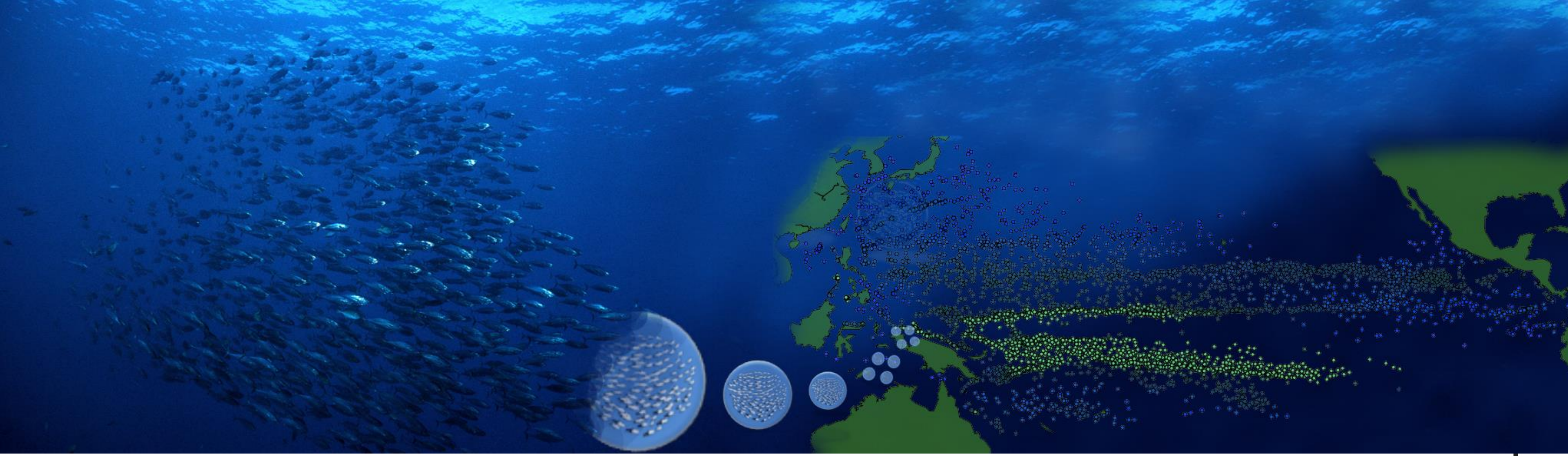


Individual-based Methods for Simulation of WCPO Skipjack

Joe Scutt Phillips*, Alex Sen Gupta, Erik van Sebille, Inna Senina, Patrick Lehodey & Simon Nicol

*** University of New South Wales**

WCPFC SC12, Aug 2016, Bali

Climate Change Research Centre

Grantham Institute

SPC Secretariat of the Pacific Community

CLS GROUP COLLECTE LOCALISATION SATELLITES

Individual-based Model of Tuna Movement and Distribution

SC11 recommendations included:

- *"[regarding] information related to identifying changes in the spatial distribution of skipjack (including range contraction) in response to increase in fishing pressure… SC11 recommends that WCPFC12 take note of the analyses completed to date and that further work on this issue be undertaken, including:*
  - *more extensive skipjack tagging activities, including in sub-tropical and temperate regions to provide better information on stock connectivity and movement"*

PTTP work plan also recommended that analyses of movement data from tagging should:

- *"provide external validation to [movement] estimates from within MFCL and SEAPODYM."*

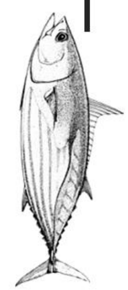
Individual-based Model of Tuna Movement and Distribution

Aims:

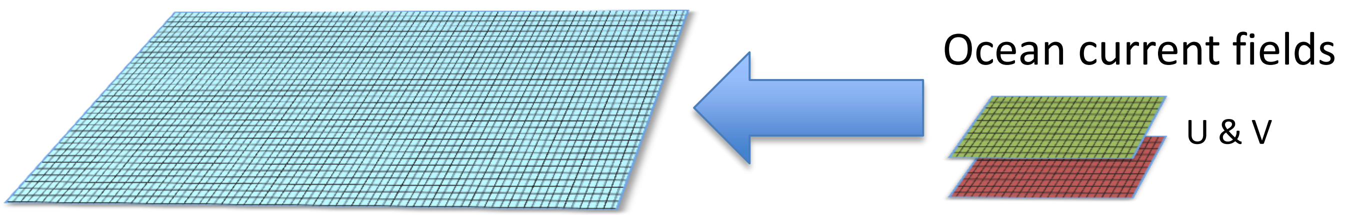
- Build a individual-based model of skipjack tuna distribution in the WCPO
- Use to quantify sensitivity of tuna distribution to:
  - Variable resolution ocean forcing fields
  - Alternative behaviours and foraging strategies
  - Effect of small and meso-scale interactions (tuna-prey, tuna-tuna, tuna-FAD etc.)
- Examine connectivity and movement estimates used in MULTIFAN-CL and SEAPODYM
- Not an ecosystem dynamics model!
- An "assumption analyser"

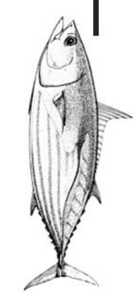
Simple SEAPODYM IBM - SIMPODYM

- ‘Spin-up’ SEAPODYM interim-NEMO-PISCES
- Recruit single cohort at age 4-months, and use as initial conditions for biomass distribution
- Package biomass into schools of ‘super-individual’ particles
- Advect single cohort using same ocean forcing fields used in SEAPODYM and equivalent taxis behaviours
- Diffuse with individual behaviours in response to same prey field given by SEAPODYM
- Keep only natural mortality
- Run until final age-class and compare!

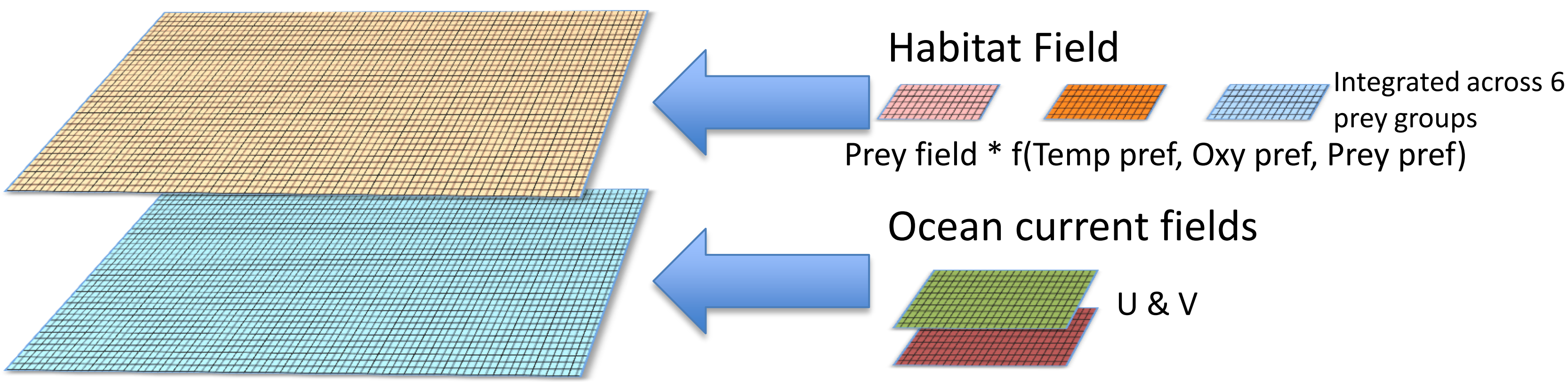


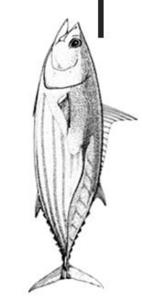
SEAPODYM - Overview





SEAPODYM - Overview





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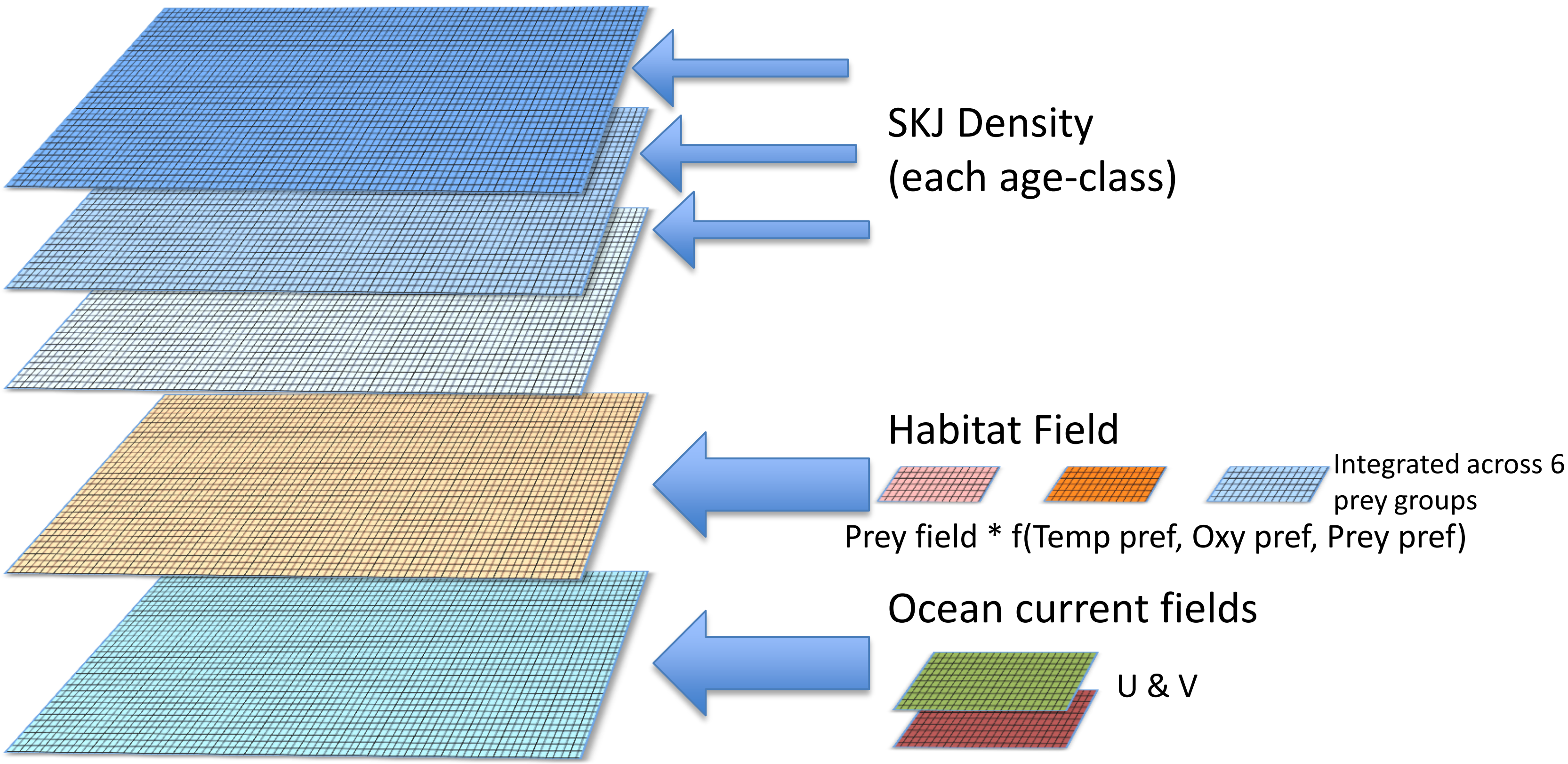
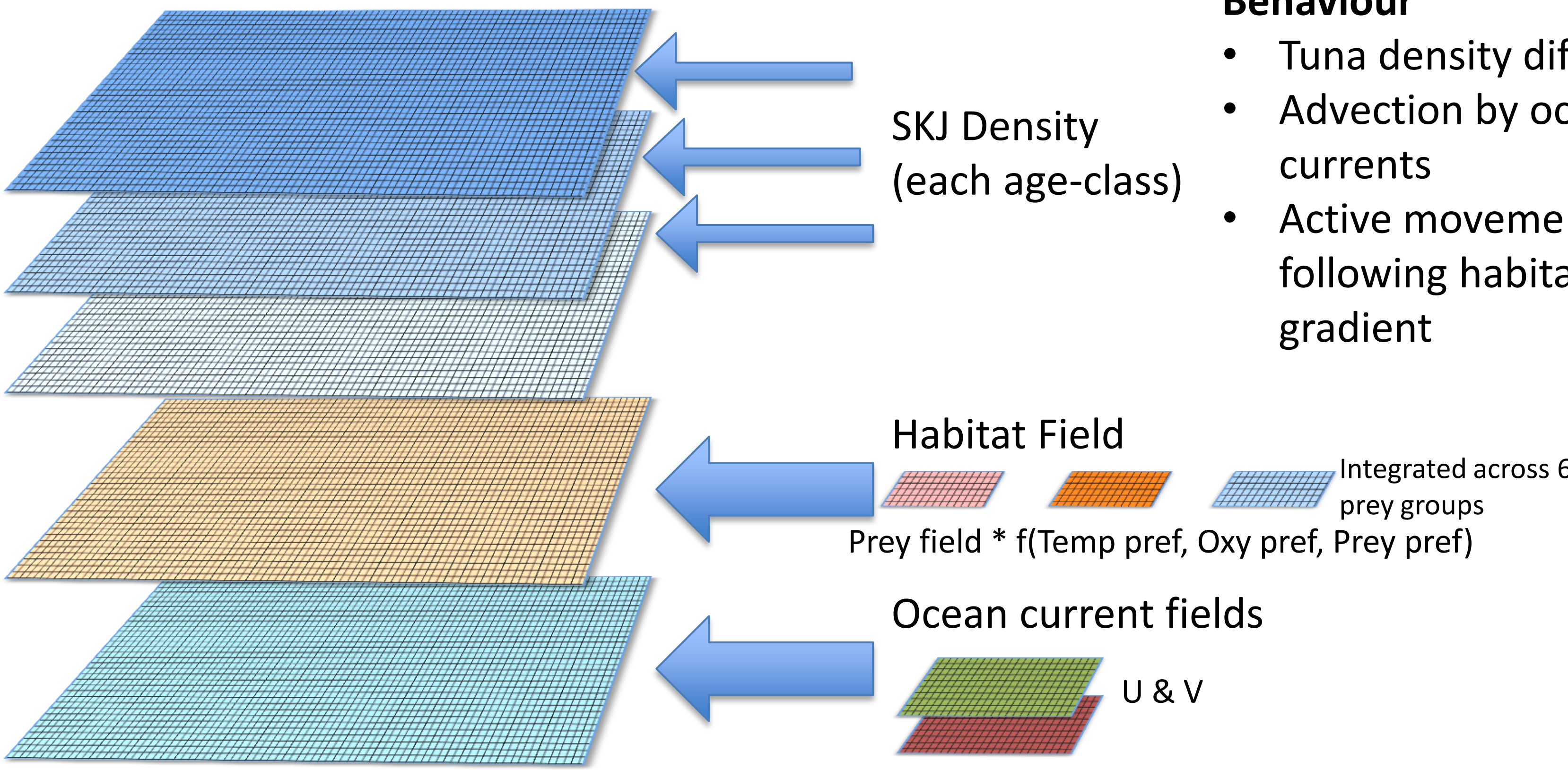
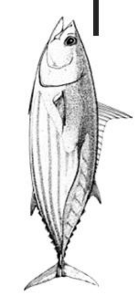


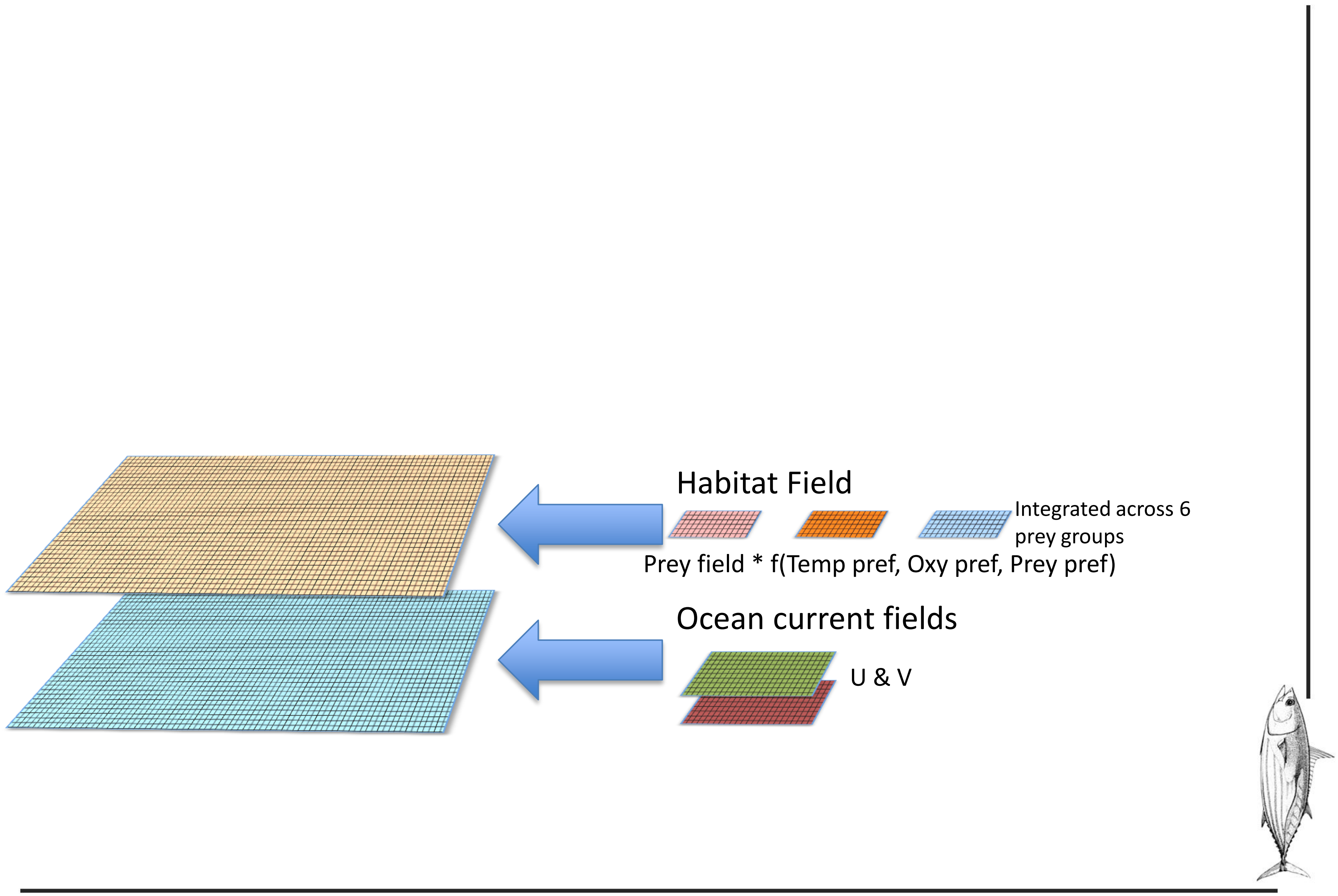
SEAPODYM - Overview

Behaviour

- Tuna density diffuses
- Advection by ocean currents
- Active movement following habitat gradient

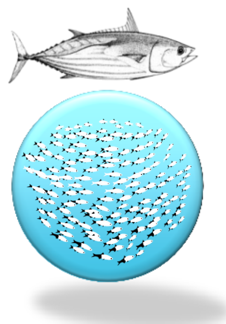




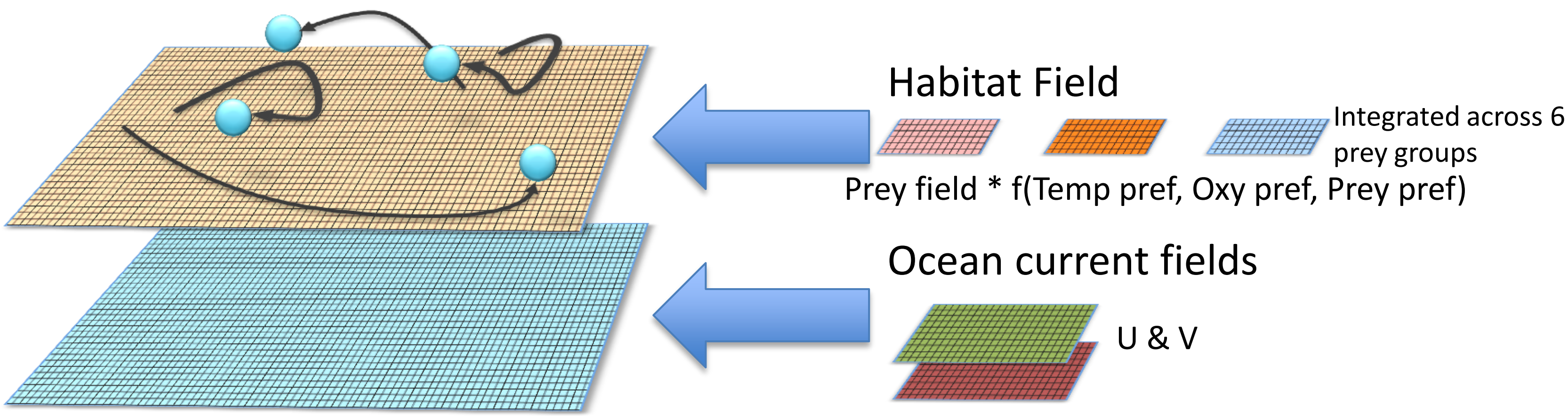

Habitat Field
Integrated across 6 prey groups
Prey field * f(Temp pref, Oxy pref, Prey pref)
Ocean current fields
U & V

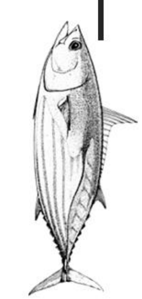
Individual-based "SIMPODYM"

Particle "super-individuals"



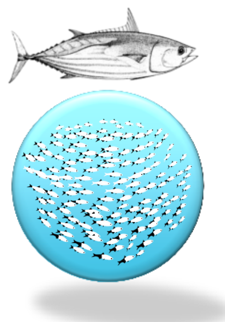
- Number of individuals in school
- Continuous age (and mortality)
- Continuous position
- Recorded trajectories
- Memory of fields sampled (e.g. forage components)
- Variable behaviours





Individual-based "SIMPODYM"

Particle "super-individuals"



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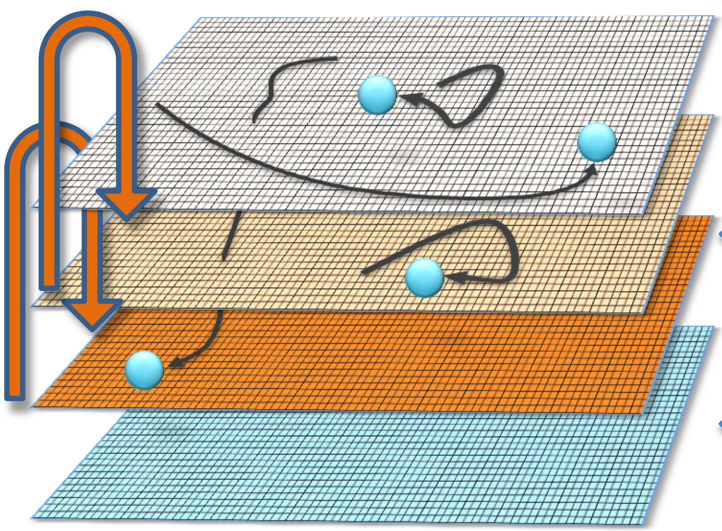
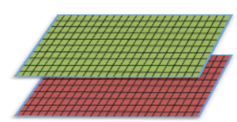
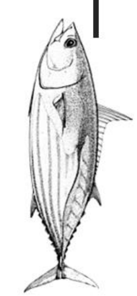


Potentially use raw forage biomass and simulate direct spatial interactions in 3D

Ocean current fields





Individual-based “SIMPODYM”

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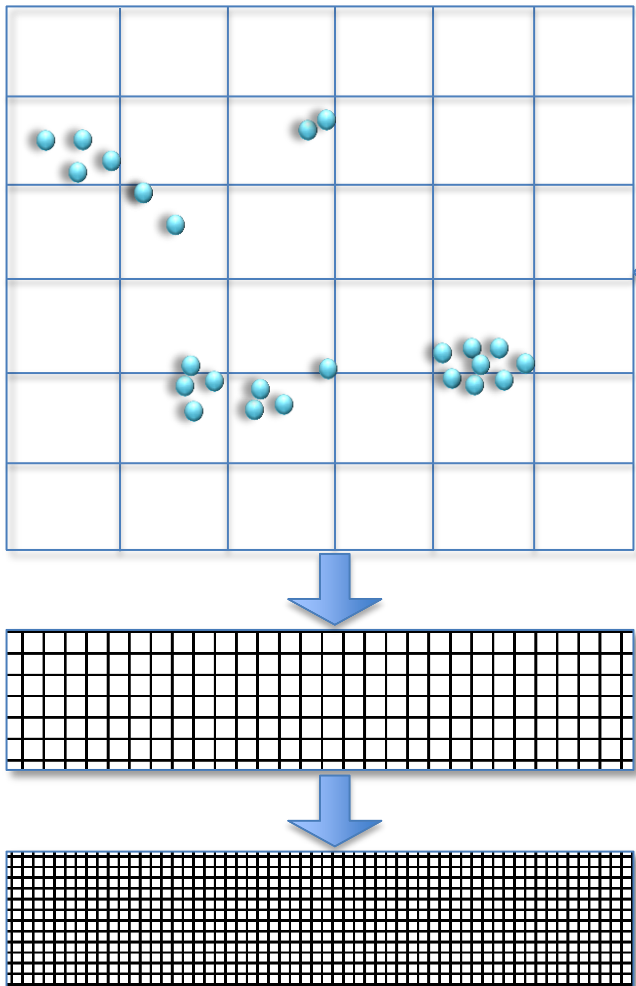
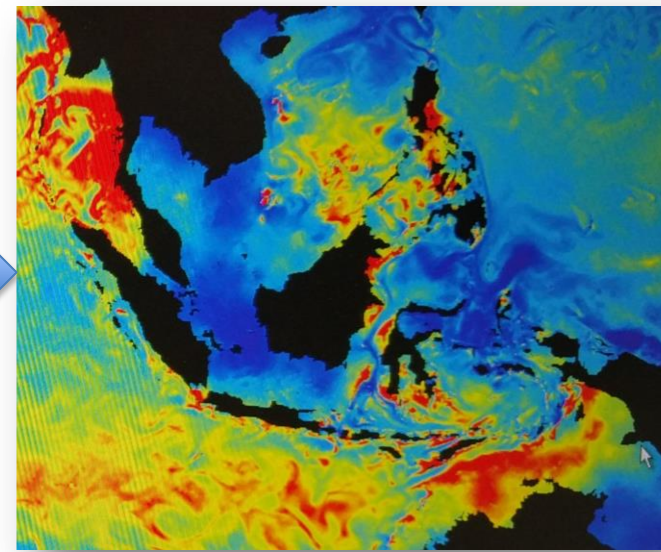
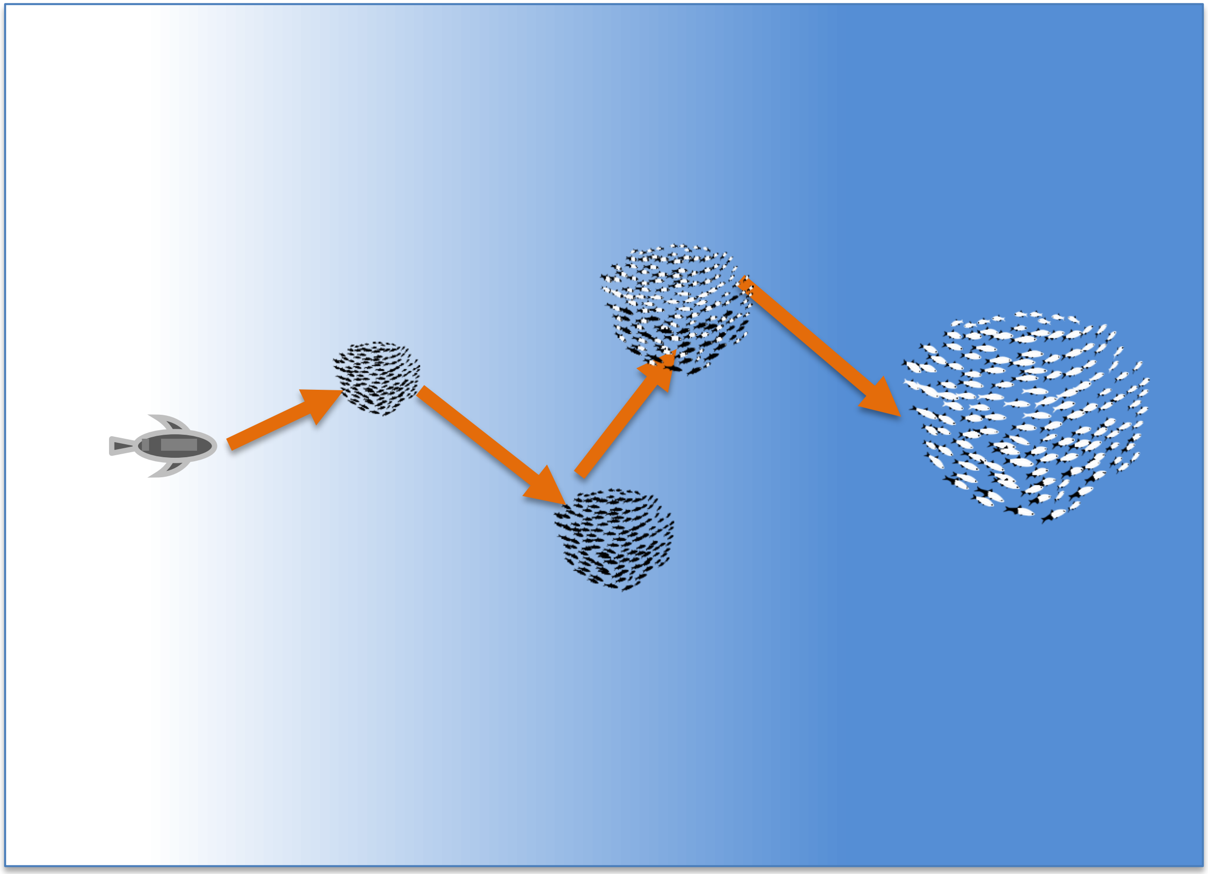




- Compare particle densities with SEAPODYM biomass
- Examine differences across grid resolutions
- Use a baseline to begin deviating using alternative assumptions

Example – Habitat Sampling

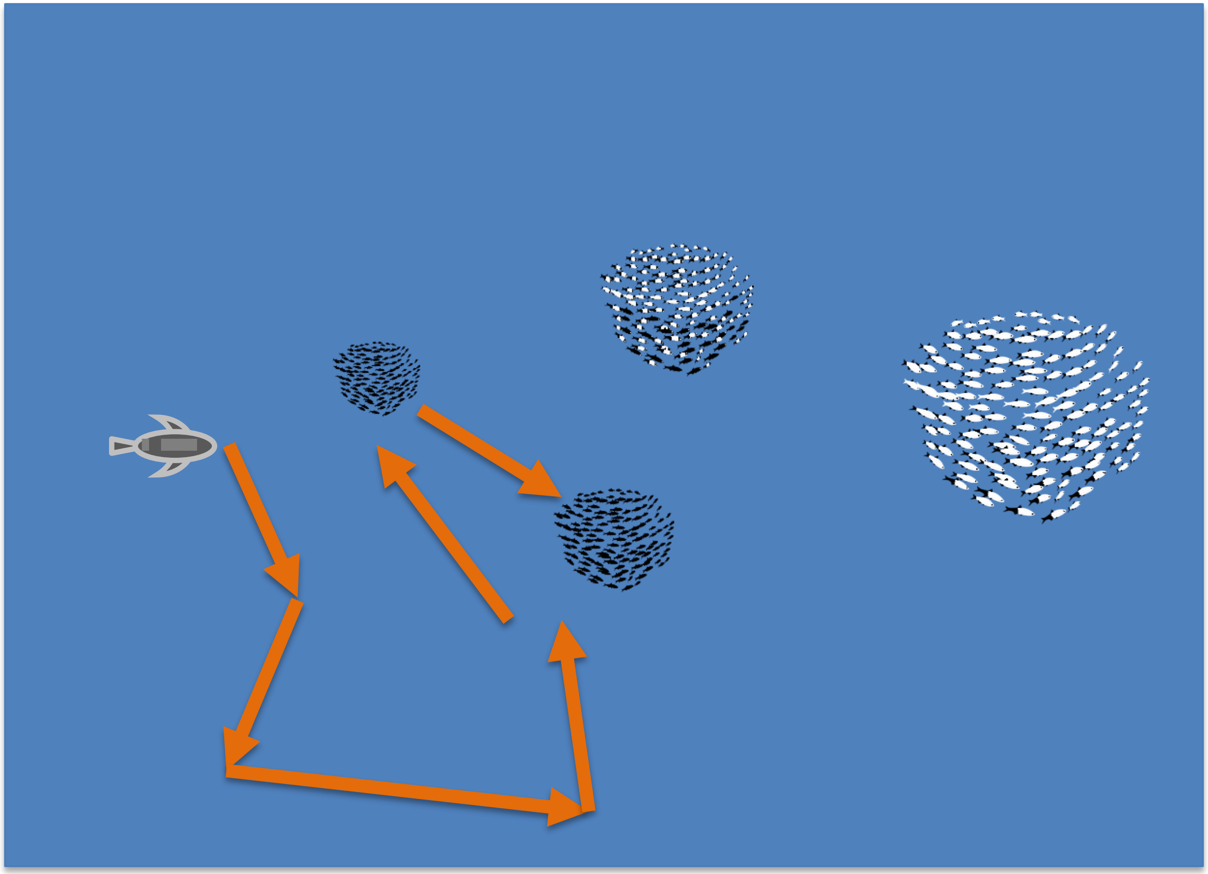
- Strong gradient -> move in direction fast
- Weak gradient -> move in direction slow
- Good habitat -> move slowly



Example – Habitat Sampling

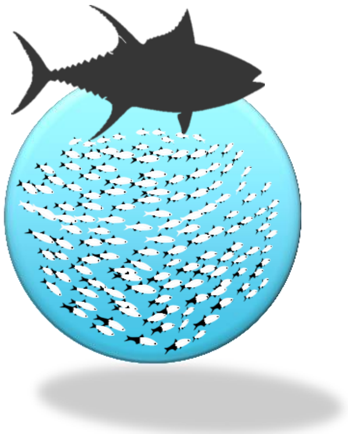
- Strong gradient -> move in direction fast
- Weak gradient -> move in direction slow
- Good habitat -> move slowly

- In real ocean, no gradient information
- Animals use clues and sample their environment
- We will use individual-level gradient information



Thinking Ahead – IKAMOANA tool

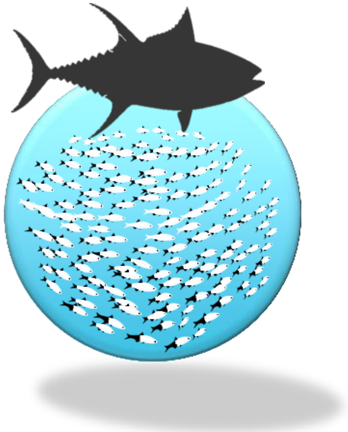
Individual-based Kinesis, Advection and Movement of Ocean ANimAls



Thinking Ahead – IKAMOANA tool

Individual-based Kinesis, Advection and Movement of Ocean ANimAls

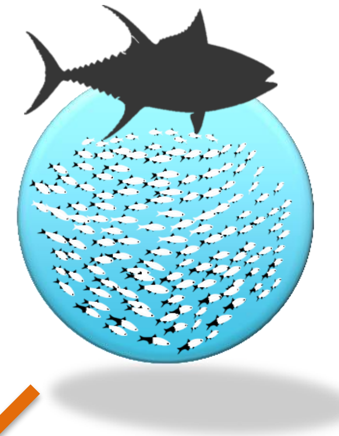
- Movement simulation tool for pelagic species

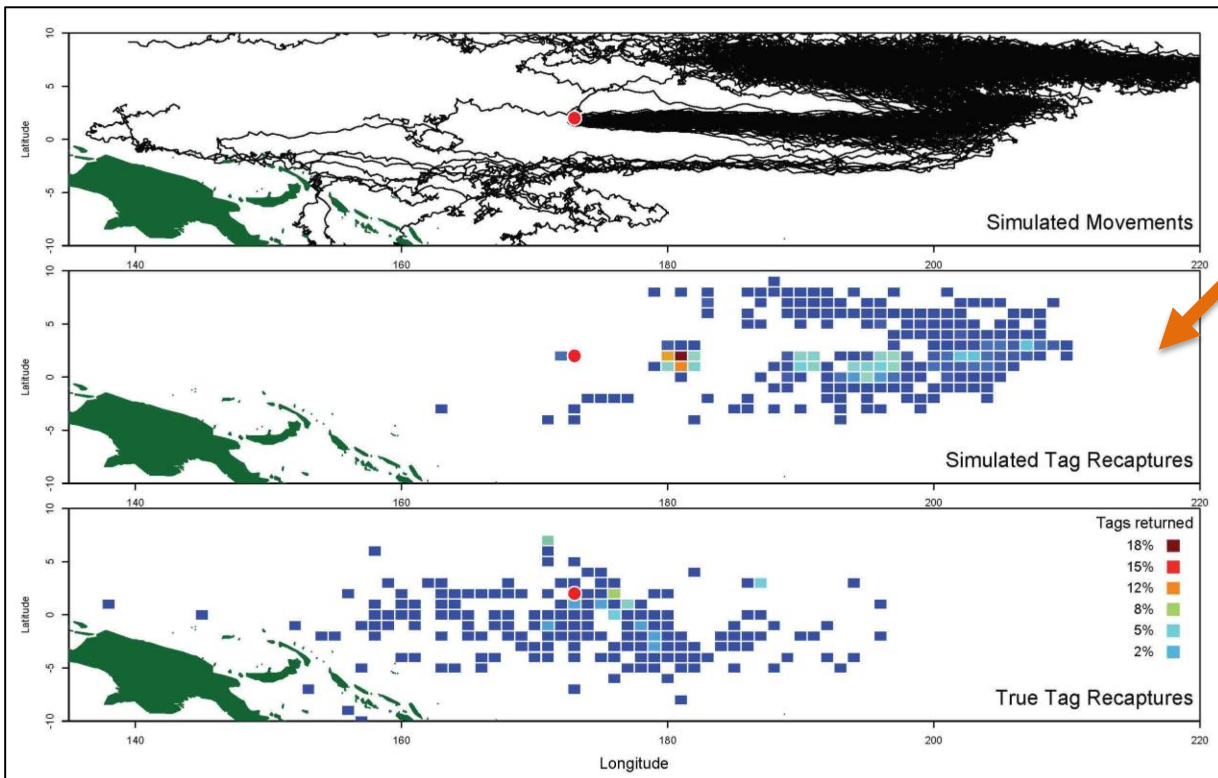


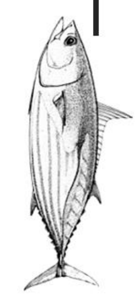
Thinking Ahead – IKAMOANA tool

Individual-based Kinesis, Advection and Movement of Ocean ANimAls

- Movement simulation tool for pelagic species
- Use in analysis and design of tagging experiments



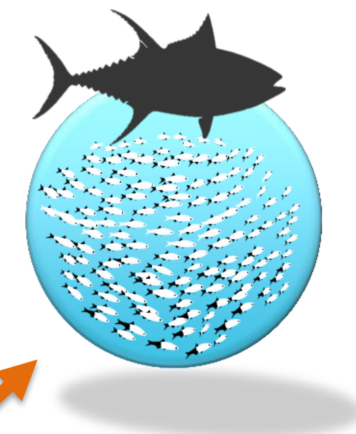


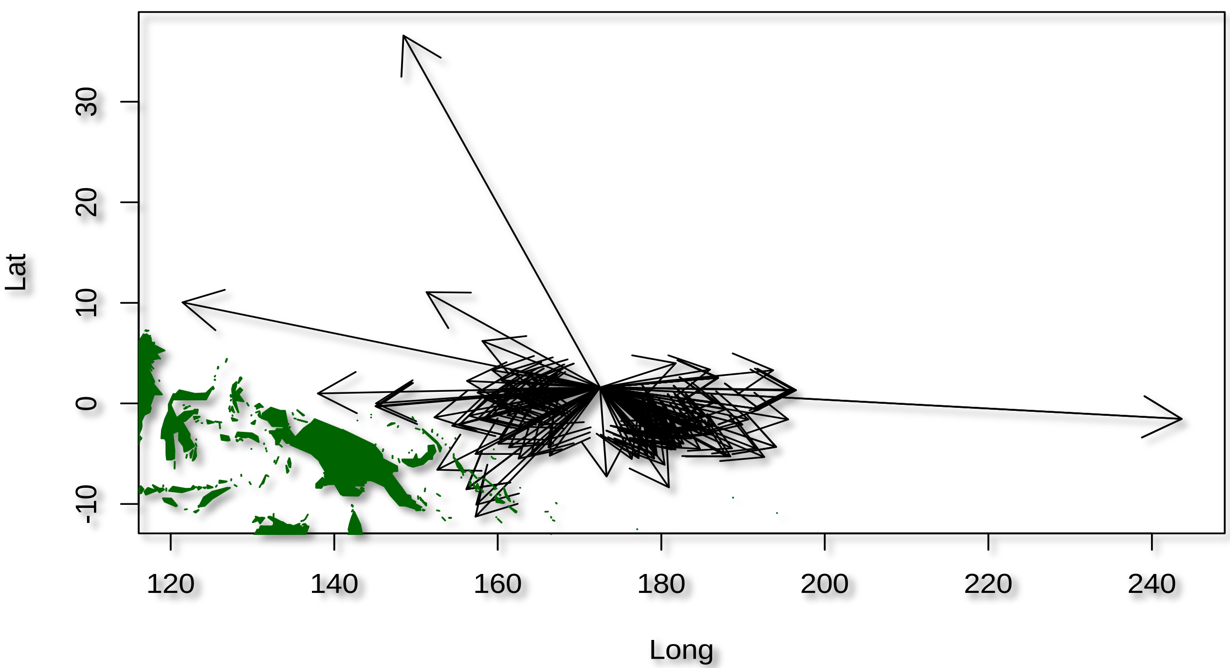


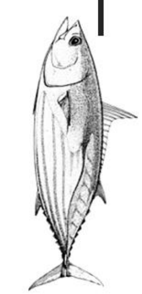
Thinking Ahead – IKAMOANA tool

Individual-based Kinesis, Advection and Movement of Ocean ANimAls

- Movement simulation tool for pelagic species
- Use in analysis and design of tagging experiments
- Parameterise from conventional tag data



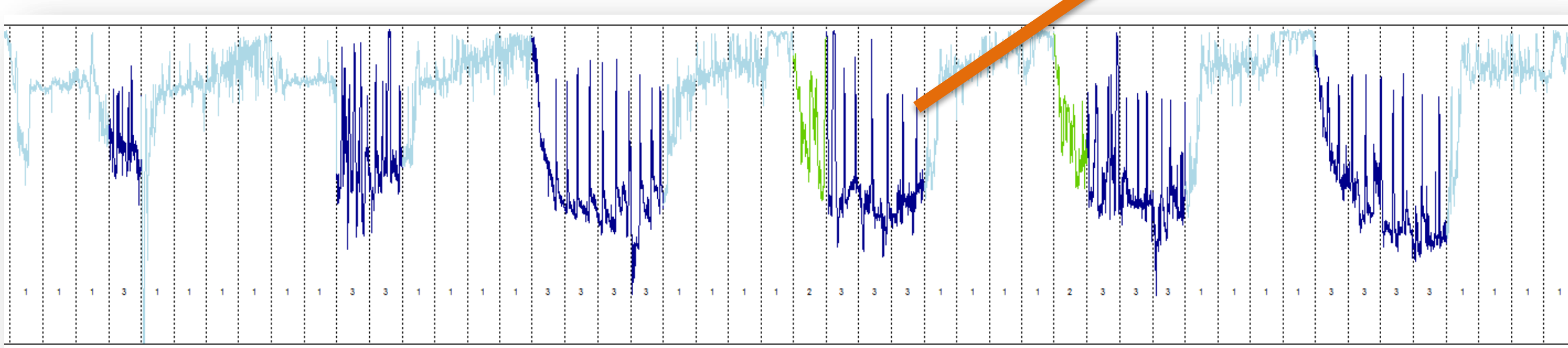




Thinking Ahead – IKAMOANA tool

Individual-based Kinesis, Advection and Movement of Ocean ANimAls

- Movement simulation tool for pelagic species
- Use in analysis and design of tagging experiments
- Parameterise from conventional tag data
- Horizontal and vertical movement from electronic tags



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Individual-based Kinesis, Advection and Movement of Ocean ANimAls

- Movement simulation tool for pelagic species
- Use in analysis and design of tagging experiments
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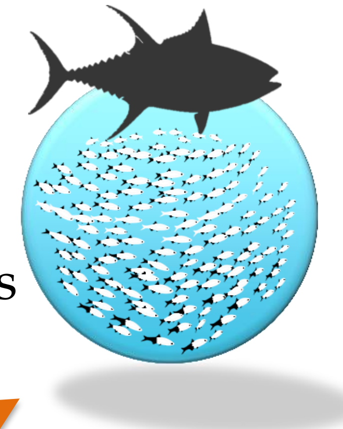
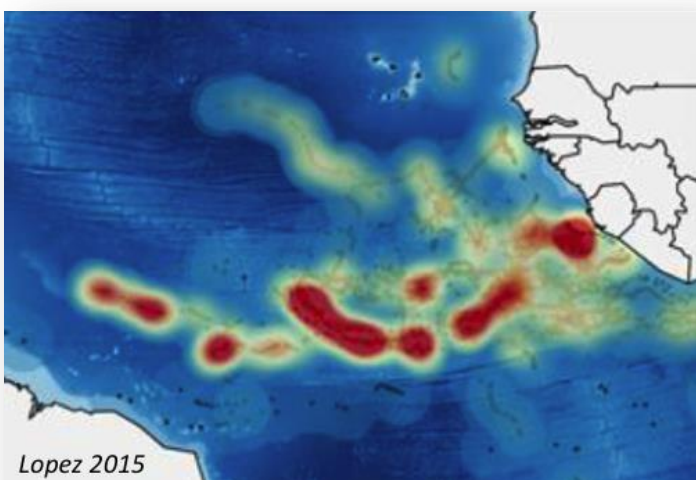
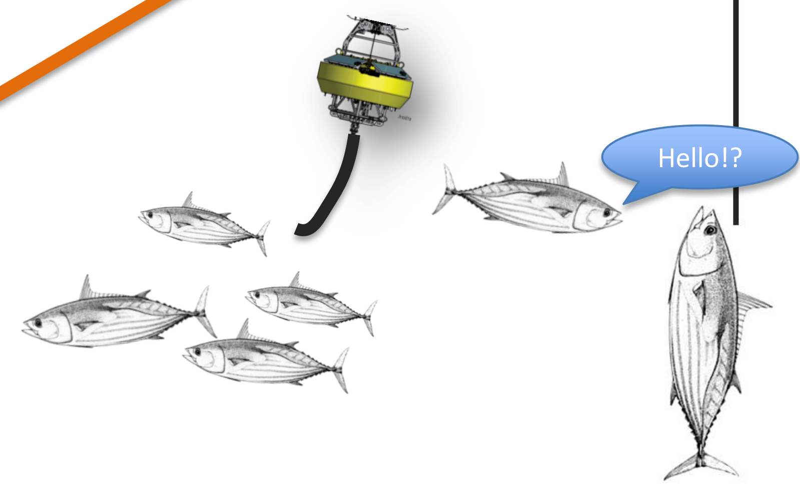
- Horizontal and vertical movement from electronic tags
- Incorporate feedbacks between environment and individuals (particularly FADs)







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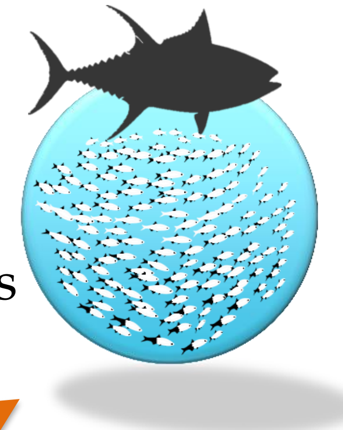
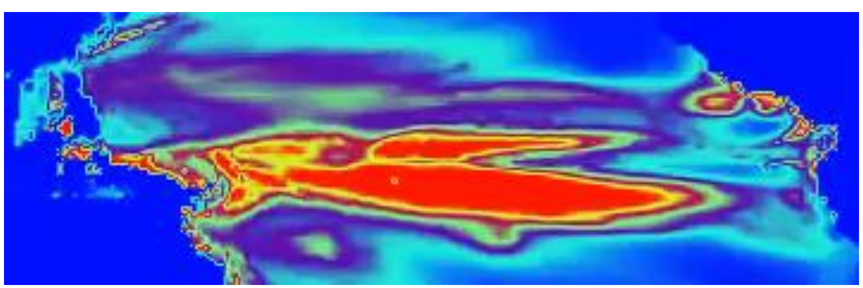
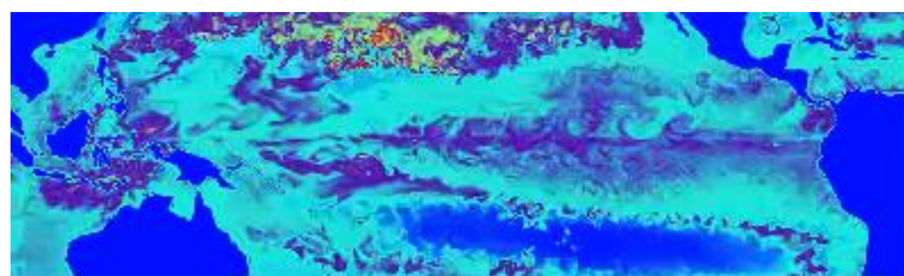
- Movement simulation tool for pelagic species
- Use in analysis and design of tagging experiments
- Parameterise from conventional tag data
- Horizontal and vertical movement from electronic tags
- Incorporate feedbacks between environment and individuals (particularly FADs)
- Eddy-resolving resolution ocean forcing







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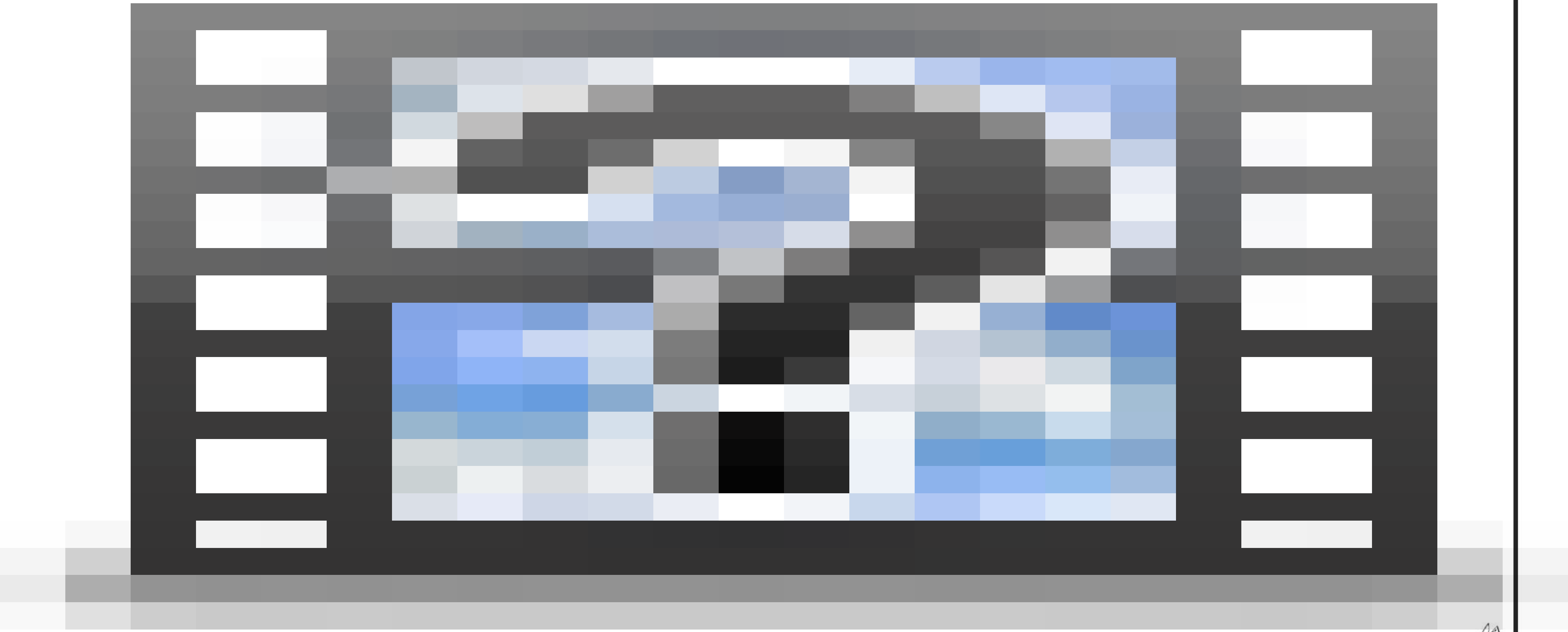

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