natural capital PROJECT

Marine Water Quality

InVEST 3.0

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Woods Institute for the Environment
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WWF

The Nature Conservancy

Institute on the Environment
University of Minnesota
Driven to Discover℠

Sewage Outfall Pollution

(Steve Spring)

This sewage outfall discharges 15-20 million gallons per day of treated sewage up-current of a coral reef in Delray Beach, Florida. (Jim Cagle, Palm Beach County Reef Rescue)

Photo Story

Sewage Outfalls – The greatest volume of waste discharged into the ocean, by far, is sewage. Sewage contains a wide range of pollutants including toxic chemicals, natural and synthetic hormones, pharmaceuticals, pathogens, and organic matter. Nutrients and decaying organic matter can lead to eutrophication and facilitate the formation of harmful algal blooms.

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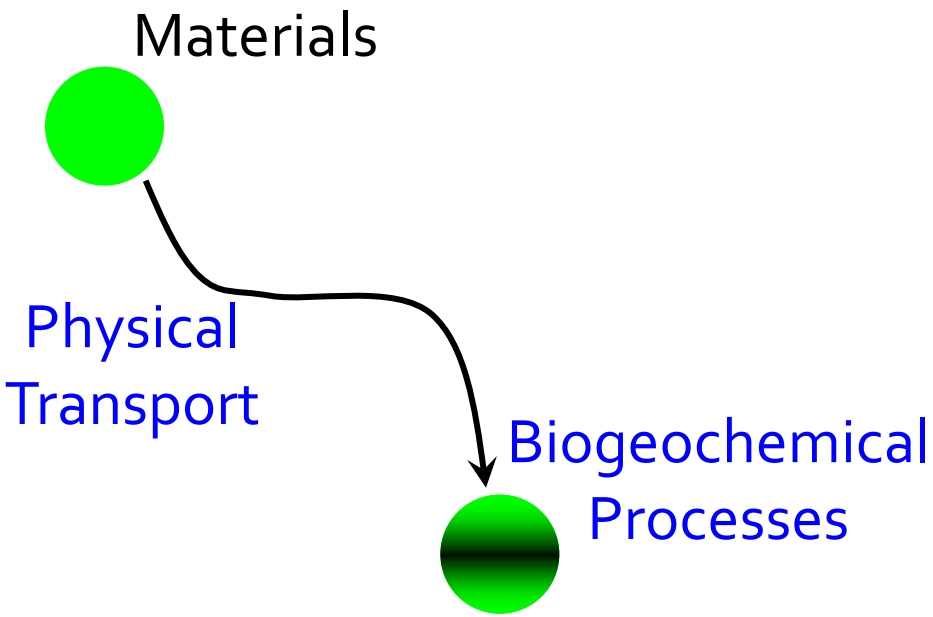


The objective of a WQ modeling is to simulate these processes all together.

Mass Balance Equation

Tidal dispersion **Advective Transport**

$$E^T \left(\frac{\partial^2 C}{\partial x^2} + \frac{\partial^2 C}{\partial y^2} \right) - \left(U \frac{\partial C}{\partial x} + V \frac{\partial C}{\partial y} \right) + S = 0$$

- C = tidal averaged concentration of a water quality state variable
- E^T = tidal dispersion coefficient
- U and V advective velocities
- S = sources and sinks of pollutant

$$S = -K_B C + \frac{W}{VOL}$$

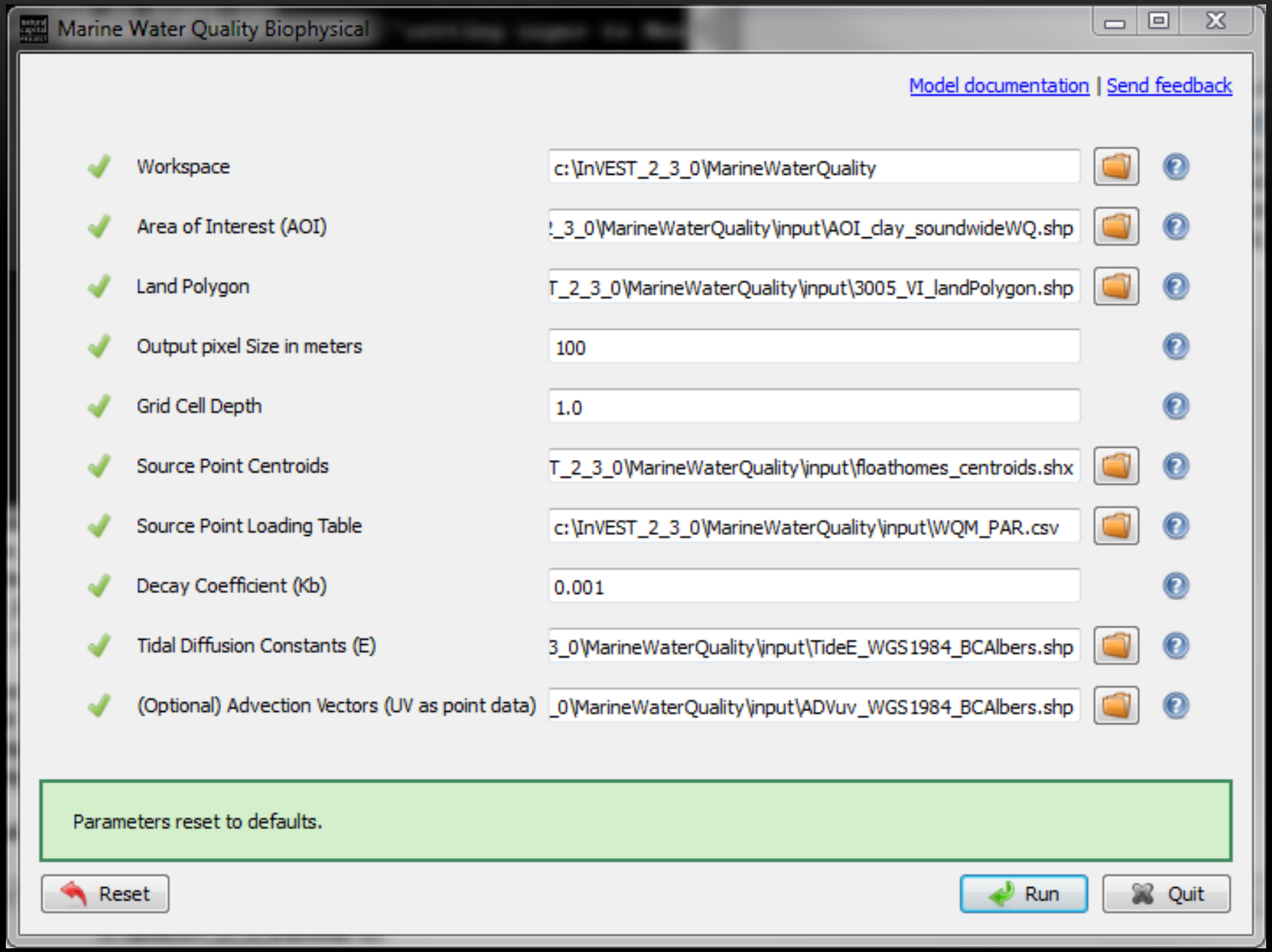
- K_B = decay rate (day^{-1})
- W = external load of FC (organism count day^{-1})
- VOL = volume of water cell (m^3)

Objectives

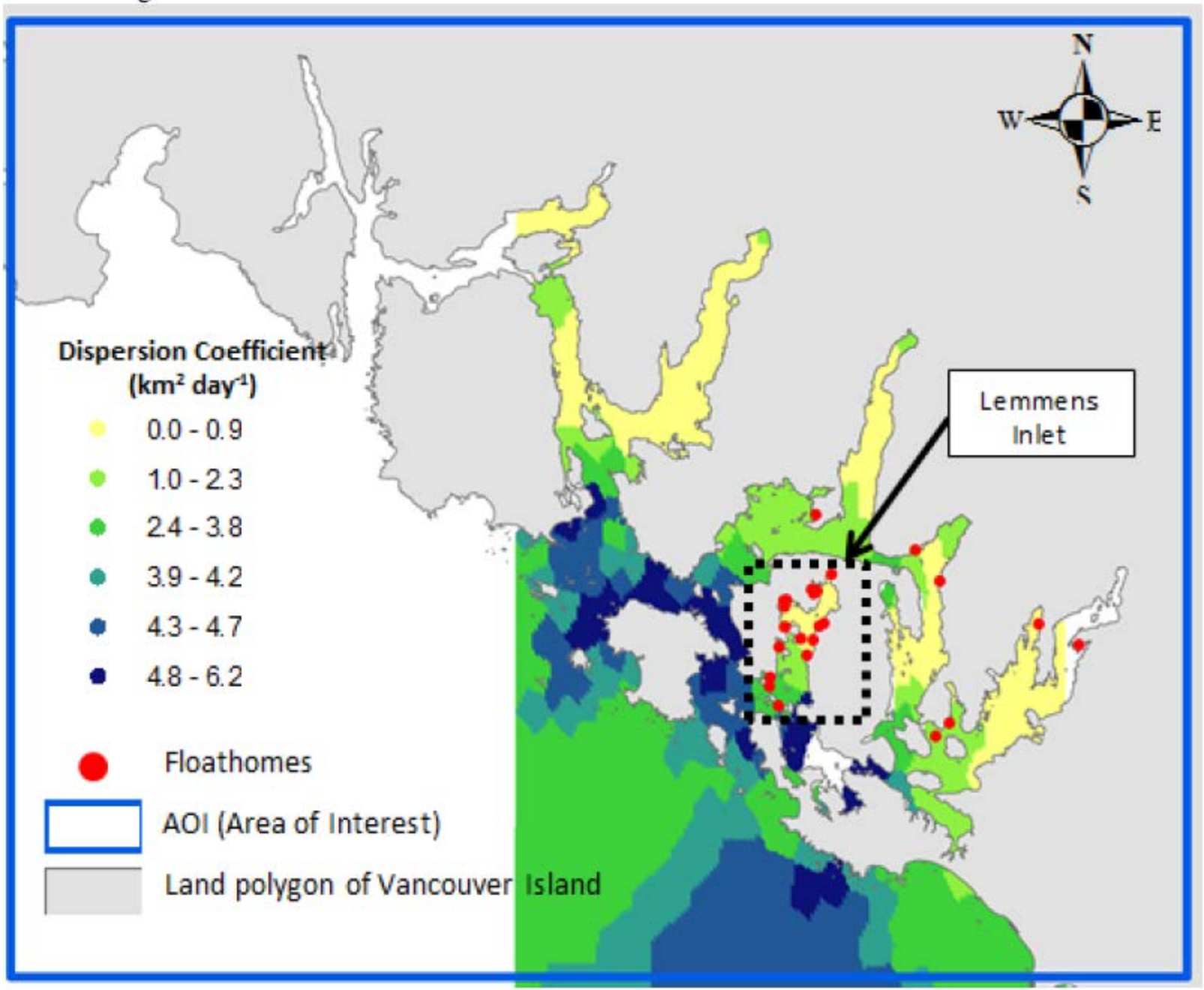
- To simulate the **movement and fate of water quality variables** in response to changes in ecosystem structure
- To assess **how management and human activities influence the water quality** in estuarine ecosystems
- To **help decision-makers establish management strategies** for desirable use of a water body.

Demo

Inputs


Marine Water Quality Biophysical
Model documentation | Send feedback
Workspace
c:\InVEST_2_3_0\MarineWaterQuality
Area of Interest (AOI)
_3_0\MarineWaterQuality\input\AOI_clay_soundwideWQ.shp
Land Polygon
T_2_3_0\MarineWaterQuality\input\3005_VI_landPolygon.shp
Output pixel Size in meters
100
Grid Cell Depth
1.0
Source Point Centroids
T_2_3_0\MarineWaterQuality\input\floathomes_centroids.shx
Source Point Loading Table
c:\InVEST_2_3_0\MarineWaterQuality\input\WQM_PAR.csv
Decay Coefficient (Kb)
0.001
Tidal Diffusion Constants (E)
3_0\MarineWaterQuality\input\TideE_WGS1984_BCAlbers.shp
(Optional) Advection Vectors (UV as point data)
_0\MarineWaterQuality\input\ADVuv_WGS1984_BCAlbers.shp
Parameters reset to defaults.
Reset
Run
Quit

shown in Fig. 3.



Scenarios for Float Homes in Lemmons Inlet

- Baseline run
  : 15 float homes
  : discharge = 10 m^3/day, 10,000 FC/m^3

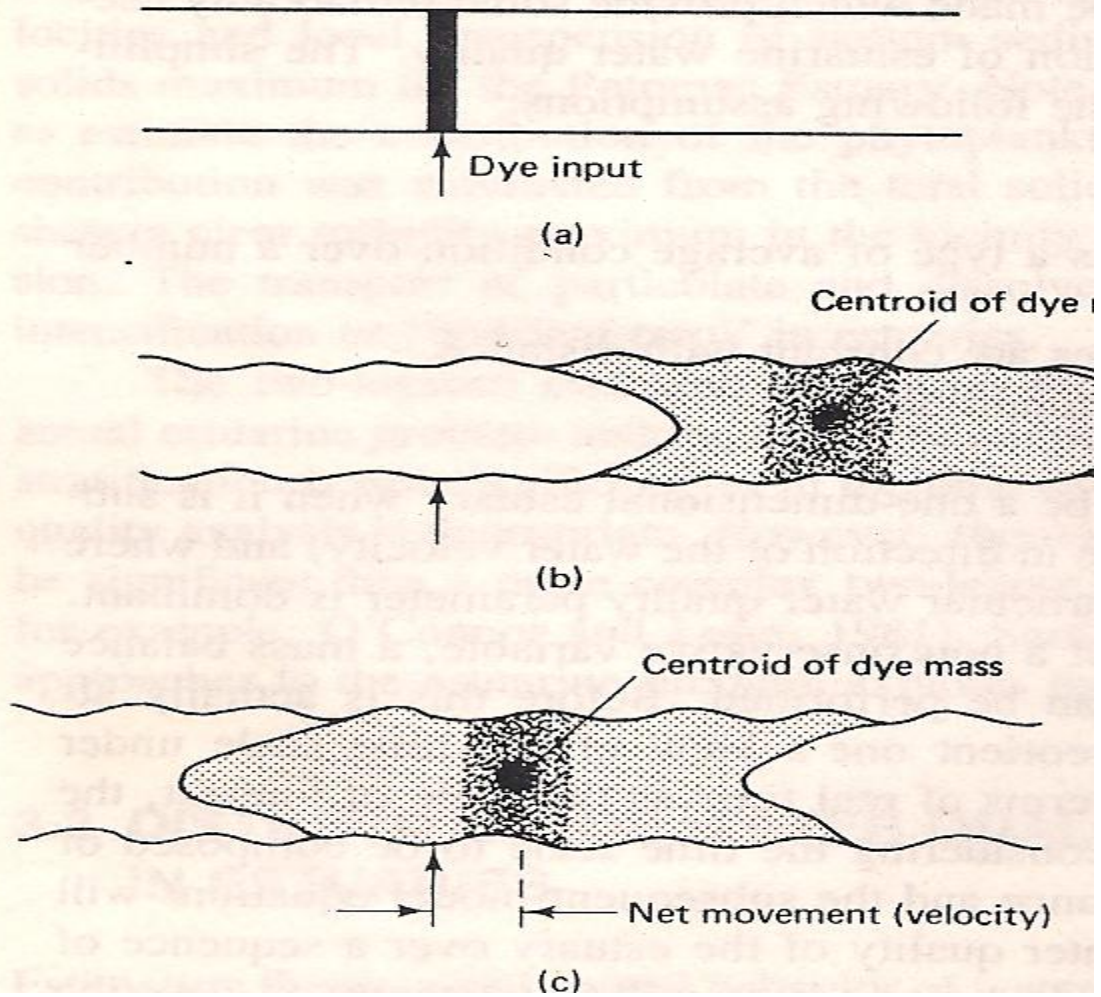
- Scenarios
  : 2nd level treatment (95 removal of bacteria)
  : 5 additional float homes

- Sensitivity Tests
  : advection by wind driven currents
  : Decay rate changes

11.4 Limitations and simplifications

- 1. Assumes a steady state condition (no time variation of model results). So, users should be aware that the model produces a distribution of a water quality state variable once it reaches an equilibrium status under defined conditions.
- 2. Grid size of a water cell: A finer grid size better resolves spatial differences in model outputs. However, it requires more computation and memory
- 3. The credibility of physical transport: Reliable information on physical transport processes is critical for reasonable model results.
- 4. No vertical transport: The governing mass balance equation of the model considers only horizontal transport of mass; it simulates vertically averaged conditions.
- 5. Size of the modeling domain: If the ocean boundary is too close to the pollutant loading points, inaccurate boundary values may artificially affect the model results.

Figure 3.13 Illustration of tidal mixing. (a) Dye "
tide. (c) At end of tidal cycle.



Tidal Mixing

Estuaries	**Tidal dispersion coefficient** ($km^2 day^{-1}$)
Hudson River, NY	52
East River, NY	26
Wappinger and Fishkill Creek, NY	1-3
Delaware River, upper	5-18
Delaware River, lower	18-28
San Francisco Bay, southern	2-16
San Francisco Bay, northerns	4-161
Rio Quayas, Ecuador	65
Thames River, England, low flow	5-7
Thames River, England, high flow	28

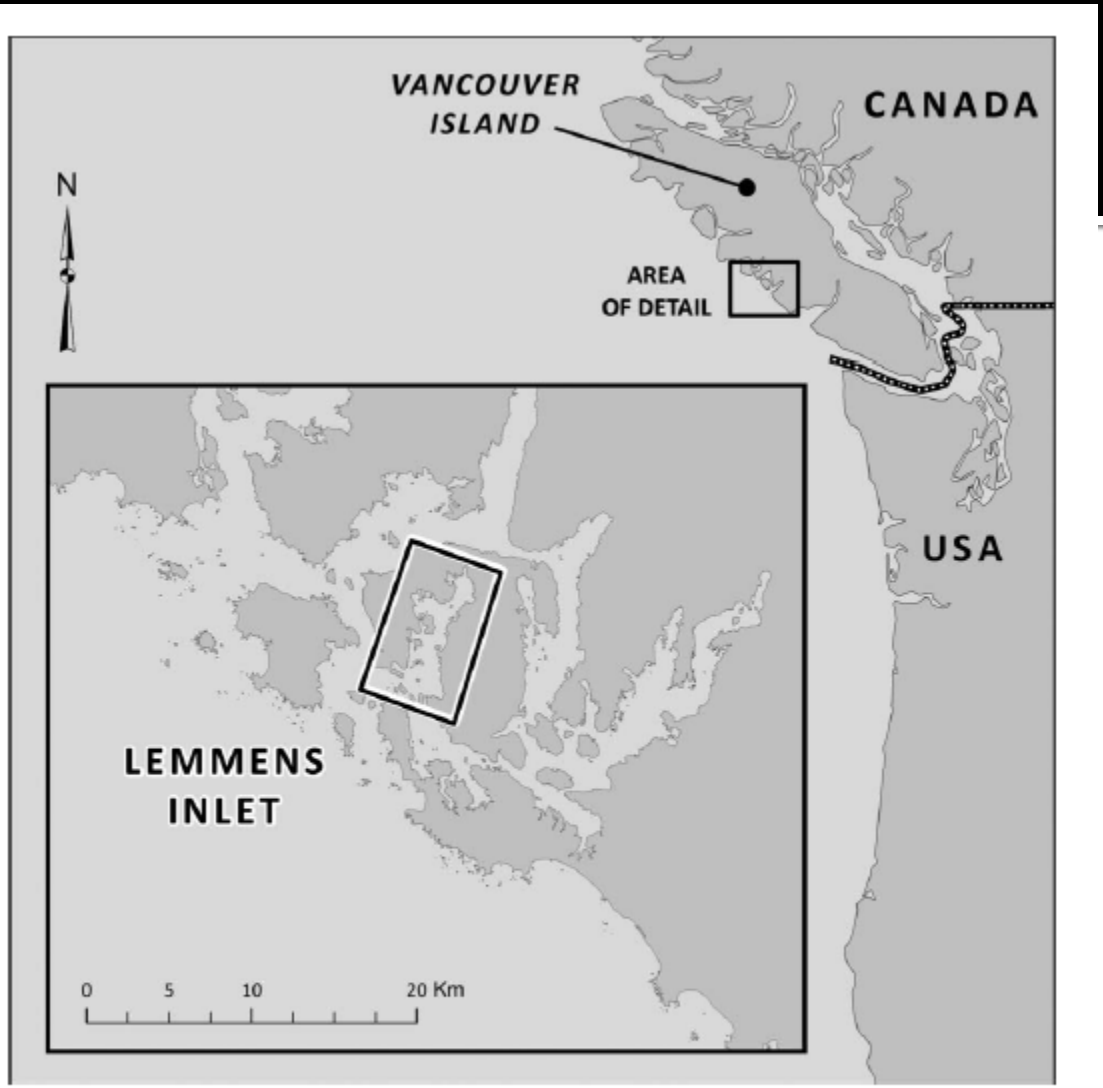
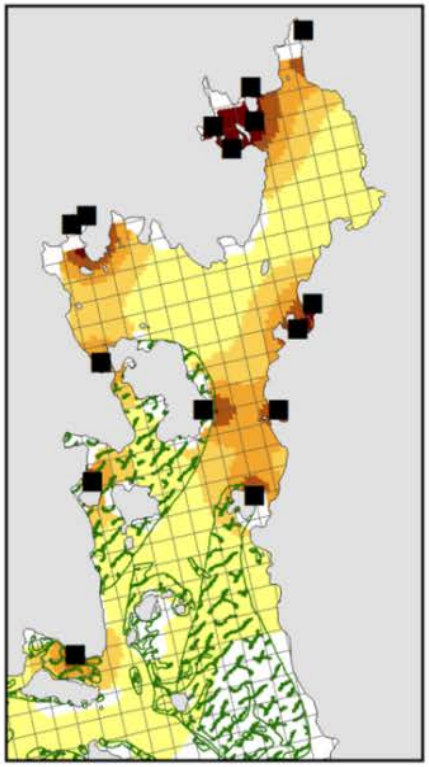
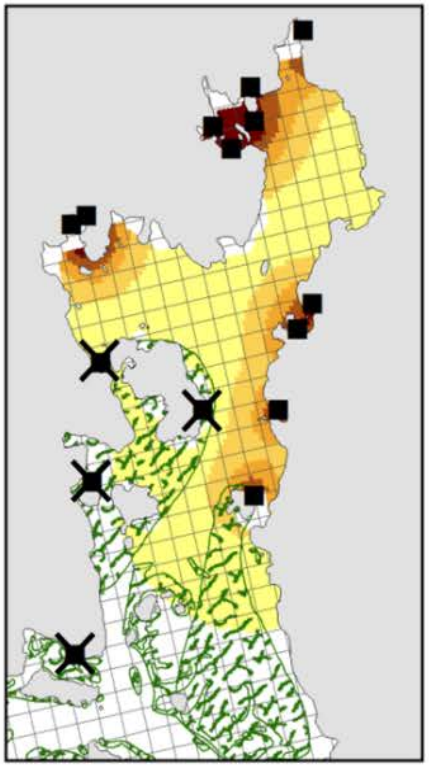


Figure 3. Lemmens Inlet, near Tofino, on the West Coast of Vancouver Island.

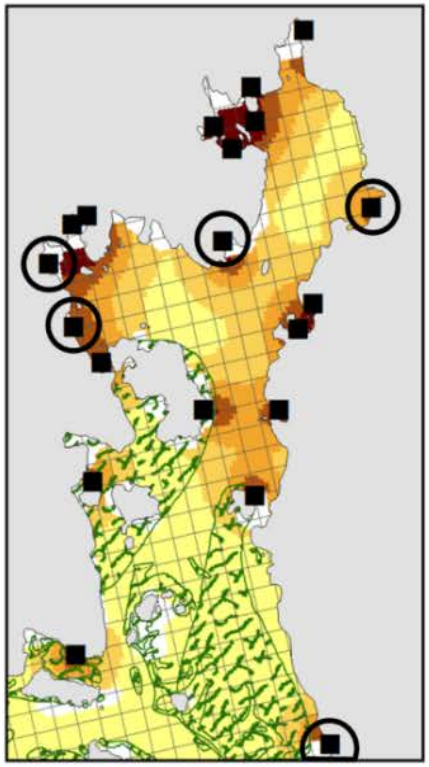
Marine InVEST-Water Quality Model Results



AVG WQI = 50



AVG WQI = 35



AVG WQI = 65

Water Quality Index
(relative to the source concentration of fecal coliform bacteria)

High WQ

0%
20%
40%
60%
80%
100%

Low WQ