Fitting observed fish trajectories to catchability 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

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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 Dao Tiessheim

Modelling fish trajectories
Modelling fish trajectories

Ohrnstein Uhlenbeck process

\[ \frac{dX_t}{dt} = U_t + m(z, t) \]

\[ dU_t = -B(z, t)U_t \, dt + S(z, t) \, dZ(t) \]

m, B and S to be estimated from data.

Then trajectories can be simulated.
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\[ \hat{P} \{ E_{eb} \mid X_{t_0} = x_0 \} = 0.32 \]
Results
Results

\[ P\{E_{tr}|X_{t_0} = x_0\} = 0.17 \]
Results
Results
Results

\[
\hat{P}\{E_{tr}|E_{eb}, Z_{t_0} = -285\} = 0.2
\]
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

\[ \frac{\int_{z_0=-300}^{0} g(z_0) \hat{P}(E_{tr} | E_{eb}, Z_{i0} = z_0) \, dz_0}{\int_{z_0=-300}^{0} g(z_0) \, dz_0} = 0.092 \]
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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.

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Thank you

- ICES Cooperative Research Report on fish avoidance

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