H2020

TOOLS IMPLEMENTATION EXAMPLE

Where

North Eastern USA

Issue type(s):

Eutrophication amelioration by shellfish cultivation

Specific Issue:

Nutrient discharges cause eutrophication and existing land-based management measures are not giving expected reductions and water quality improvement. Current eutrophication levels are not responding to nutrient reductions thus alternative management measures, such as implementation of shellfish aquaculture are being considered.

Case study:

6. Long Island Sound and Great Bay Piscataqua, USA

Tool(s):

This page introduces 4 tools implementation factsheets relating to this issues. The tools are:

Cost avoided/replacement cost method for valuing ecosystem services provided by aquaculture;

ASSETS procedure for determining estuarine trophic status;

FARM model used to estimate potential of shellfish aquaculture to remove nutrients on local (farm) scale

EcoWin model to estimate potential of shellfish aquaculture to remove nutrients on ecosystem (water-body) scale

The information in this fact-sheet has been assembled as part of Milestone 20 (WP5) of the AquaSpace project (Ecosystem Approach to making Space for Aquaculture, aquaspace-h2020.eu, which has received funding from the European Union's Horizon 2020 Framework Programme for Research and Innovation under grant agreement n° 633476.

Where

North Eastern USA

Issue type(s):

Estimating value of ecosystem service provided by shellfish cultivation

Specific Issue:

Nutrient discharges cause eutrophication and existing land-based management measures are not giving expected reductions and water quality improvement. Current eutrophication levels are not responding to nutrient reductions thus alternative management measures, such as implementation of shellfish aquaculture are being considered. The *value of this ecosystem service* can be used to make decisions about development and implementation of the most cost effective nutrient management measures.

Case study:

6. Long Island Sound and Great Bay Piscataqua, USA

Objective:

Determination of the value of the water cleaning service provided by the filtration of cultivated oysters that might be paid to a grower in a nutrient credit trading program.

Tool(s):

The cost avoided, or replacement cost method, estimates the value of N removal by oysters assuming that costs of restoring clean water through nitrogen removal by wastewater treatment plants (WWTP), agricultural and urban BMPs, provides a useful estimate of the value of the ecosystem service of that removal by oysters. The method assumes that if oysters are no longer harvested, the nitrogen removal services they provide would need to be replaced. The value of nitrogen removal is estimated by taking the difference in minimum total costs for reduction targets in the watershed with and without the inclusion of shellfish farms. The value of shellfish production is determined not only by its marginal cost in relation to other abatement measures (e.g., WWTPs), but also by its cleaning capacity.

How tool(s) has/have been implemented:

In Long Island Sound and Great Bay Piscataqua, estimated replacement costs for incremental upgrades of nitrogen reduction from current WWTP effluent concentration levels to 8 mg L^{-1}, then to 5 mg L^{-1}, and then to 3 mg L^{-1} include total capital costs, annual operating and maintenance costs, and the combined annualized capital cost (20 year depreciation). Average annual costs of removal by the three treatment levels were \$32.19 kg^{-1} (8 mg L^{-1}), \$37.00 kg^{-1} (5 mg L^{-1}), and \$98.58 kg^{-1} (3 mg L^{-1}). Estimated average annual cost for agricultural controls including riparian buffers and cover crops for the entire CT River Basin give a unit cost of about \$12.98 kg^{-1} yr^{-1}. The two most cost-effective urban BMPs are wet ponds and submerged gravel wetlands and costs include construction costs and the cost of land acquisition for full implementation. Total annual per unit cost for the Connecticut River Basin was estimated as \$349 $kg^{-1} yr^{-1}$ (e.g. Bricker et al., 2018).

Results:

The model determined that the nitrogen removal ranged in valued from \$8.5 - \$470 million for current and expanded aquaculture in Long Island Sound, and \$1.1 - \$ 5 million in Great Bay Piscataqua depending on the alternative treatment considered (Bricker et al, 2018). This analysis allows for planning of comprehensive nutrient management programs for cost effective nutrient management.

Links:

AquaSpace D4.2 at aquaspace-h2020.eu on Library/Reports page

Reference

Bricker, S. B., J. Ferreira, C. Zhu, J. Rose, E. Galimany, G. Wikfors, . . . M. Tedesco. (2015). An ecosystem services assessment using bioextraction technologies for removal of nitrogen and other substances in Long Island Sound and the Great Bay/Piscataqua Region Estuaries. NOAA Technical Memorandum NOS NCCOS. 194: 154 pp + 3 appendices. NOAA, Silver Spring, MD.

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Cite as:
NOAA (2017) Valuing ecosystems services provided by shellfish cultivation. Implementation factsheet from Aquaspace toolbox. aquaspace-h2020.eu/

H2020

TOOLS IMPLEMENTATION EXAMPLE

Where

North-Eastern USA

Issue type(s):

Determination of estuarine status with respect to eutrophication.

Specific Issue:

Nutrient discharges cause eutrophication including low dissolved oxygen, algal blooms leading to fish kills and other undesirable water quality impairments . The eutrophication assessment tool is designed to evaluate the need for nutrient management additional to existing traditional land-based nutrient reduction measures.

Case study:

6. Long Island Sound and Great Bay Piscataqua, USA

Objective:

Evaluation of the sources of nutrients, status of eutrophication and expected future changes in eutrophication status. The results are used to justify additional nutrient management in locations where eutrophication is moderate to severe and / or is expected to worsen in the future.

Tool(s):

The Assessment of Estuarine Trophic Status (ASSETS; www.eutro.org/register) eutrophication assessment tool is designed to evaluate the primary sources of nutrients, the nutrient related water quality within a waterbody, and the expected change in future years given current conditions and expected future changes in nutrient load due to land use and population density changes and changes in nutrient management measures.

How tool(s) has/have been implemented:

The ASSETS is a highly aggregated integrative screening model that includes an assessment of pressure (Influencing Factors), state (Eutrophic Condition), and expected future response (Future Outlook) within a water body. The three components are then combined into a single overall score, called ASSETS. *Influencing Factors* rating is determined as a matrix based combination of nitrogen loading from the watershed and/or ocean and the capability of the system to dilute or flush the nutrient inputs. *Eutrophic Condition* rating is evaluated based on two groups of variables that reflect the direct and indirect water body response to nutrients. The extreme concentration or occurrence, frequency of occurrence, and spatial distribution are taken into account. Primary symptoms include (1) chlorophyll a and (2) macroalgae. Secondary symptoms include: (1) bottom water dissolved oxygen; (2) nuisance and toxic; and (3) submerged aquatic vegetation (SAV). The rating is determined by a matrix that combines the average score of primary and the highest score (worst impact) of the secondary symptom indicators using a precautionary approach. *Future Outlook* rating is determined as a matrix based combination of susceptibility (addressed above) and the prediction of future pressures (e.g., population pressure, agricultural pressure, and sewage treatment). The ASSETS rating combines the three components by matrix into a single rating of bad, poor, moderate, good, and high trophic status. (Bricker et al. 2003).

Results:

This model assesses the primary sources of nutrients such that appropriate management measures can be applied, and provides a status of water quality degradation currently and how it is expected to change in the future. This assessment allows for planning of nutrient management within a watershed or region (if all regional waterbodies are evaluated) and justifies additional management, such as implementation of shellfish aquaculture, in cases where land-based management measures have not shown expected reductions in impairment.

Links:

AquaSpace D4.2 at aquaspace-h2020.eu on Library/Reports page

Reference

Bricker, S. B., J. G. Ferreira & T. Simas (2003). An integrated methodology for assessment of estuarine trophic status. Ecological Modelling 169(1): 39-60.

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Cite as:
NOAA (2017) Use of ASSETS in Long Island Sound, USA.
Implementation factsheet from Aquaspace toolbox. aquaspace-h2020.eu/

H2020

TOOLS IMPLEMENTATION EXAMPLE

Where

North-eastern USA

Issue type(s):

Modelling potential of shellfish aquaculture to amelioerate eutrophication

Specific Issue:

Current eutrophication levels are not responding to nutrient reductions thus alternative management measures, such as implementation of shellfish aquaculture are being considered as a complement to traditional land-based nutrient management measures to take nutrients directly from the water.

Case study:

6. Long Island Sound and Great Bay Piscataqua, USA

Objective:

Determination of the capacity of oyster aquaculture to reduce eutrophication impacts at current and expanded oyster aquaculture lease areas.

Tool(s):

The Farm Aquaculture Resource Management Model (FARM) is an aquaculture production model that also evaluates the nutrient reductions associated with shellfish aquaculture operations, in this case oyster production.

How tool(s) has/have been implemented:

The Farm Aquaculture Resource Management model (FARM; www.farmscale.org) is a local scale model that combines physical and biogeochemical models, shellfish growth models, and screening models at the farm scale for the determination of shellfish production and for the assessment of water-quality changes on account of shellfish cultivation. The model inputs are water quality (temperature, salinity, chlorophyll, particulate matter), farm dimensions and operations (seeding density, mortality, culture period, and type of operation [i.e. cage or bottom with no gear], seed price, harvest value). Outputs include harvest amount, value of product, particulate and nutrient removal, changes in dissolved oxygen and chlorophyll. The model has been used previously for decision support for aquaculture siting taking into account food conditions inside a farm, shellfish ecophysiological characteristics, and farming practices and has also been used to evaluate the capacity for aquaculture operations to remove nutrients directly from the water (e.g. Rose et al, 2015).

Results:

This model can be used to determine the most successful location to site a farm if more than one location is available and also has been used to evaluate the nutrient removal capabilities of current and expanded aquaculture operations (Bricker et al, 2016, 2017). Evaluation of potential nutrient removal allows for planning of comprehensive nutrient management programs within a watershed or region where shellfish cultivation might be used as a complement to traditional land-based measures where those measures have not shown expected reductions in impairment. In Chesapeake Bay, for example, harvested oyster tissue can now be included as best management practices within a nutrient management plan to fulfil required nutrient reductions (Oyster BMP Expert Panel, 2016).

Links:

AquaSpace D4.2 at aquaspace-h2020.eu on Library/Reports page

Reference

Rose, J. M., S. B. Bricker & J. G. Ferreira (2015). Comparative analysis of modeled nitrogen removal by shellfish farms. Marine Pollution Bulletin 91(1): 185-190. doi: 10.1016/j.marpolbul.2014.12.006

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Cite as:
NOAA (2017) Use of FARM model to estimate shellfish removal of nutrient in Long Island Sound, USA. Implementation factsheet from Aquaspace toolbox. aquaspace-h2020.eu/

Where

North-eastern USA

Issue type(s):

Modelling potential of shellfish aquaculture to amelioerate eutrophication

Specific Issue:

Current eutrophication levels are not responding to nutrient reductions thus alternative management measures, such as implementation of shellfish aquaculture are being considered as a complement to traditional land-based nutrient management measures to take nutrients directly from the water.

Case study:

6. Long Island Sound, USA

Objective:

Determination of the capacity of oyster aquaculture to reduce eutrophication impacts at current and expanded oyster aquaculture lease areas using an ecosystem scale model.

Tool(s):

The EcoWin.net model is an ecosystem scale aquaculture production model that also evaluates the nutrient reductions associated with shellfish aquaculture operations, in this case oyster production.

How tool(s) has/have been implemented:

The EcoWin.net model is an ecosystem scale ecological model that combines a 3D hydrodynamic model with biogeochemical models, shellfish growth models, and a eutrophication screening model for the determination of shellfish production and for the assessment of water-quality changes on account of shellfish cultivation. In Long Island Sound a 2 layer, 42 box EcoWin model grid was used to simulate system-scale oyster production, and associated drawdown of Chl, POM, and N using relevant transport, biogeochemistry, and shellfish model components. Oyster populations were modeled using standard population dynamics equations driven by individual growth and mortality, using 20 heterogeneous weight classes spanning 0-100 g live weight. Seeding and harvest are explicitly simulated, defined from expert knowledge of local growers. Seeding takes place annually from Year 1, with first harvest in Year 3. Harvest is regulated by the availability of market-sized animals and market demand. Model inputs include water quality (temperature, salinity, chlorophyll, particulate matter), farm dimensions and operations (seeding density, mortality, culture period, and type of operation [i.e. cage or bottom with no gear], seed price, harvest value). Outputs include harvest amount, value of product, particulate and nutrient removal, nutrient excretion, feces and mortality of oysters, changes in dissolved oxygen and chlorophyll. The model was used to evaluate the capacity for aquaculture operations to remove nutrients directly from the water, and the value of that ecosystem service, at current and expanded oyster cultivation areas (e.g. Bricker et al., 2014, 2017).

Results:

Evaluation of potential nutrient removal allows for planning of comprehensive nutrient management programs within a watershed or region where shellfish cultivation might be used as a complement to traditional land-based measures where those measures have not shown expected reductions in impairment. In Chesapeake Bay, for example, harvested oyster tissue can now be included as best management practices within a nutrient management plan to fulfil required nutrient reductions (Oyster BMP Expert Panel, 2016).

Links:

AquaSpace D4.2 at aquaspace-h2020.eu on Library/Reports page

Reference

Bricker, S., J. Ferreira, C. Zhu, J. Rose, E. Galimany, G. Wickfors, . . . M. Tedesco. (2018). Role of Shellfish Aquaculture in the Reduction of Eutrophication in an Urban Estuary. Environmental Science & Technology **52**(1): 173-183. doi: 10.1021/acs.est.7b03970

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Cite as:
NOAA (2017) Modelling capacity of cultivated oysters to ameliorate eutrophication in Long Island Sound, USA. Implementation factsheet from Aquaspace toolbox. aquaspace-h2020.eu/