Analysis of loggerhead turtles tracks in the North Pacific to parameterize a feeding habitat and movement model

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CLS

COLLECTE LOCALISATION SATELLITES

Loggerhead turtles in the North Pacific

80% decrease of nesting females between 1970 and 2000 on Japanese nesting beaches (Kamezaki et al. 2003, Limpus & Limpus 2003)

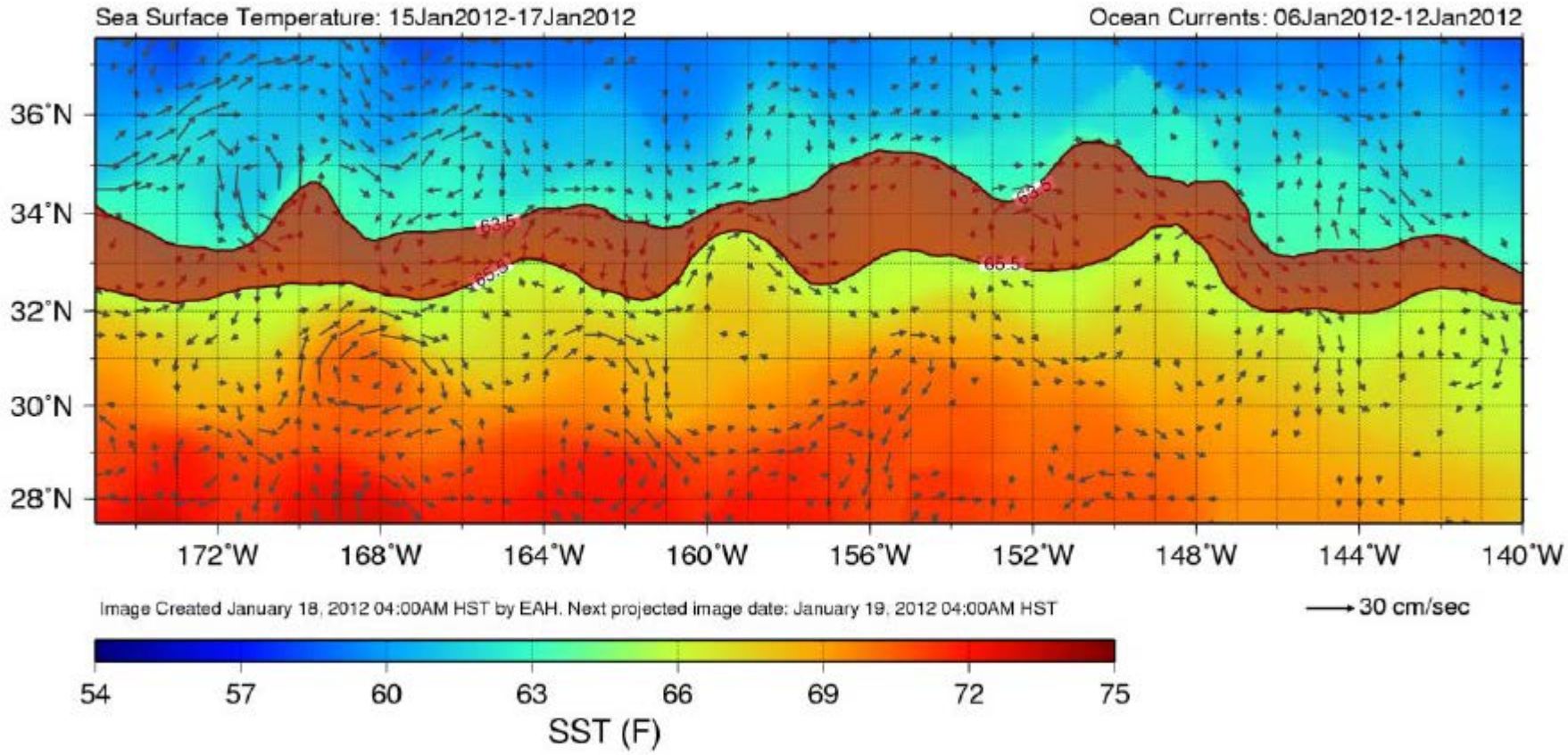
-> protection measures at each life stage

Loggerheads are frequent fishery bycatch, especially in the longline fisheries targeting swordfish at night (shallow sets)

North Pacific population relisted as endangered in 2011.

EXPERIMENTAL PRODUCT

avoid fishing between solid black 63.5°F and 65.5°F lines
to help reduce loggerhead sea turtle interactions



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Data provided by Central Pacific CoastWatch node

TURTLEWATCH

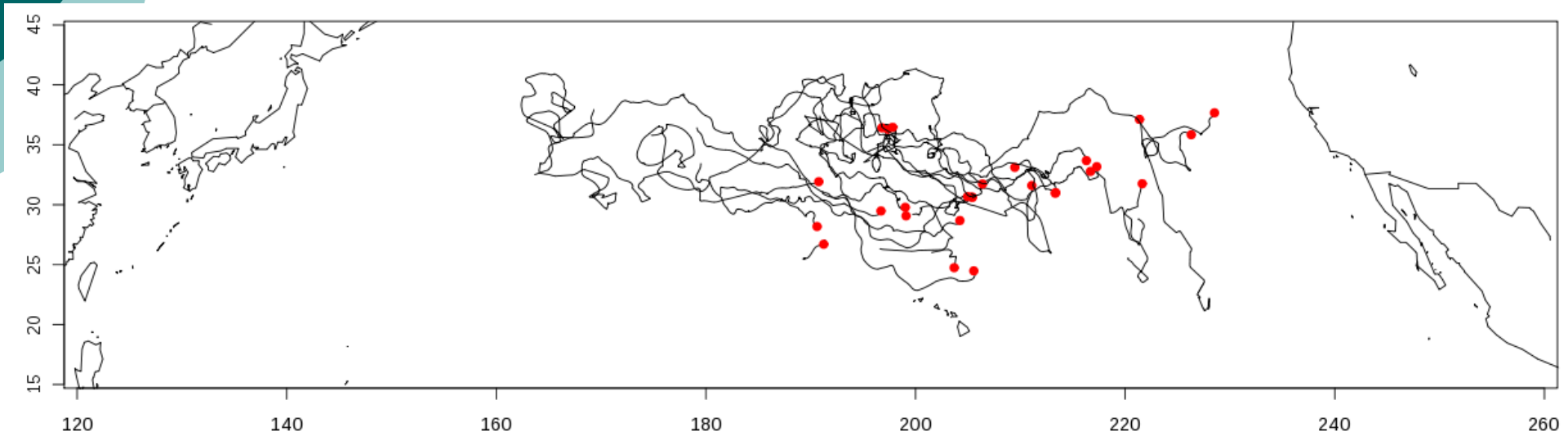
Howell et al. 2008

Study of loggerhead habitat


NATIONAL MARINE
FISHERIES SERVICE
MARINE
TURTLE
PROGRAM

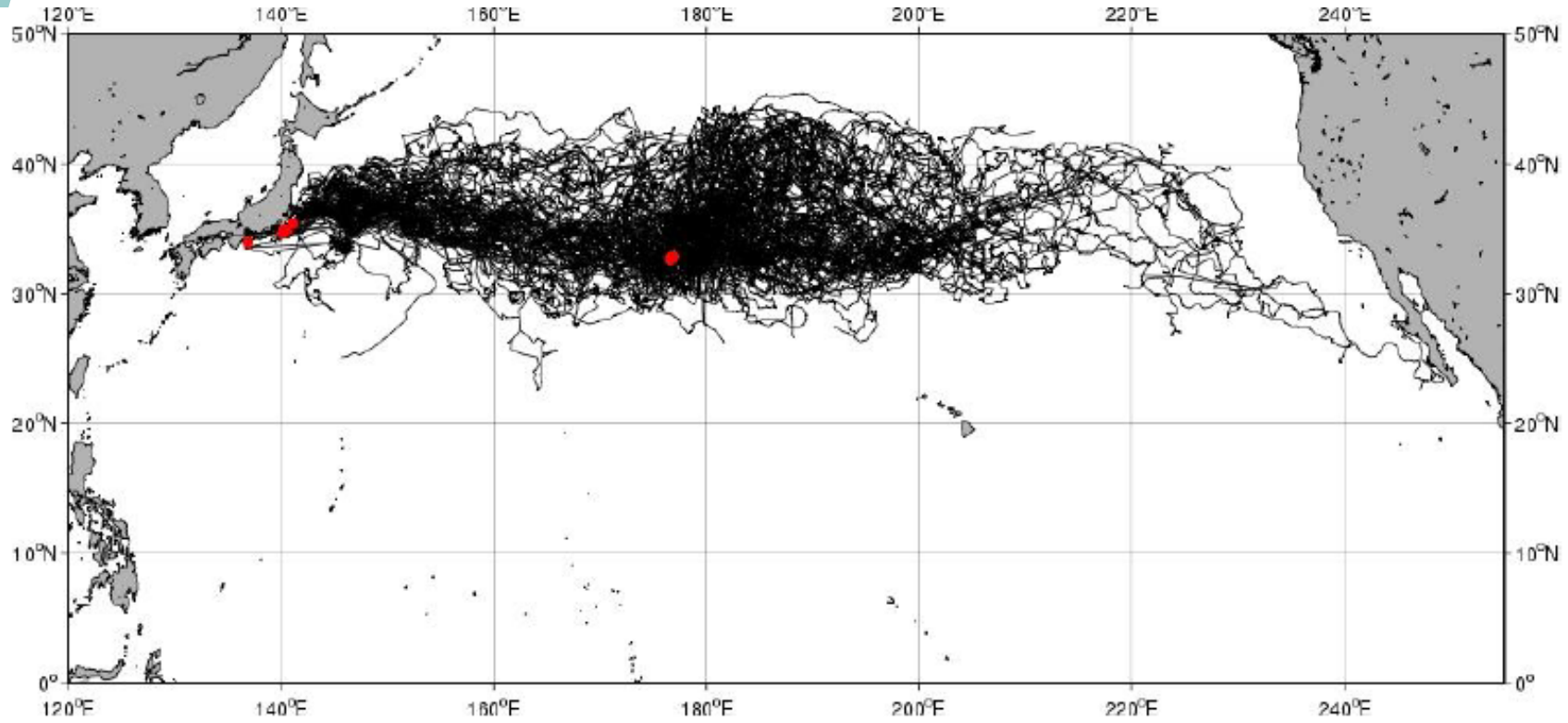
Hawaiian releases

sizes=41-83cm, n=27
Released from Jan. 1997 to Aug. 2000
From commercial longliners
Track durations: 13 - 597 days

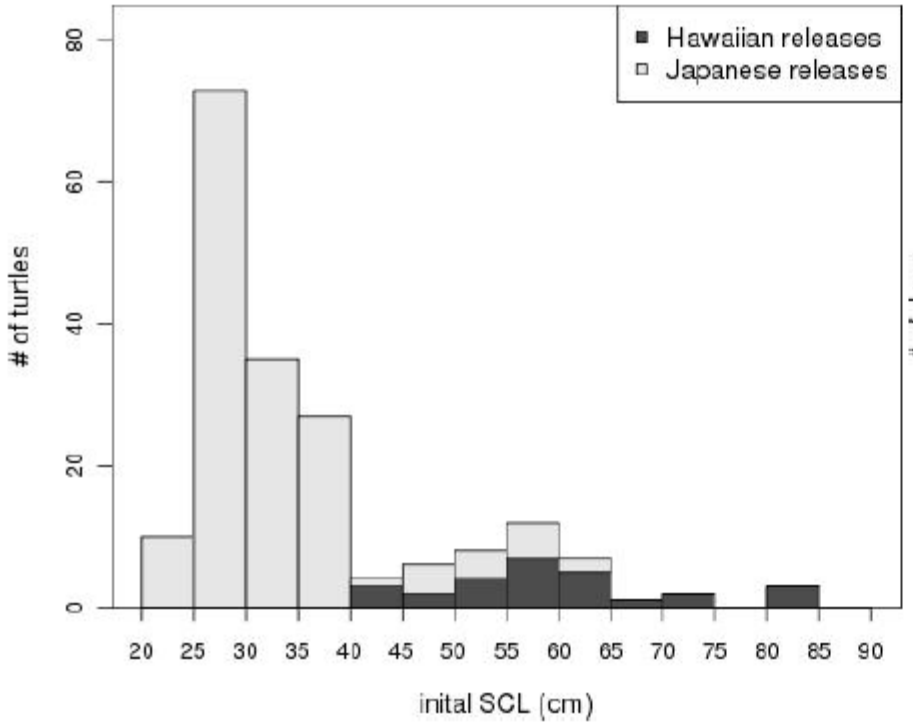


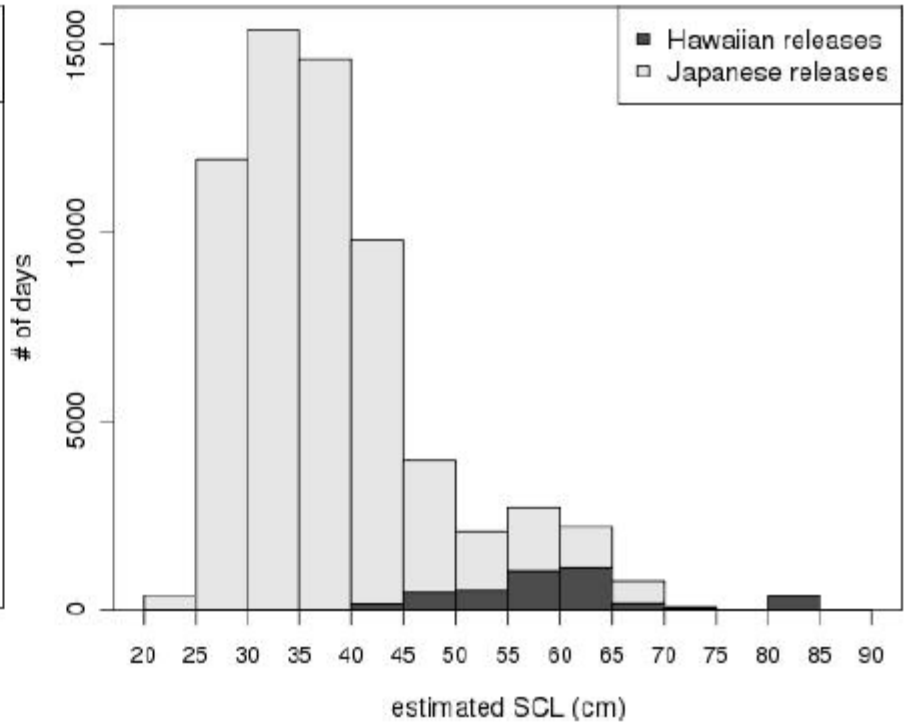
Japanese releases

Reared at the Nagoya Aquarium
sizes=23-65 cm, n=116
Released from Apr. 2003 to Sept. 2007
Track durations: 27 - 1368 days



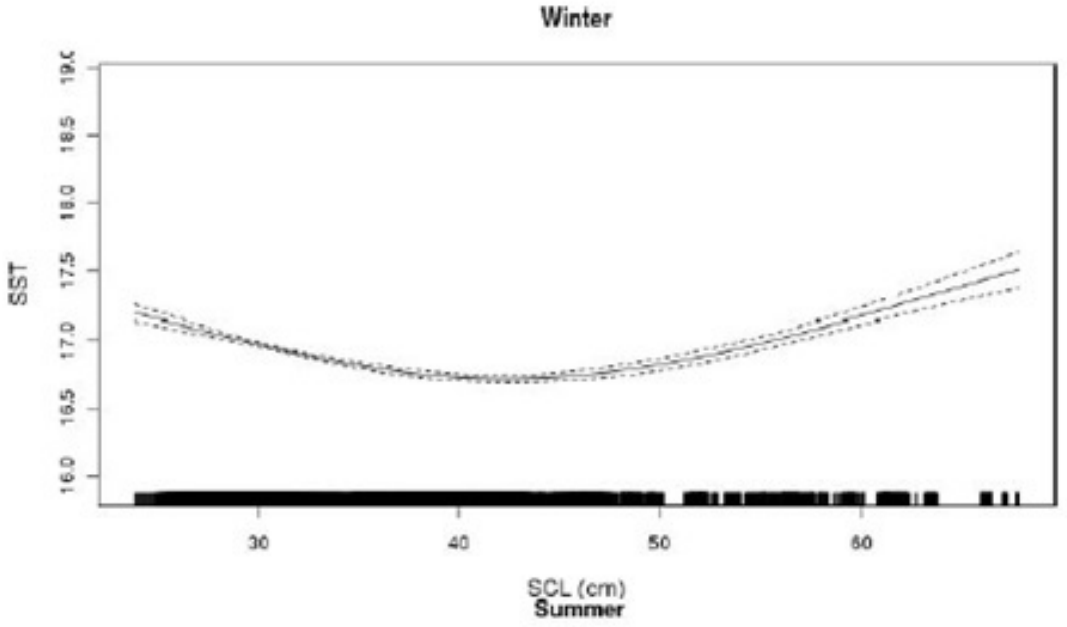
Size distribution

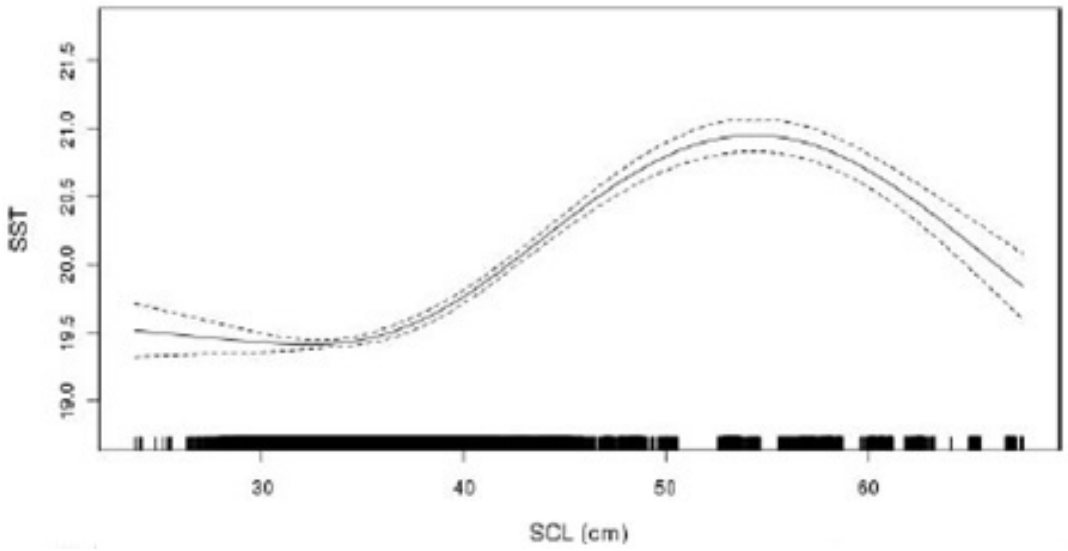




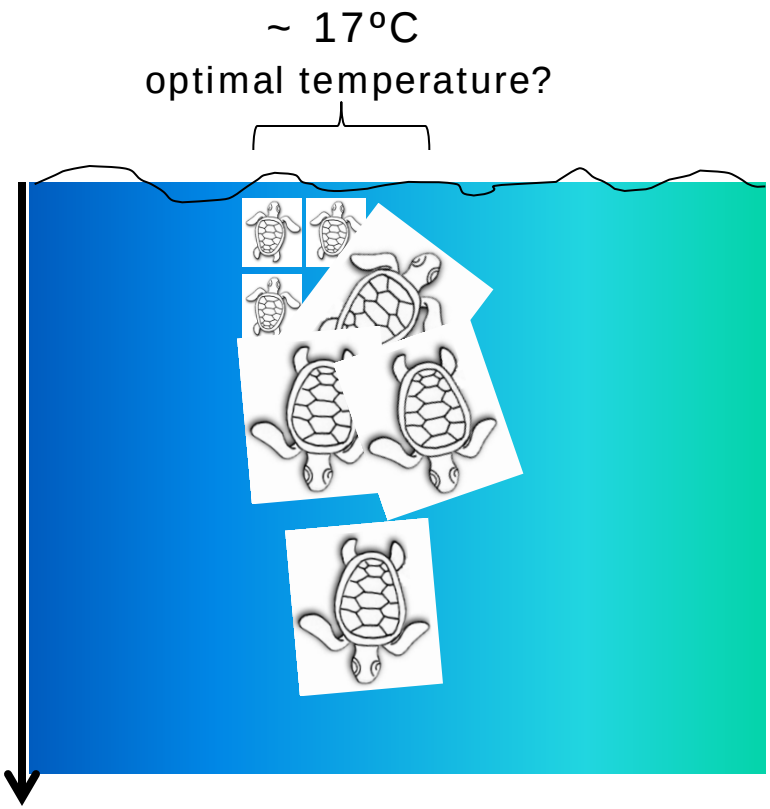
Scott et al. 2011

Temperature preference

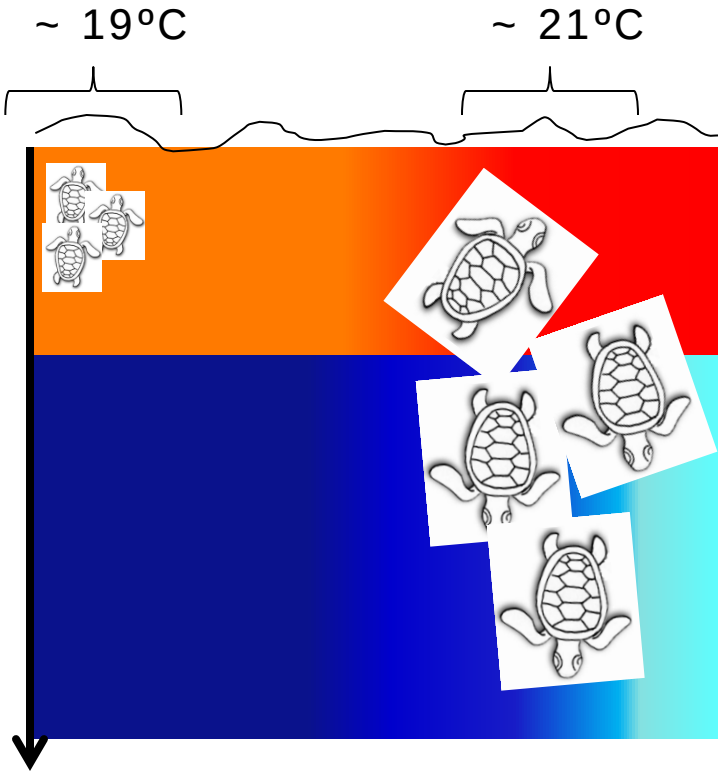




-> optimal temperature ~ 17ºC ?



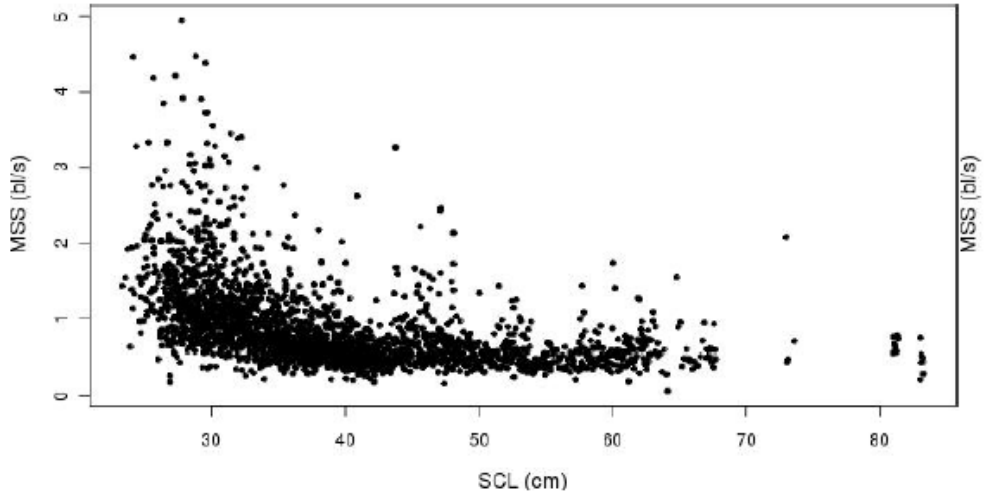
winter : no stratification

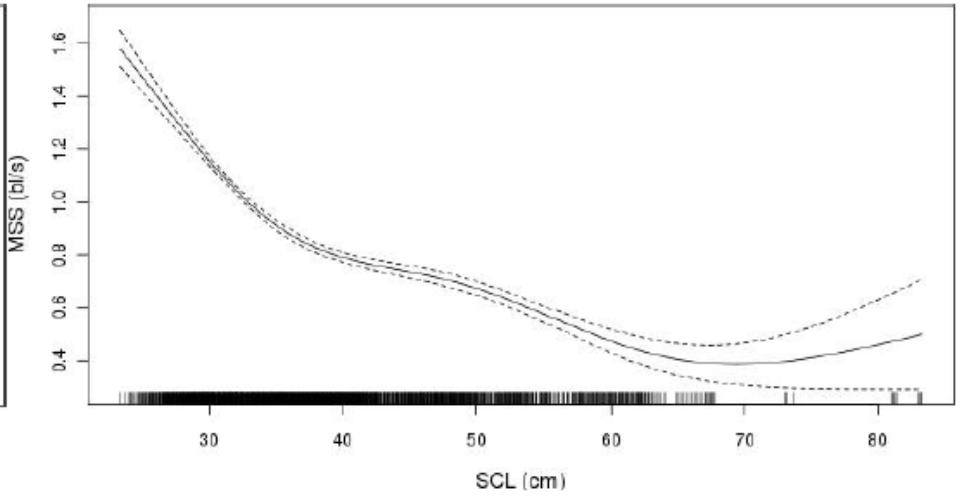


summer : strong stratification

Rewarming behavior: Hochscheid et al. 2010

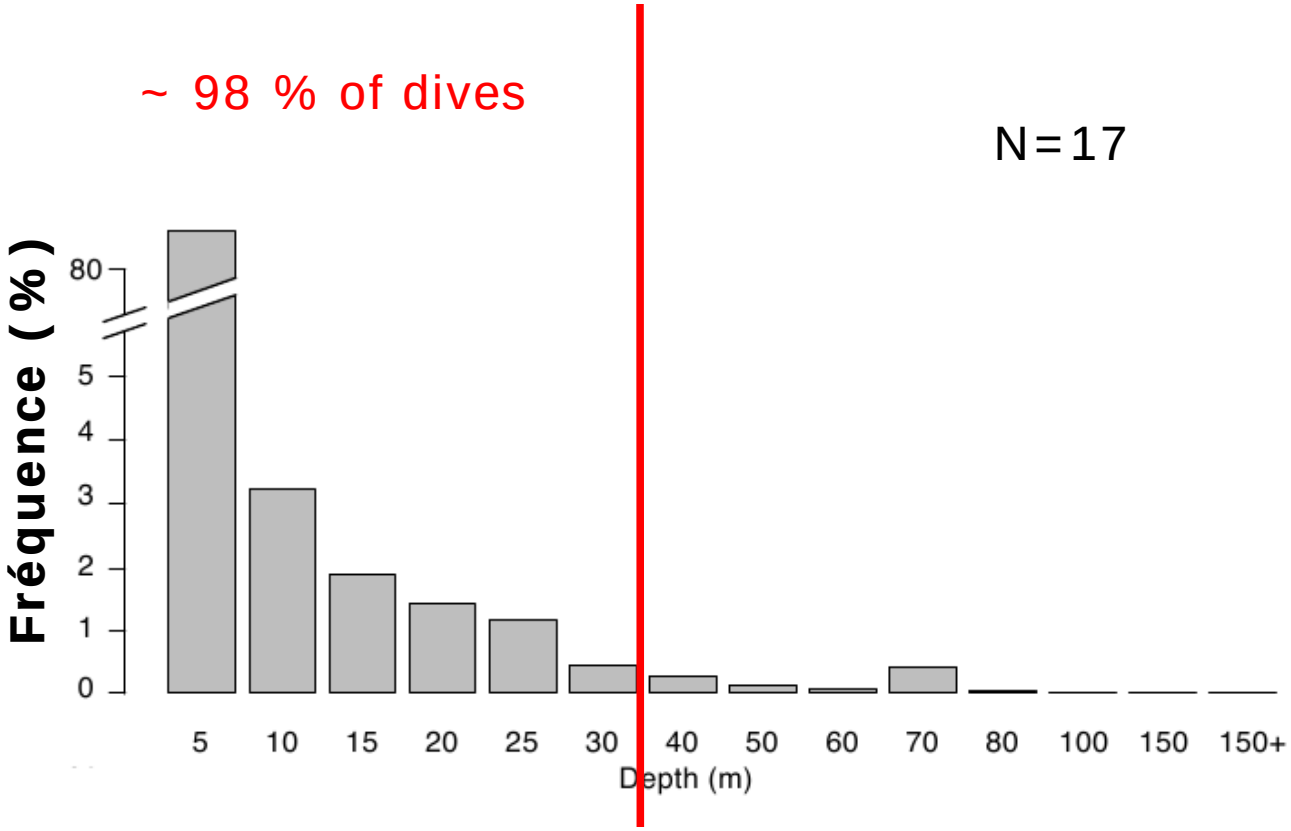
Maximum Sustainable Speed (MSS)





After removing the velocity of ocean currents from the velocity observed for each animal (Gaspar et al. 2006)

Vertical distribution of turtles

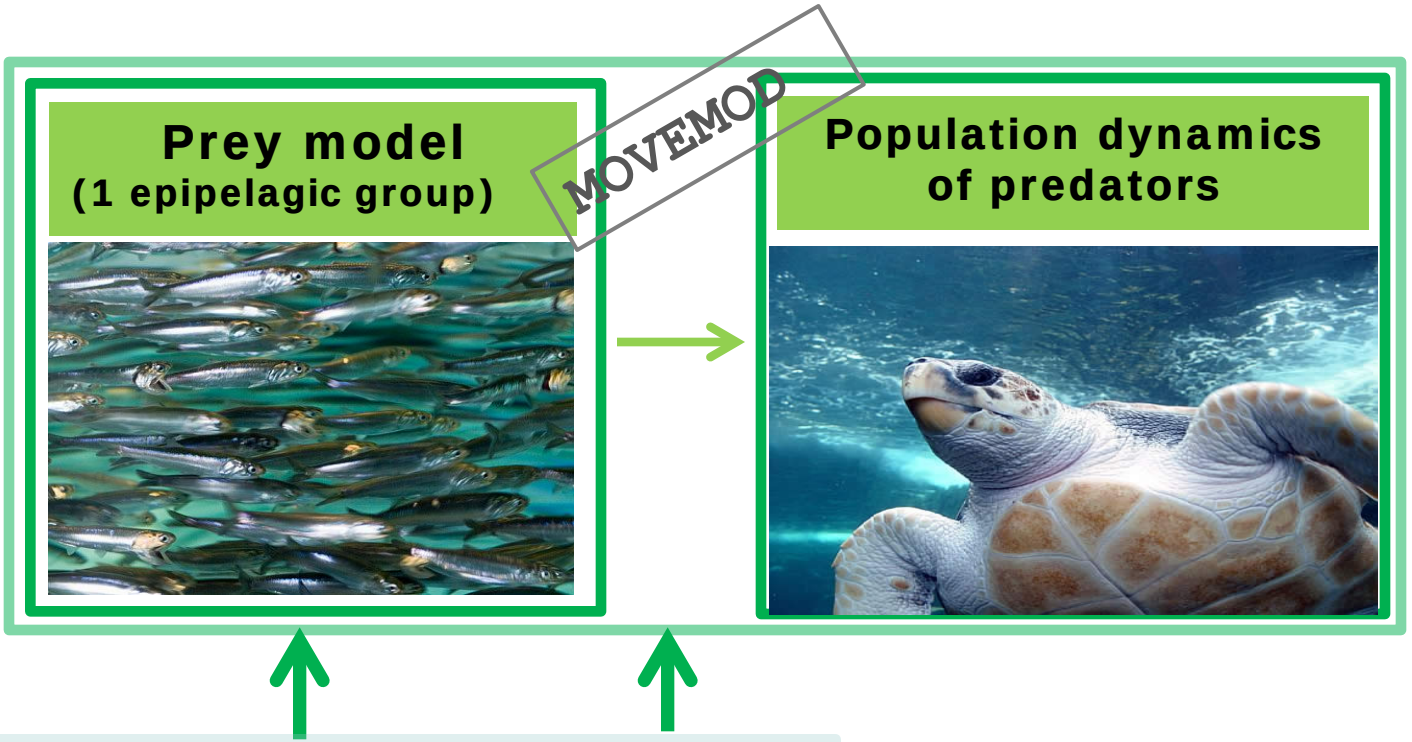


Howell et al. 2009

A simplified version of SEAPODYM for turtles

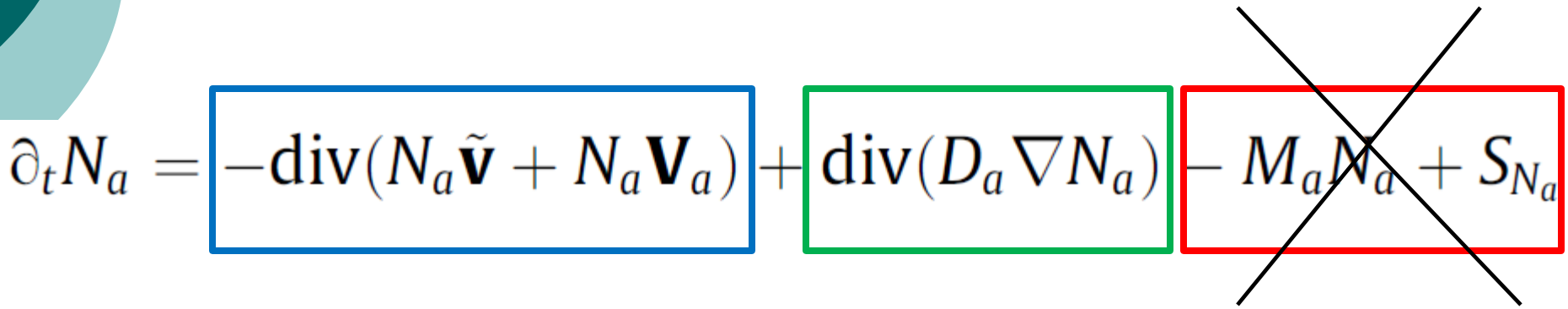
MOVEMOD

MOVEMOD



Adapted from I. Senina

Advection - Diffusion - Reaction



N_a = density of fish at age a

$\tilde{\mathbf{v}}$ = weighted mean of current velocity in each vertical layer

V_a = speed of fish at age a
D_a = diffusion rate of fish at age a
M_a = total mortality (natural + fishing) for fish of age a
S_{Na} = sources of fish of age a

Advection - Diffusion

Only one age cohort

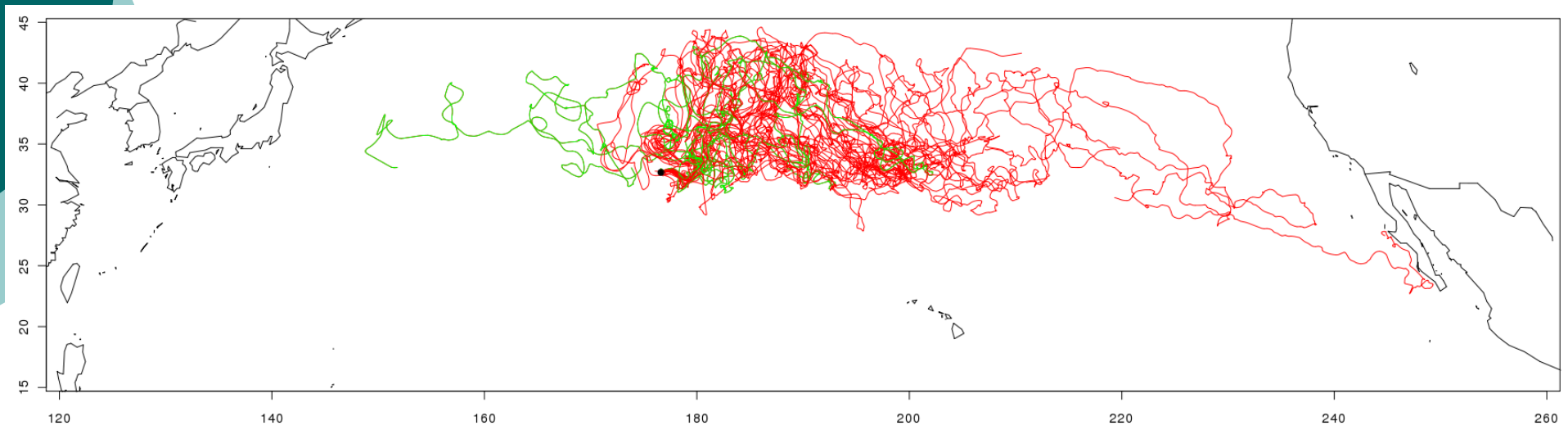
$$\partial_t N = -\mathrm{div}(N\ \tilde{\mathbf{v}} + N\ \mathbf{V}) + \mathrm{div}(D\ \nabla N)$$

Turtles movements directed towards areas of favorable habitat :
favorable temperature and **abundance of preys**

Turtles preys: neuston (organisms floating at the surface)
Not available in seapodym
-> proxy used : epipelagic component of the micronekton

Group “japanese” turtles released the same day

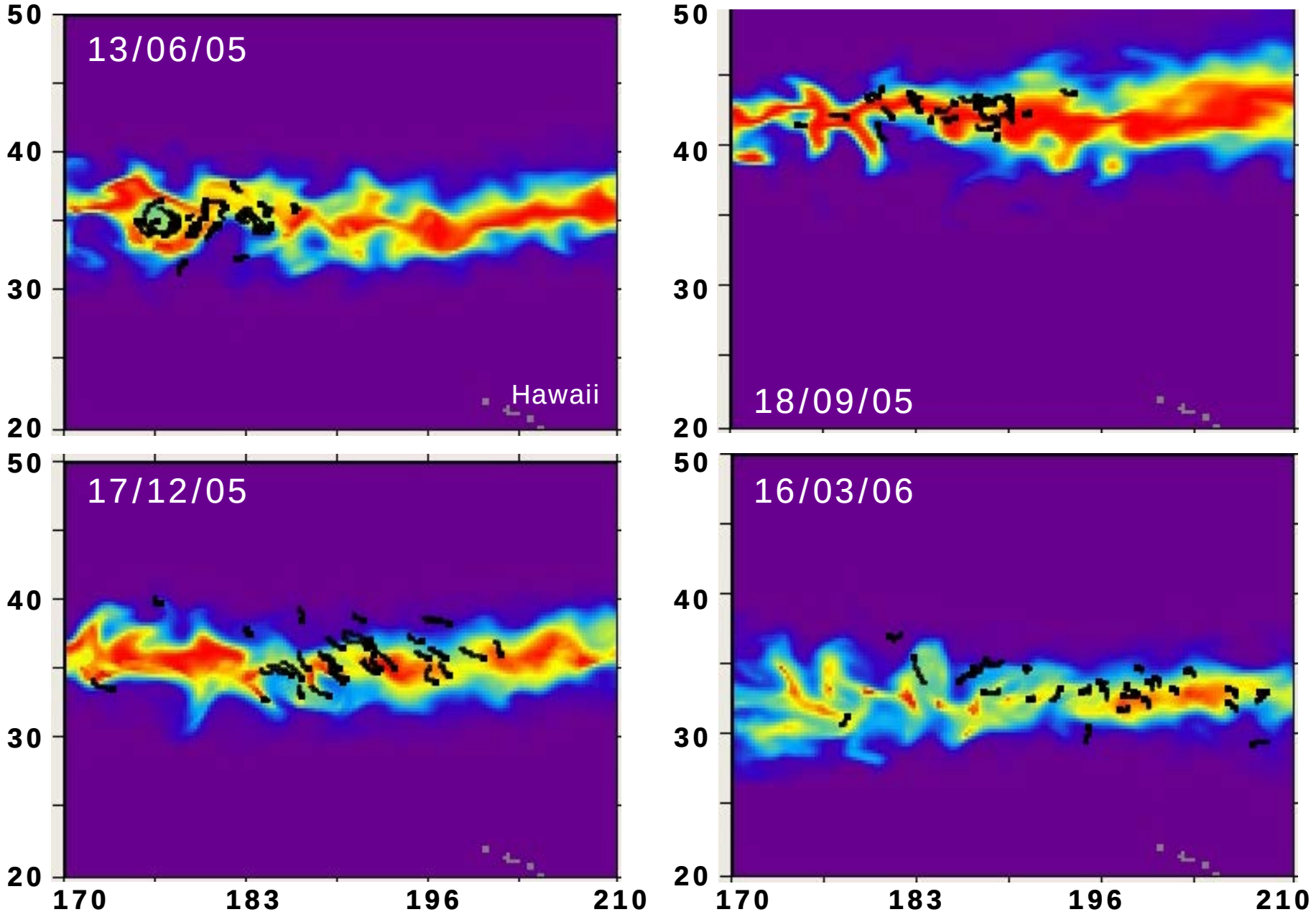
04/05/05 (n=29)



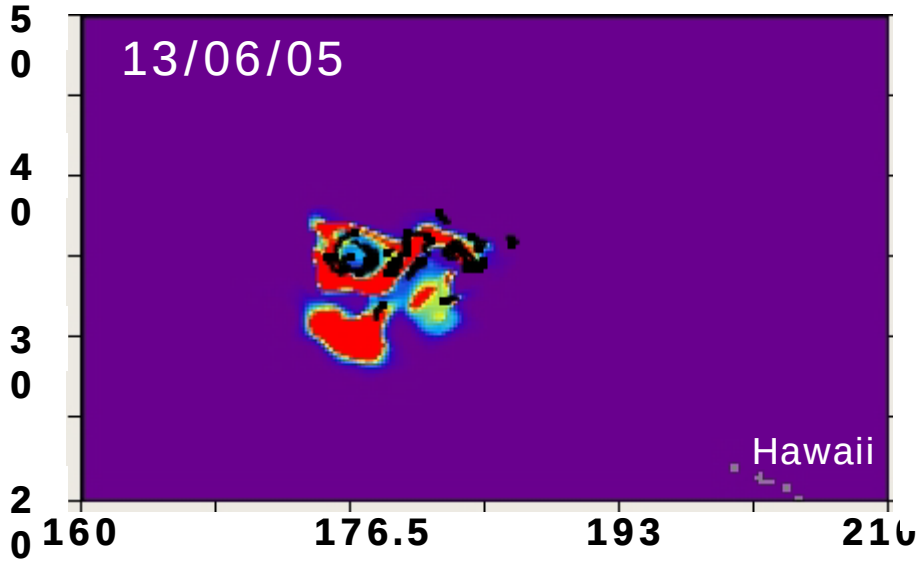
sizes = 29.6 - 38.4 cm
Mean size = 34.6 cm

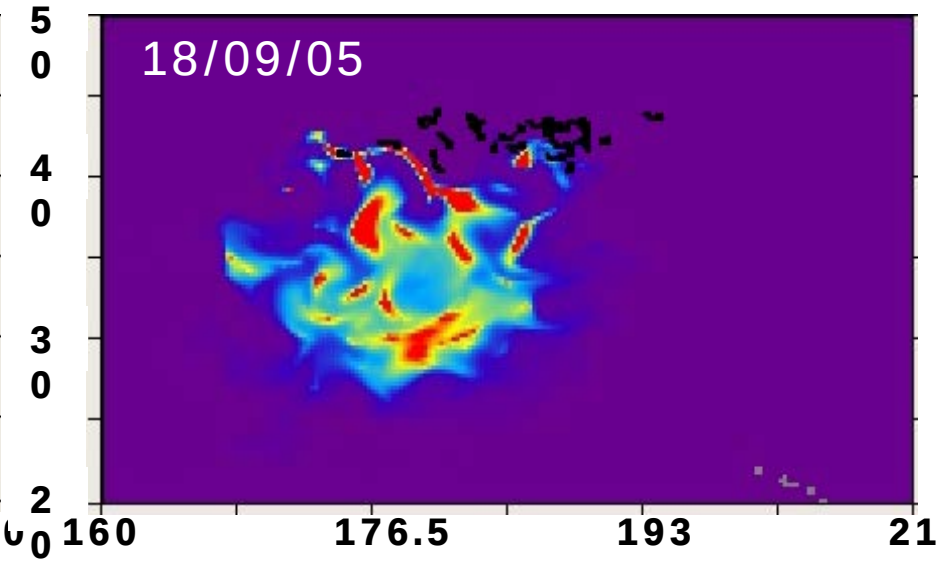
green : last location to the west of the first
red : last location to the east of the first

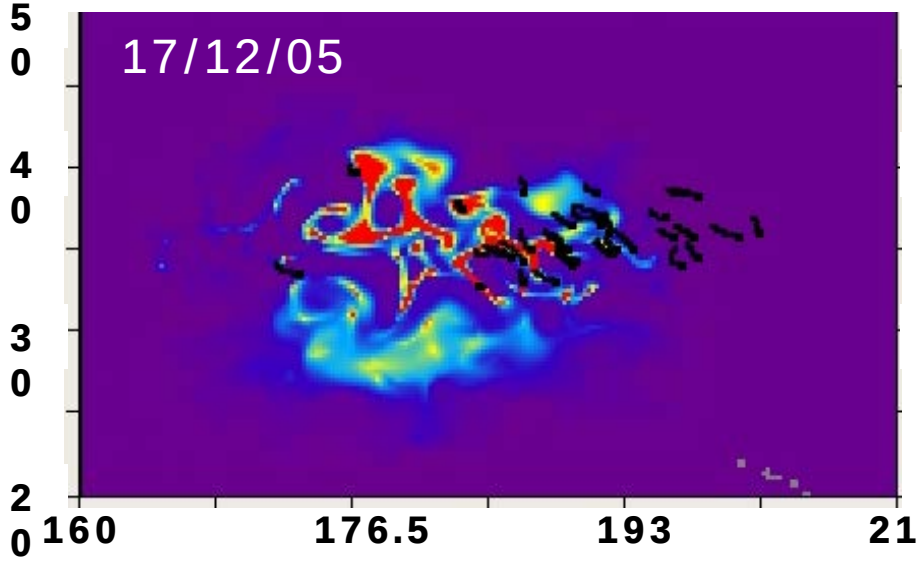
Simulation of the habitat index

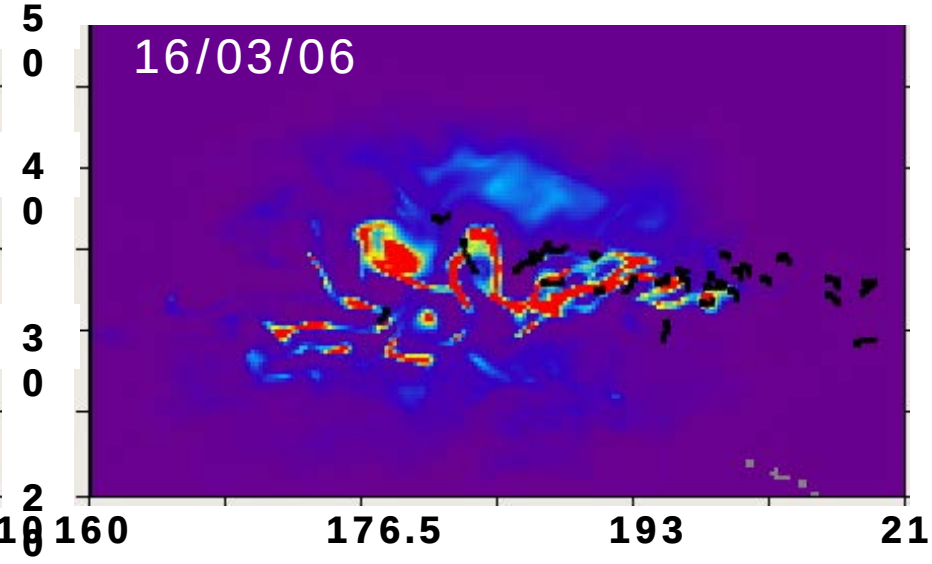


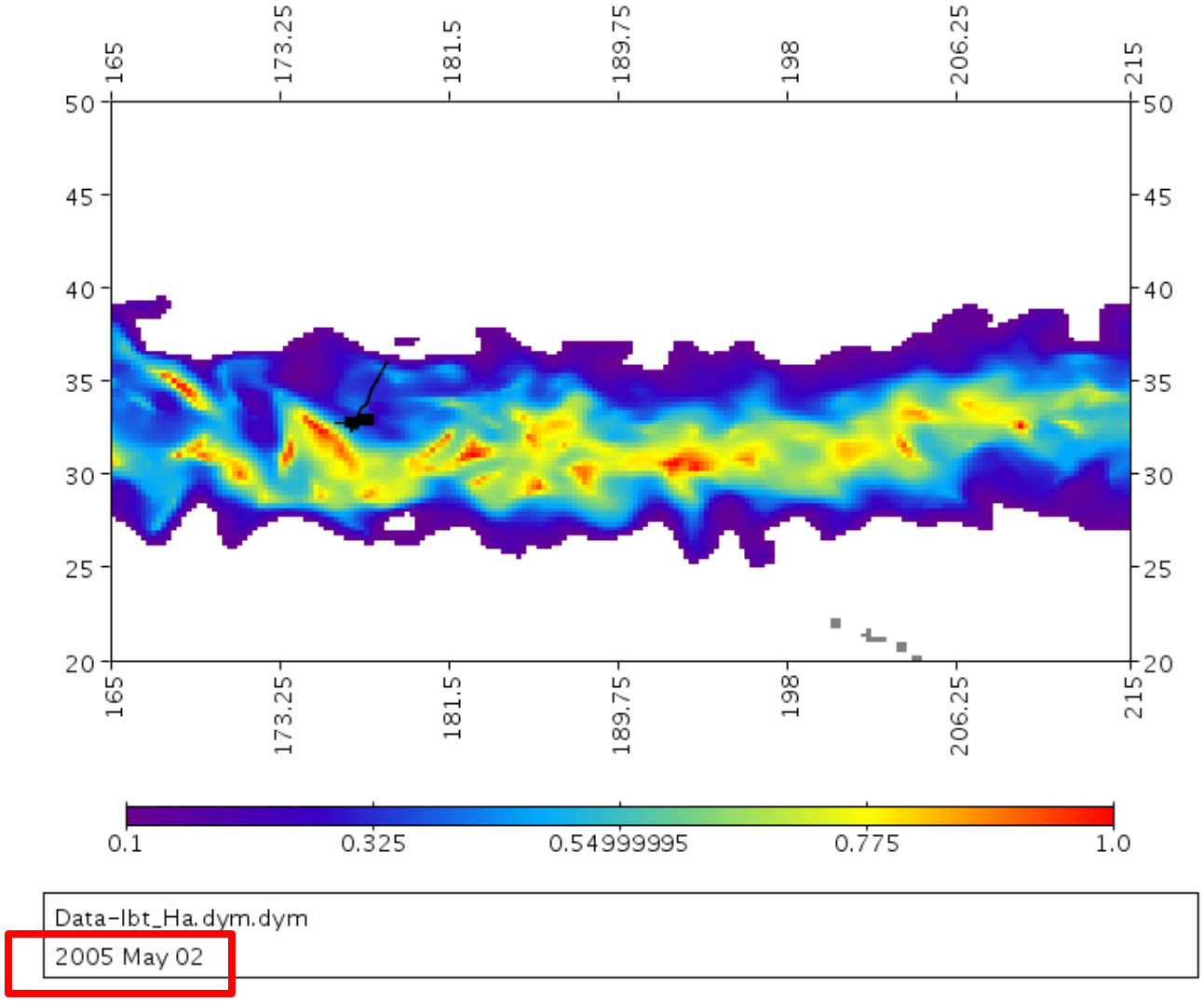
Simulation of movements





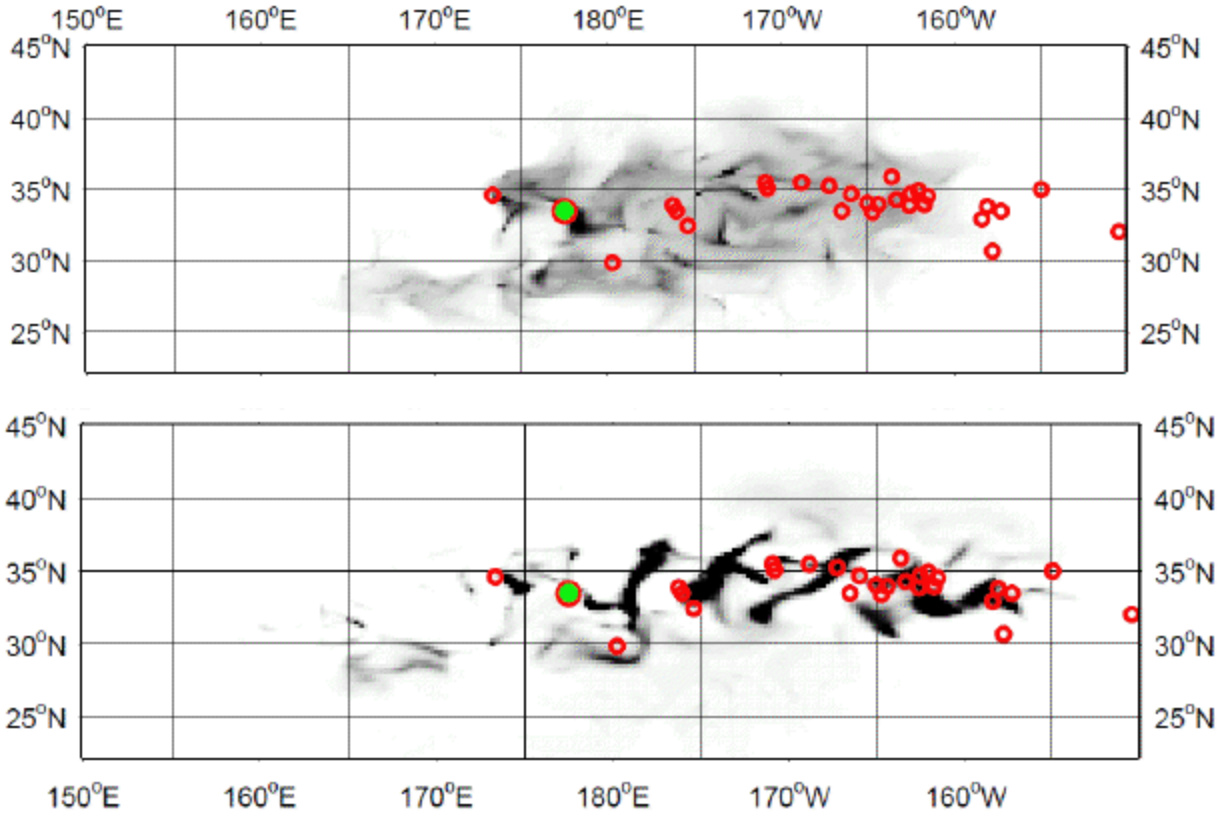






Disconnect observed in aug./sep. : possible improvement by defining a neustonic prey field

Small turtles: passive drift ?

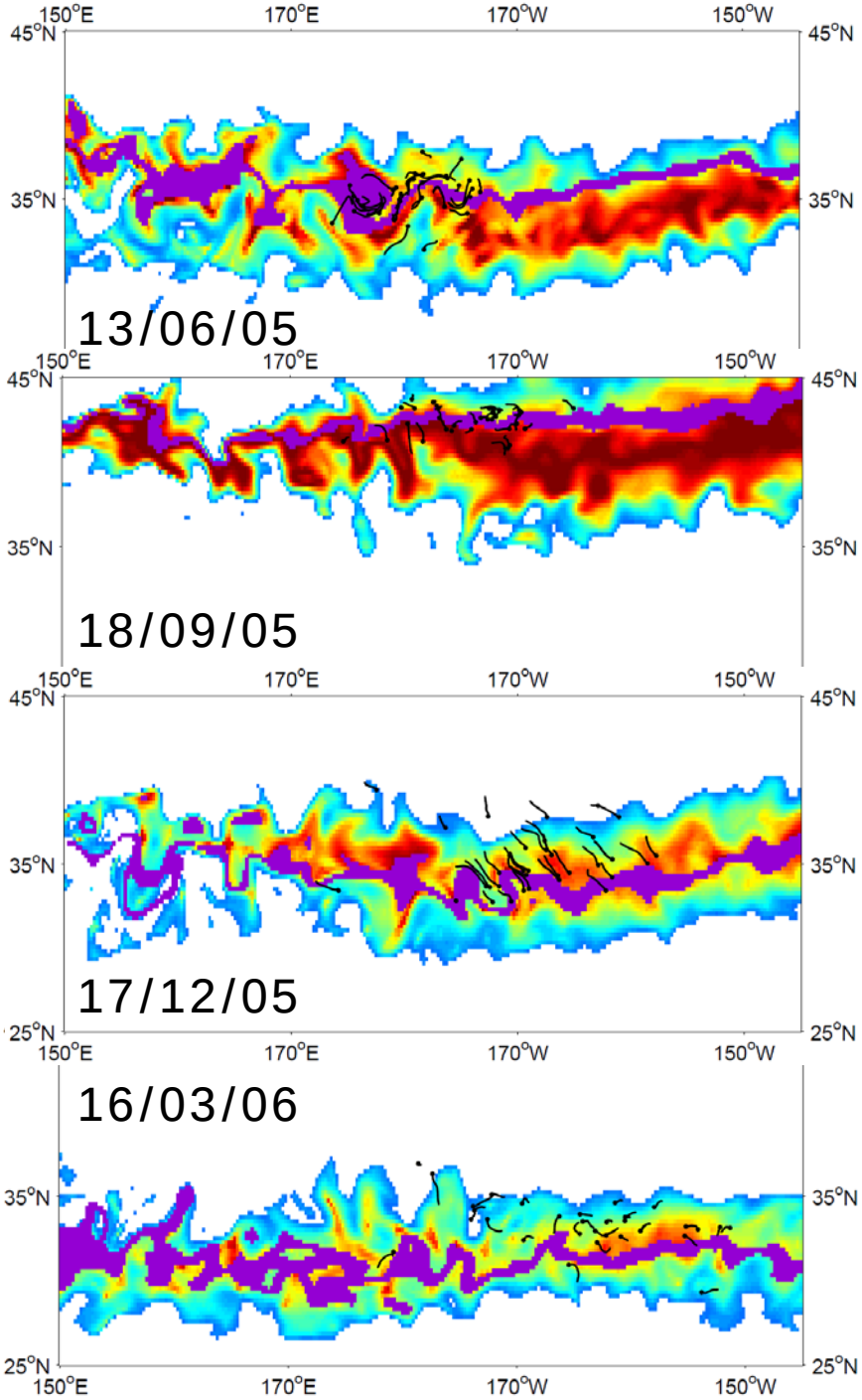


Passive drift in ocean currents only

Currents + turtle movements

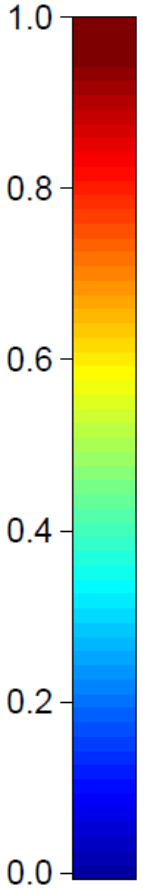
Better representation of aggregations, probably indicative of prey concentrations

-> even small turtles (35 cm) are capable directed movements

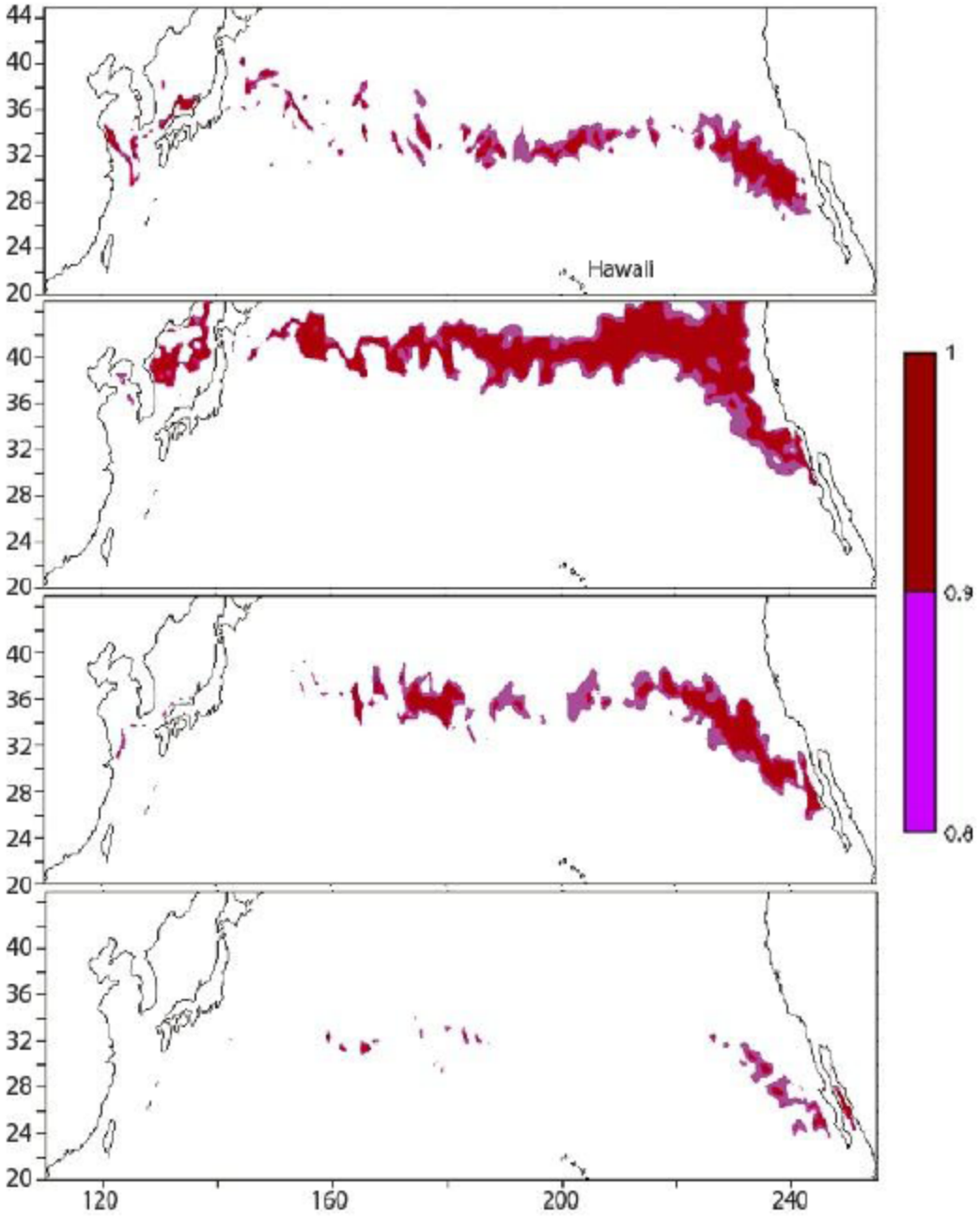


Purple area:
TurtleWatch = f(SST)

H_a = f(T) * f(preys)



Approach more complete than TurtleWatch.
General agreement between the two indices



Predicted hotspots

Movements Hawaiian releases

- Mainly westward
- Not reproduced during simulations
- Most Hawaiian releases were bigger than the Japanese
- Might mean that temperature and prey concentrations are not enough to describe older turtles dynamics (homing instinct towards nesting beaches ?)

Conclusions

- Movemod : generally good agreement with observed movements using basic concepts
- An approach more complete than turtleWatch that needs to be improved
- Need for a better representation of loggerheads prey field
- Could be refined using turtle tracks to optimize habitat and movement parameters (next version of Movemod)
- Movements towards nesting beaches ?