Environmental Effects of Once-through Cooling
Research Result Symposium, January 2008

Assessing the

Impact of Entrainment

along Open Coasts

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Outline.

One can observe entrainment of meroplankton,
but what is the effect of this on recruitment?
(entrainment vs whole population or "source water")

Three power plant scenarios: open coast, enclosed
basin $(T_r > T_{pld})$, channel between basin and ocean.

Focus on *open coast scenario*.

How much is entrained?
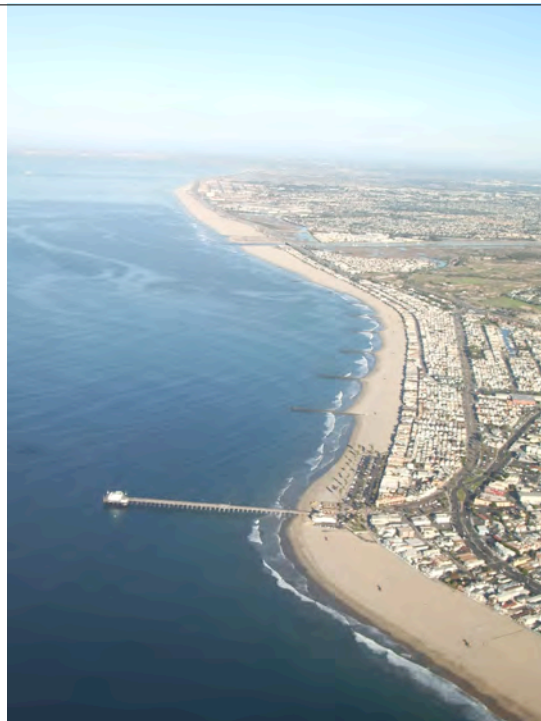
Where does it come from?

Where would it have recruited?

Cumulative effects - additional power plants,
MPAs, thermal effects, etc.

Outline.

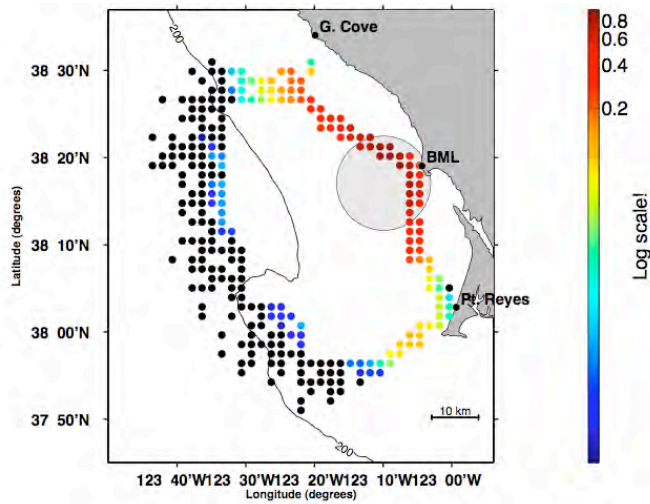Focus on *open coast scenario*:

- Observations of nearshore currents.

- Two-dimensional particle-tracking model.

- Model results for specific cases.

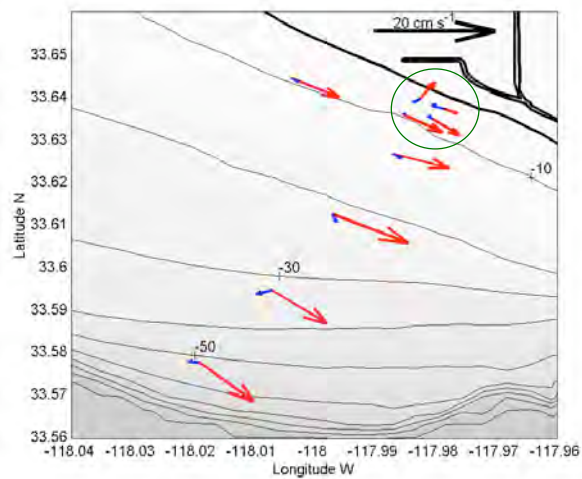- Connectivity matrices.

Nearshore Currents

Nearshore currents.

Origin of plankton off Bodega,
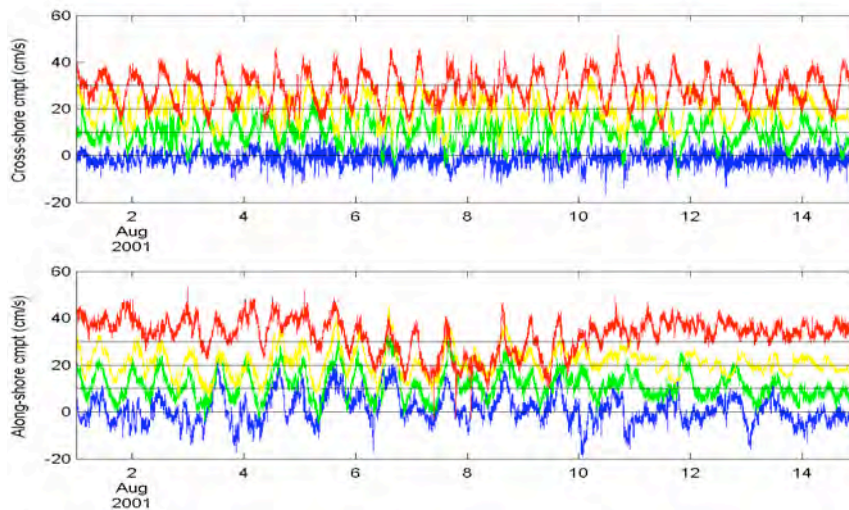using particle model with HF radar data.

Nearshore currents.

OCSD 2001 studies off Huntington Beach -
- mean surface currents weaker nearshore.

Nearshore currents.

OCSD 2001 studies -
  - cross-shore flow fluctuations weaker nearshore.

Coastal boundary layer.
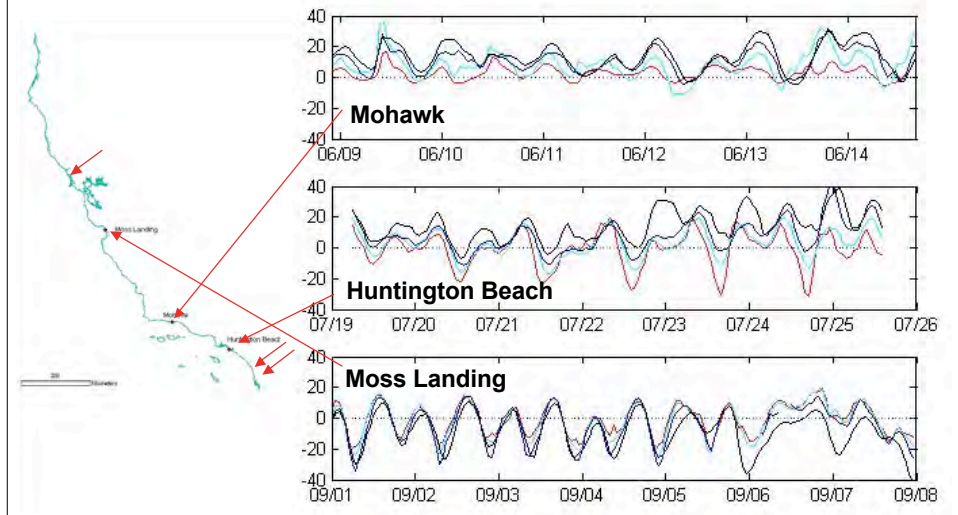
Multiple studies -
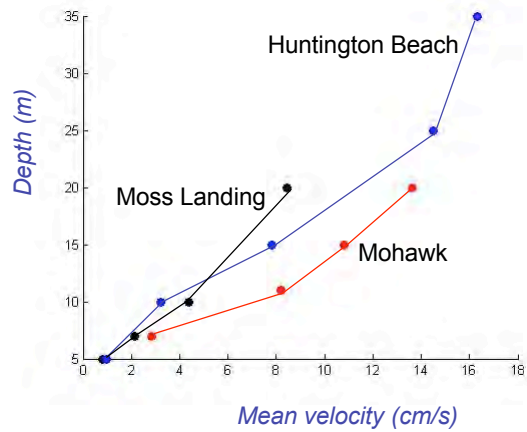 - weaker flows nearshore (mean & var. alongshore).

Coastal boundary layer.

Multiple studies -
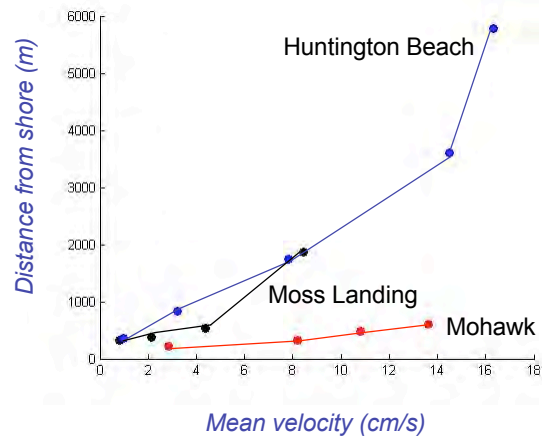- weaker flows nearshore (mean & var. alongshore).

Coastal boundary layer.

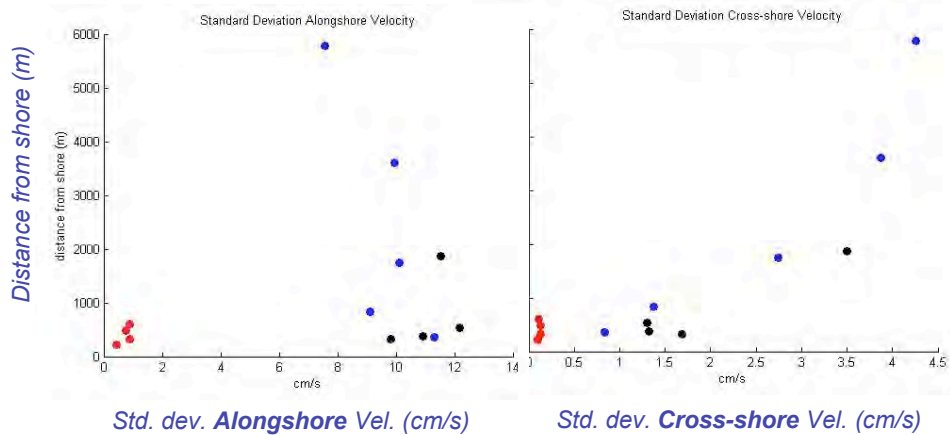Stronger mean alongshore flow in *greater depths* ?

Coastal boundary layer.

Stronger mean alongshore flow *further from shore* ?

Coastal boundary layer.

Also, important cross-shore differences in strength of variable alongshore and cross-shore flows - i.e., *diffusion*.

Numerical Model of Nearshore Dispersion

Numerical model.

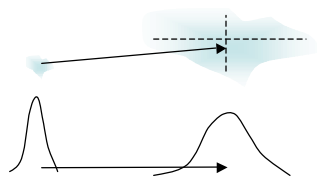Decompose real flow velocity into alongshore and cross-shore.

Mean current over period of interest (PLD) is "*advection*", while fluctuations in flow (e.g., standard deviation) give "*diffusion*".

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Numerical model.

Decompose real flow velocity into alongshore and cross-shore.

Mean current over period of interest (PLD) is "*advection*", while fluctuations in flow (e.g., standard deviation) give "*diffusion*".

Model tracks many particles, each moved by given advection every time step and also moved random amount (scaled by observed diffusivity).

Numerical model.

Base case (advective) …

Alongshore adv = 0.1m/s

Cross-shore adv = 0

Alongshore diff = $10m^2/s$

Cross-shore diff = $10m^2/s$

Time step = 2 minutes

CBL width = 10km
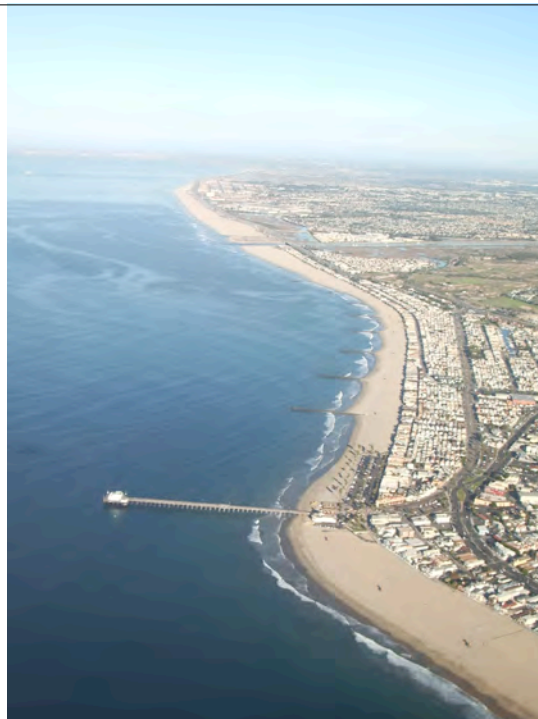
Duration = 20 days

Intake = 35 m^3/s (~900mgd)

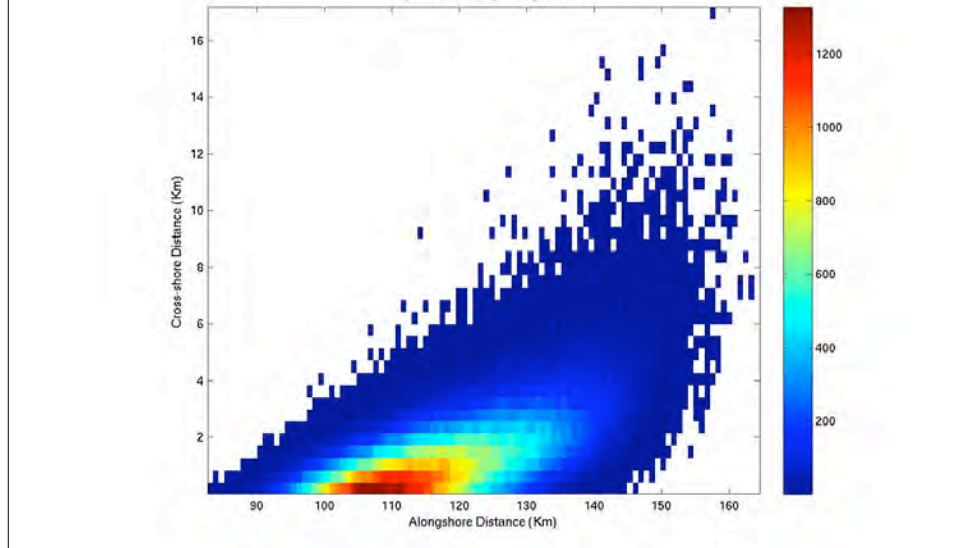No. Particles = 200,000

Model Results
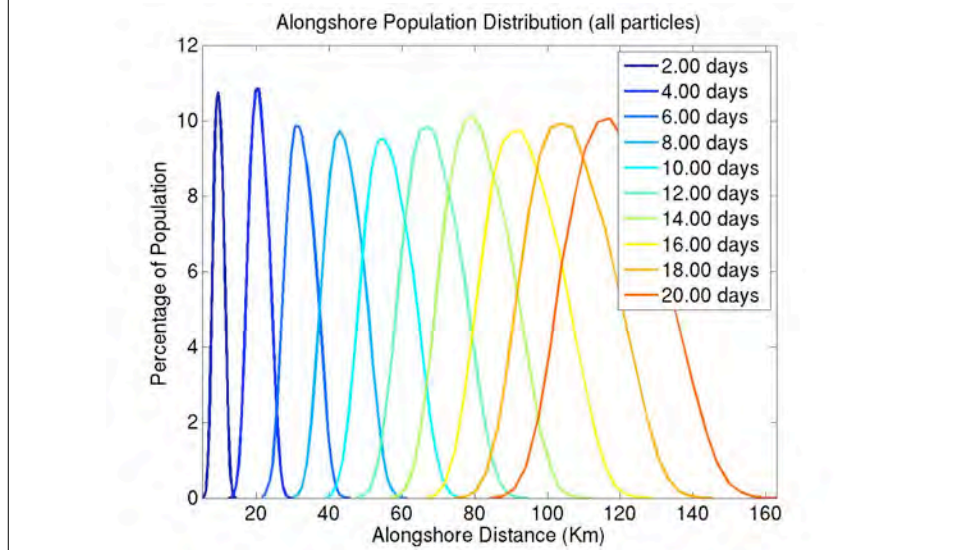
Specific Cases

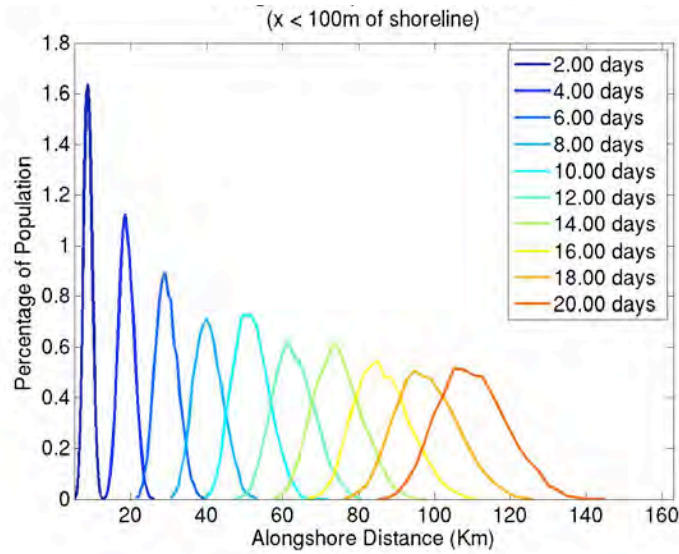# *Base case.*

Particle distribution after 20 days.

Base case.

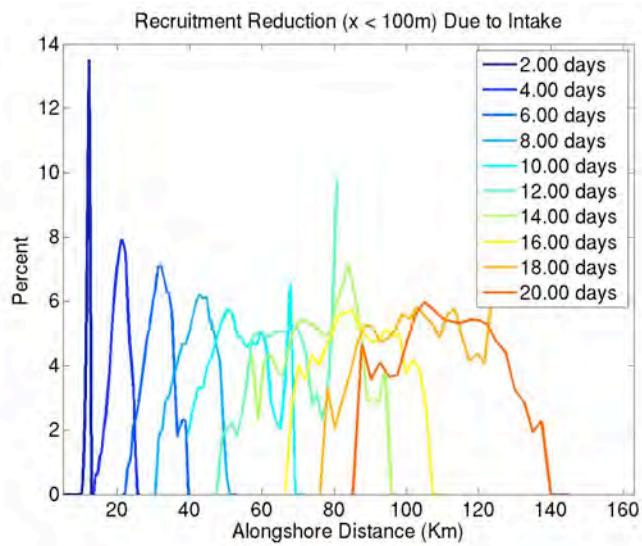Particle distributions for variety of time periods.

Base case.

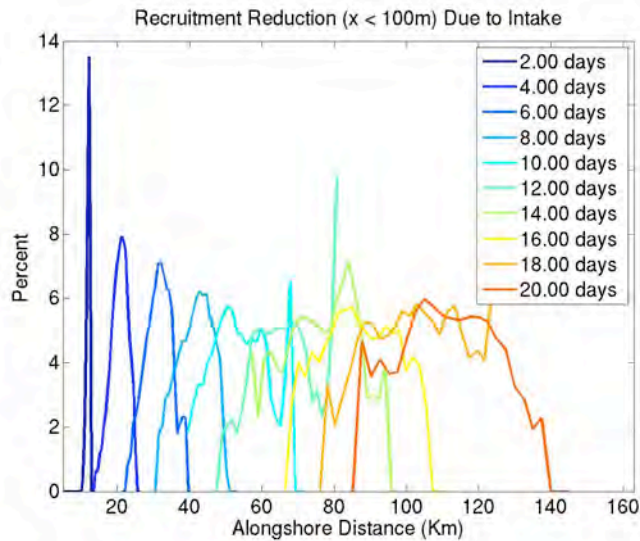"Recruitment supply" - nearshore particle distributions.

Base case.

Reduction in recruitment due to entrainment. "Mortality"

Base case.

Reduction in recruitment due to entrainment. "Mortality"

Recruitment Reduction (x < 100m) Due to Intake

Legend:
- 2.00 days
- 4.00 days
- 6.00 days
- 8.00 days
- 10.00 days
- 12.00 days
- 14.00 days
- 16.00 days
- 18.00 days
- 20.00 days

Notes …
… entrainment as intake count or reduction in recruitment
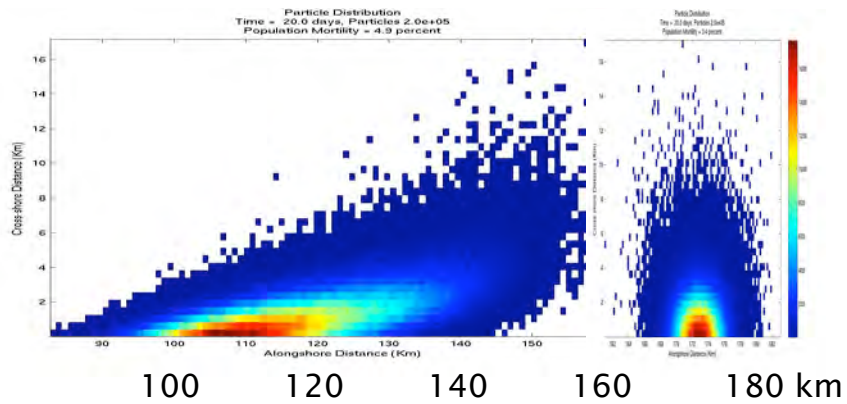… variation in age of larvae entrained (stage-specific mortality)
advective vs diffusive

Base case.

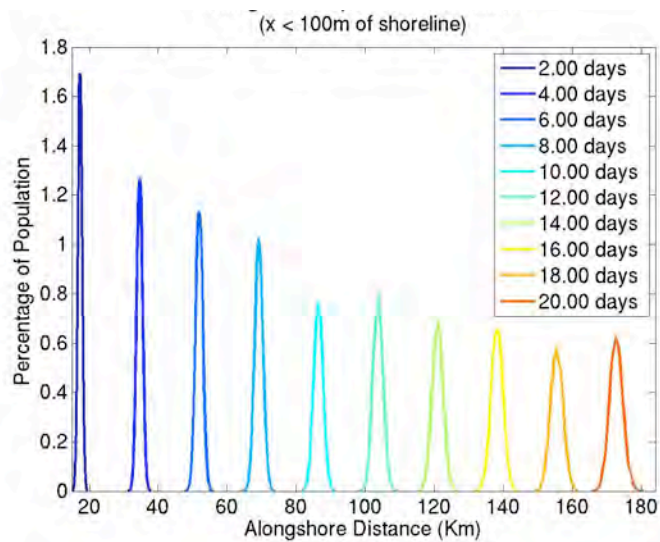Mean trajectory for larvae recruiting after 20 days.

With x < 100m at End of Model Run
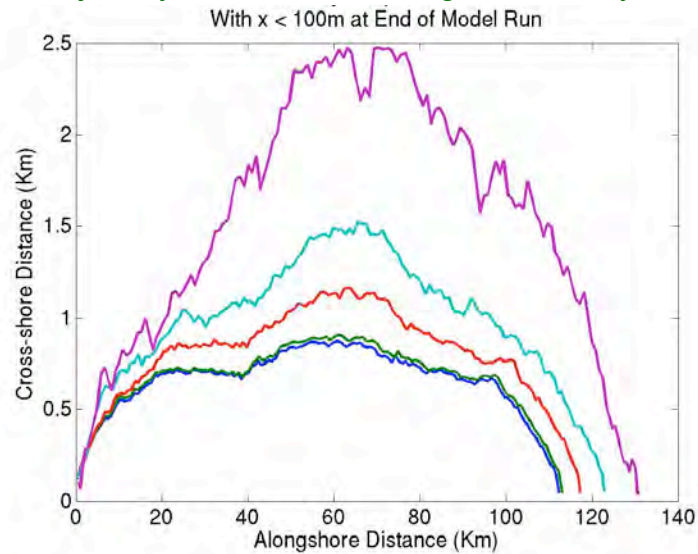
Base case _vs_ no CBL.

With and without CBL effect - no shear on right.
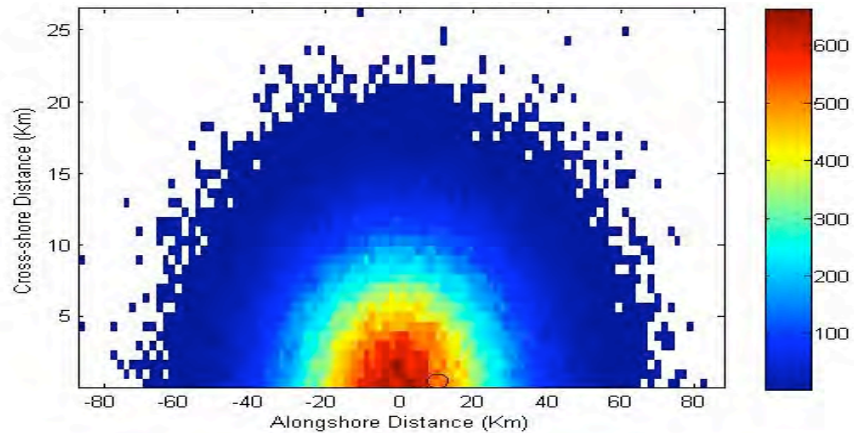

100   120   140   160   180 km

Base case - no CBL.

"Recruitment supply" - nearshore distributions w/o CBL.
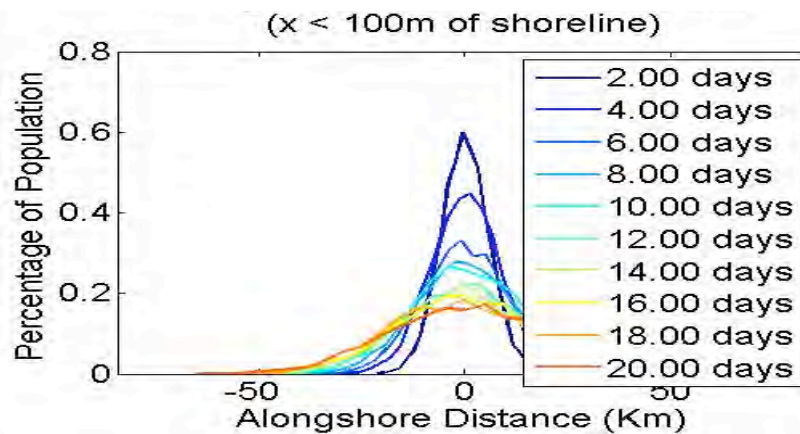
Diffusive case.

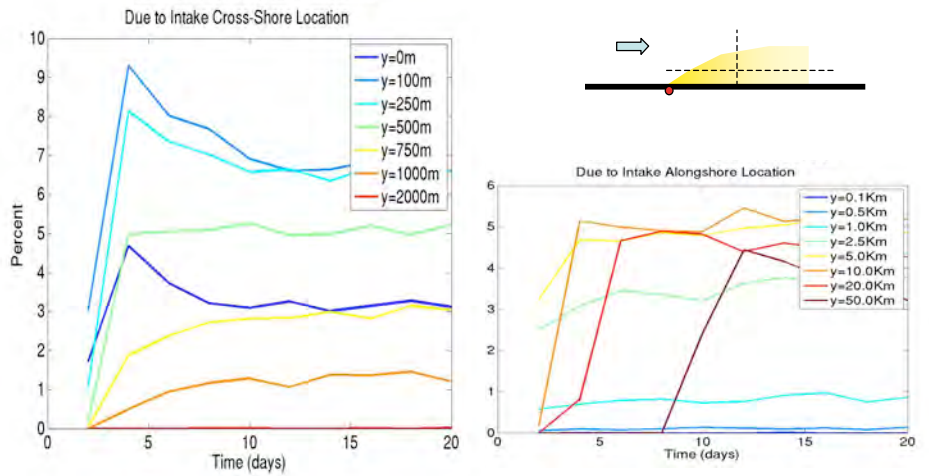Particle distribution after 20 days.

Diffusive case.

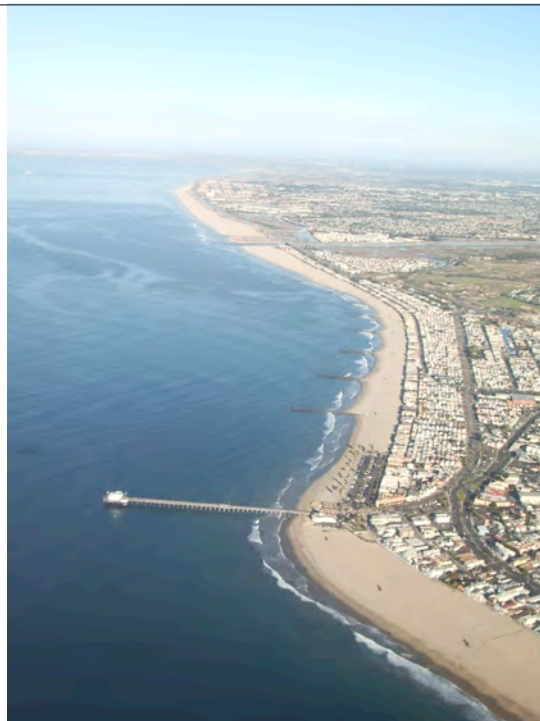"Recruitment supply" - nearshore particle distributions.

Intake position.

Spatial problem - some spawning sites and some recruitment sites more affected than others.
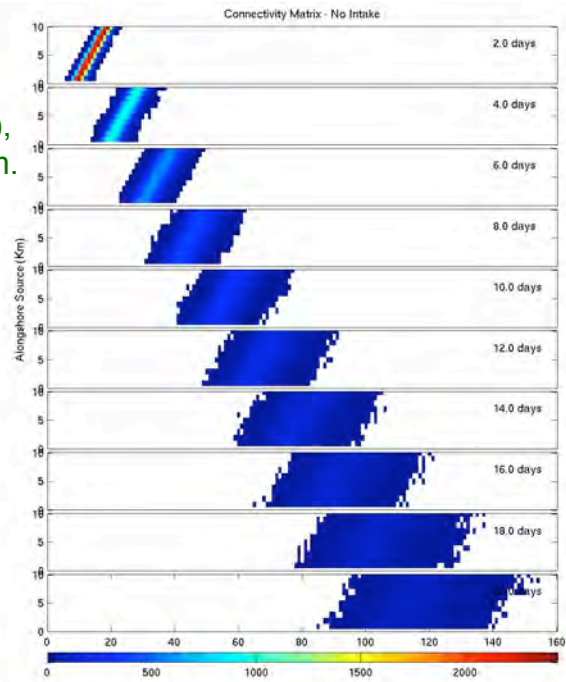Reduction in "recruitment" as function of intake location.

Model Connectivity
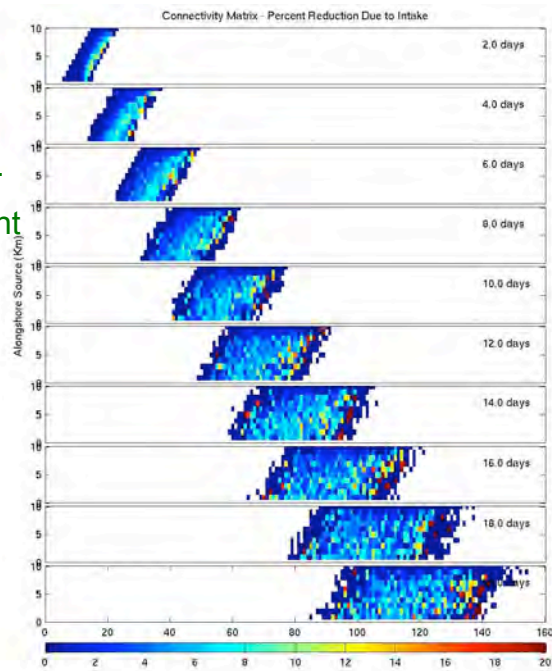
Connectivity.

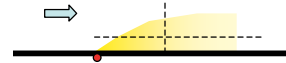Base case (*advective*), larval sources 0-10 km.

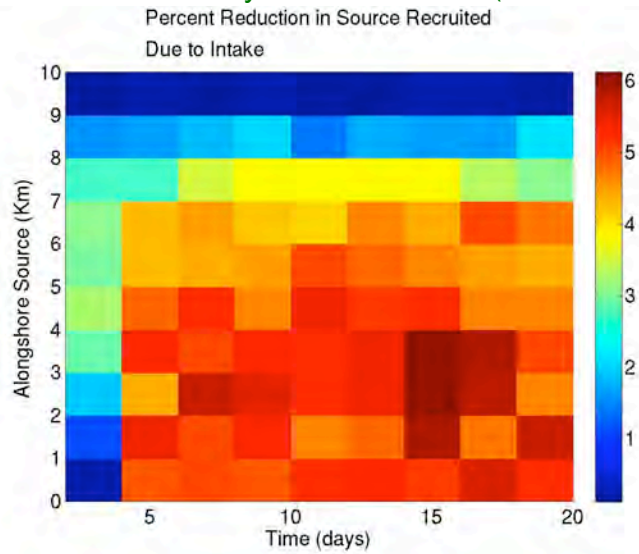*Connectivity.*

Base case (*advective*), larval sources 0-10 km.

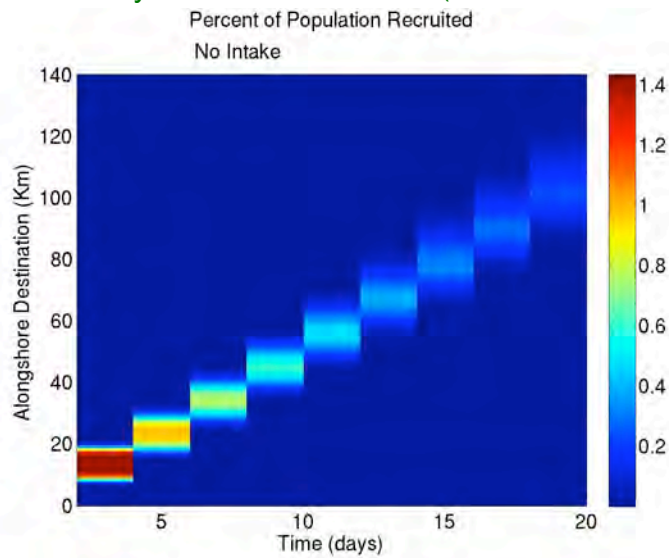Reduction in recruitment due to entrainment.

Connectivity.

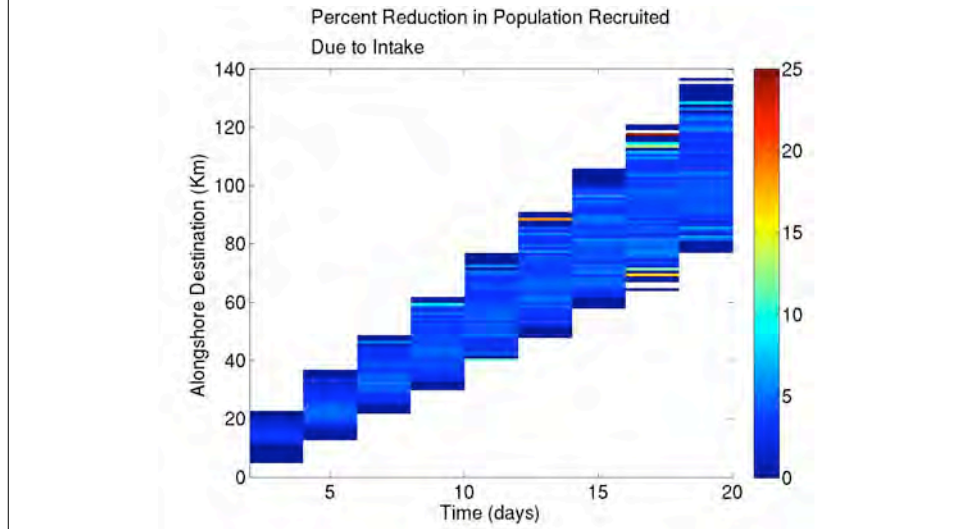Reduced recruitment by source location (zero for site at 10km).

Percent Reduction in Source Recruited Due to Intake

Connectivity.

Recruitment by destination location (advective base case).
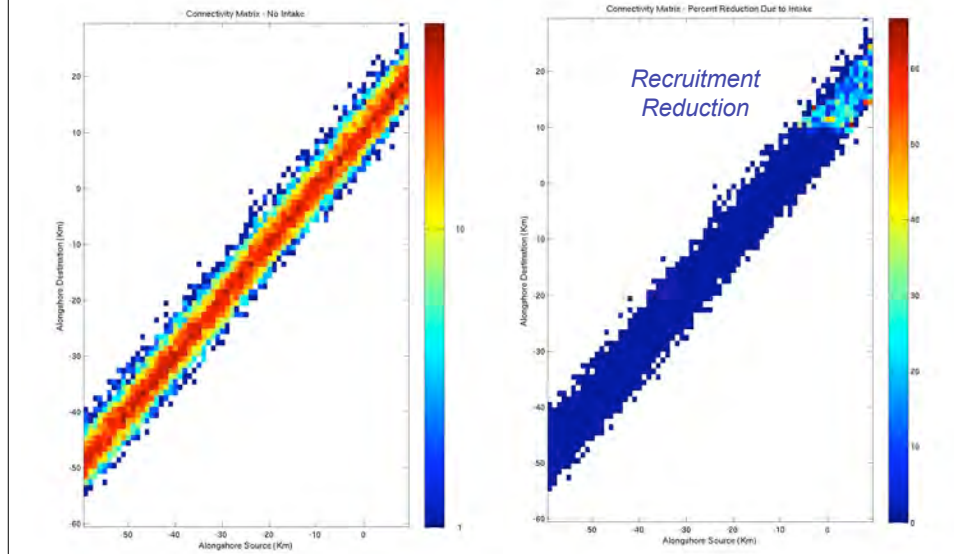

Percent of Population Recruited No Intake

Connectivity.

Reduced recruitment by destination location (variable).
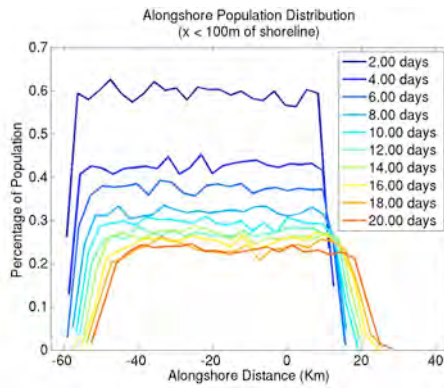

Connectivity.

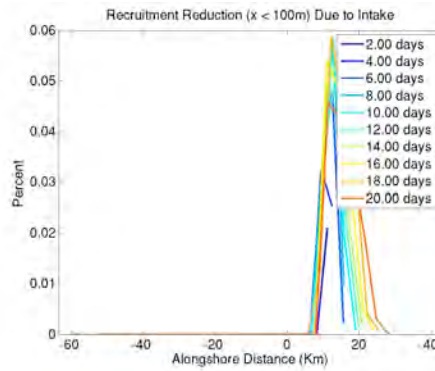*Diffusive case* (weak advection). Source -60 to +10 km.

Connectivity.

Diffusive case (weak advection). Pathways close to shore.

Alongshore distribution.
(reflects source)

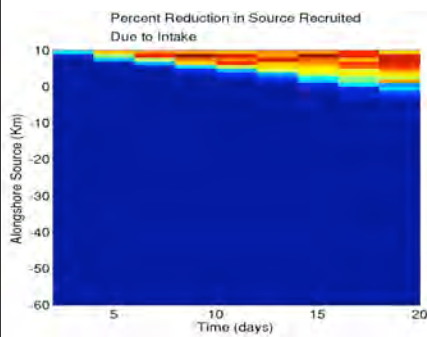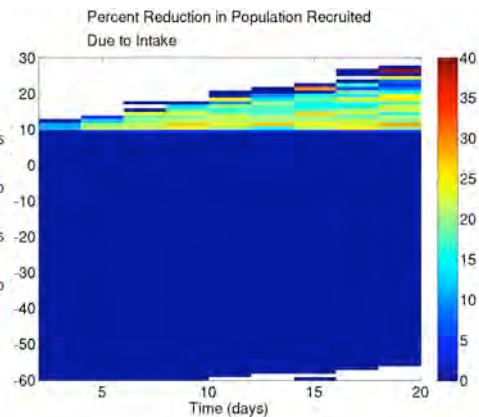**Recruitment reduction.**
(affect only near intake)

Connectivity.

Diffusive case (weak advection).
Reduction in recruitment …

Reduction per source.

Reduction per destination.

Conclusion.

Focus on *open coast scenario*:

- Observations of nearshore currents.

- Two-dimensional particle-tracking model.

- Model results for specific cases.

- Connectivity matrices.

Conclusion.

Further issues - work in progress …
   … "larval velocity" due to behavior
   … larval mortality that varies (space, time)
   … post-settlement effects (metapop model)
   … assessing CBL via observing systems
   … offshore habitats
   … cumulative effects (multiple, MPA, thermal, etc.)
       - spatial pattern of habitat, dispersal & human impact

Conclusion.

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Future needs -
  - … *data on currents (CBL)*
  - … *larval properties*

Thank You.