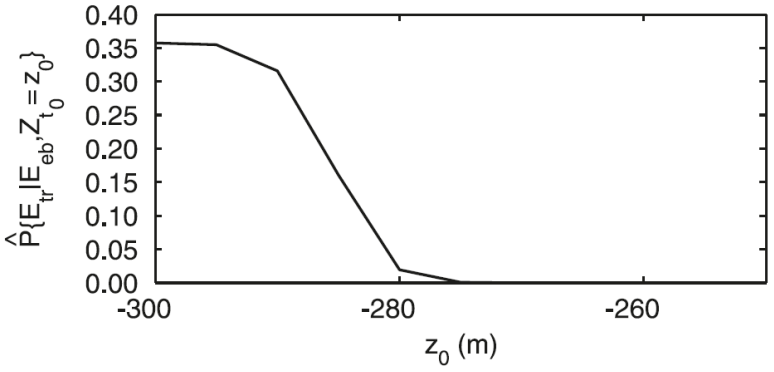
Results



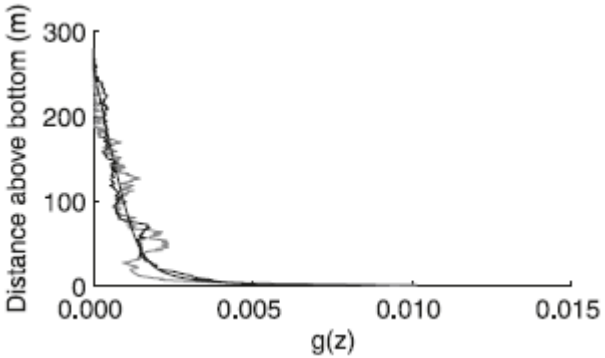
$$\widehat{P}\{E_{\mathrm{tr}} | E_{\mathrm{eb}}, Z_{t_0} = -285\} = 0.\dot{2}$$

Do you catch what you see?

Probability for being available to bottom trawl if seen on echo sounder at a given depth



Typical vertical profile



The probability of being available to the trawl given the fish was seen on echo sounder

$$\frac{\int_{z_0=-300}^{0} g(z_0)\widehat{P}\{E_{\mathrm{tr}}|E_{\mathrm{eb}}, Z_{t_0} = z_0\}\ \mathrm{d}z_0}{\int_{z_0=-300}^{0} g(z_0)\ \mathrm{d}z_0} = 0.092$$

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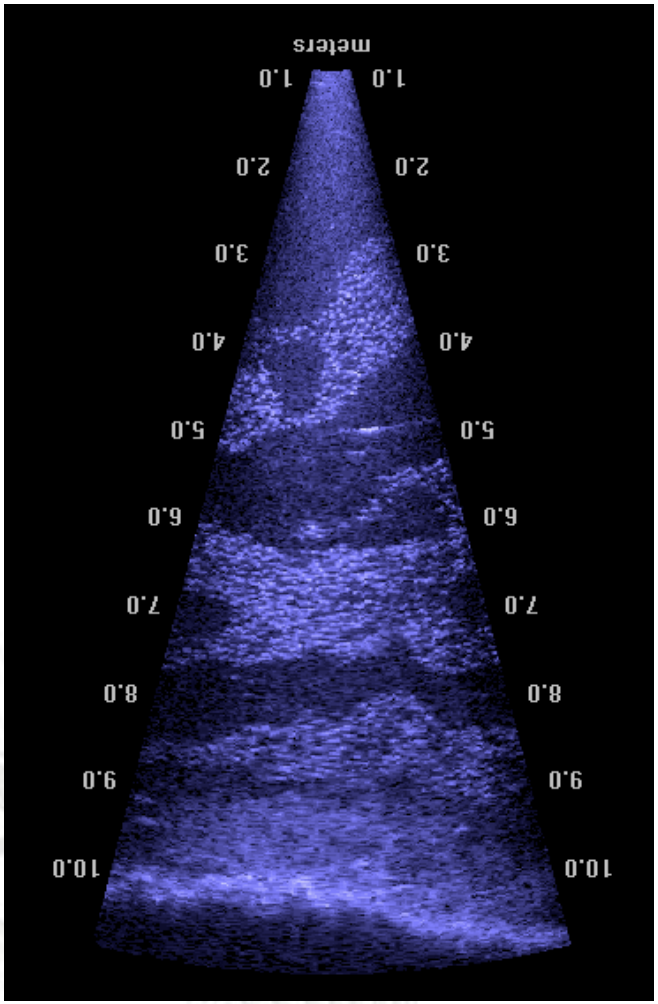
Discussion

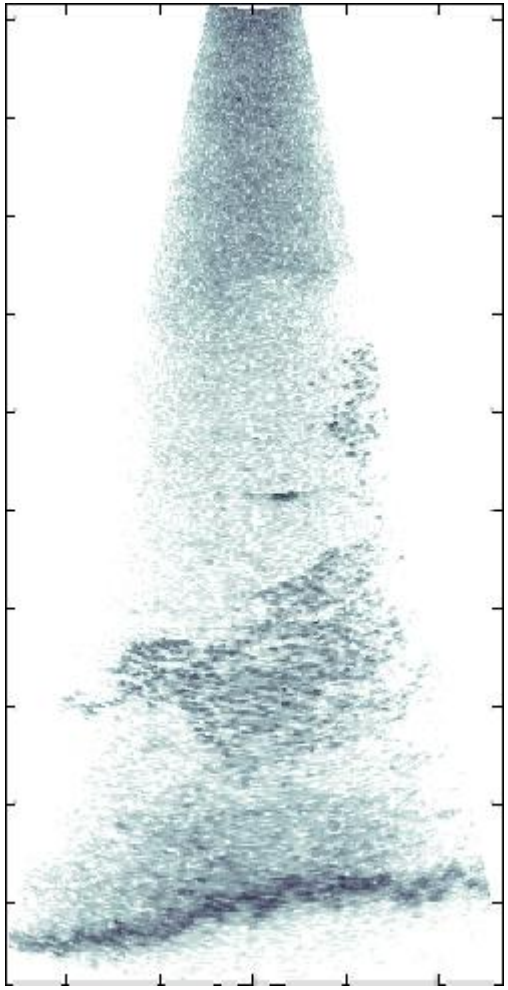
The advantage of smaller scale experiments

- More detailed observations can be obtained
  - Multibeam, splitbeam, video etc
- Build a naive model for the reaction to the various parts of the gear (the m)
  - You need accurate position estimates of the various parts of the vessel and gear
- Inter individual behavior
  - Causes higher variation, can be modeled.

Discussion

The advantage of smaller scale experiments





Handegard[1,2], Boswell[3], LeBlanc[2] & Couzin[2]. In prep.

[1]Institute of Marine Research, Norway
[2]Princeton University, US
[3]Louisiana State University, US

Thank you

- ICES Cooperative Research Report on fish avoidance

- ICES Fisheries Acoustic Science and Technology working group
  - ICES Optics study group