FishCensus: An individual-based simulation of underwater visual census of fish populations with realistic behavior

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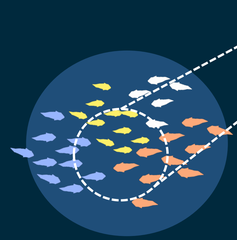
INTRODUCTION

- The choice of method and sampling design can be **crucial**, particularly if observations support **conservation and management decisions** (Blanchard *et al.*, 2008; Pais *et al.*, 2014).
- Underwater visual census (UVC) methods are **cost-effective, non-destructive** solutions to survey coastal fish communities, and therefore **their use is widespread**.
- **Lack of precision** and **inaccuracy** of estimates can have **devastating long-term effects** on managed populations, communities or ecosystems.



Observation

Random error
Sample allocation
Species movement
Habitat heterogeneity

PRECISION

Systematic error
Inadequate method
Method limitations
Observer influence

ACCURACY

Strong link to species behavior!
Very hard to detect and minimize!

MODELS!

Reefex
(Watson *et al.*, 1995)

Calculates bias due to fish approach direction

grid-based

10 second time step

AnimDens
(Ward-Paige *et al.*, 2010)

Calculates bias due to non-instantaneous sampling

correlated random walk

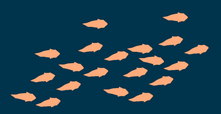
2 second time step

Very limited representation of fish behavior

FishCensus MODEL DESCRIPTION

Spatially-explicit, 2D individual-based NetLogo **model.**

0.1 second time step



Vector-based movement

Complex behavior!

- Schooling
- Territorial
- Diver attraction/ avoidance
- Cryptic

Sampling methods and parameters

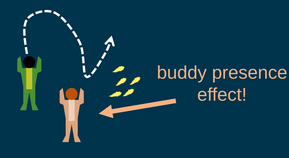
Stationary point count

- radius (m)
- Time (min.)
- rotation speed (º/sec.)

Strip transect

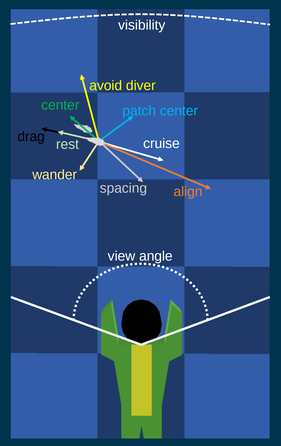
- length (m)
- width (m)
- speed (m/min.)

Random path



- max. turning angle (º/sec)
- speed (m/min.)

FISH MOVEMENT PARAMETERS



- Every 0.1 seconds up to **8 vectors per fish** are summed to establish the acceleration vector.

- Vectors are weighed in order of importance. A set of weights defines a behavior.

- A species can have up to **four** behaviors that change randomly based on pre-defined frequencies.

Parameterization by observing changes in real time

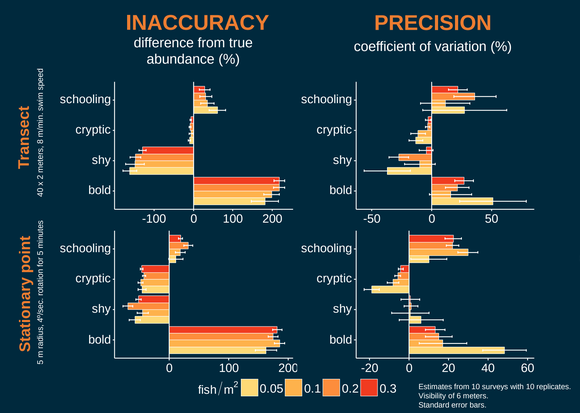
EXPERIMENTS AND APPLICATIONS

4 generic 'species' simulating problematic behaviors for UVC:

- **Schooling** species forming small schools
- **Cryptic** low detectability
- **Shy** easily scared by divers
- **Bold** curious towards divers

Behaviors video playlist

Effect of behavior on the precision and inaccuracy of abundance estimates at different population densities



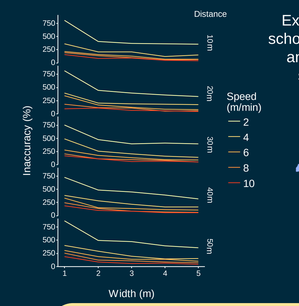
Estimates from 10 surveys with 10 replicates. Visibility of 6 meters. Standard error bars.

Species with the key behavior

VS

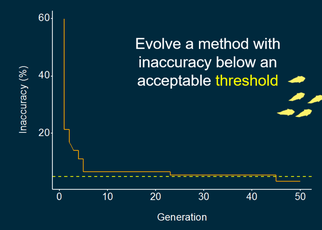
Control species lacking the key behavior

Sampling parameters and estimate inaccuracy



Example for a schooling species and transect sampling

Genetic algorithms for survey optimization



Evolve a method with inaccuracy below an acceptable threshold

For questions, collaborations, or if you want to use FishCensus, please contact the corresponding author!

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