The following excerpt is from…

Rensel, J.E., D.A. Kiefer and F.J. O'Brien. In final preparation. **Modeling Water Column and Benthic Effects of Fish Mariculture of Cobia (*Rachycentron canadum*) in Puerto Rico: Cobia AquaModel.** Prepared for Ocean Harvest Aquaculture Inc., Puerto Rico and
The National Oceanic and Atmospheric Administration, Washington D.C. by
Systems Science Applications, Inc. Los Angeles, CA. 60 pp.

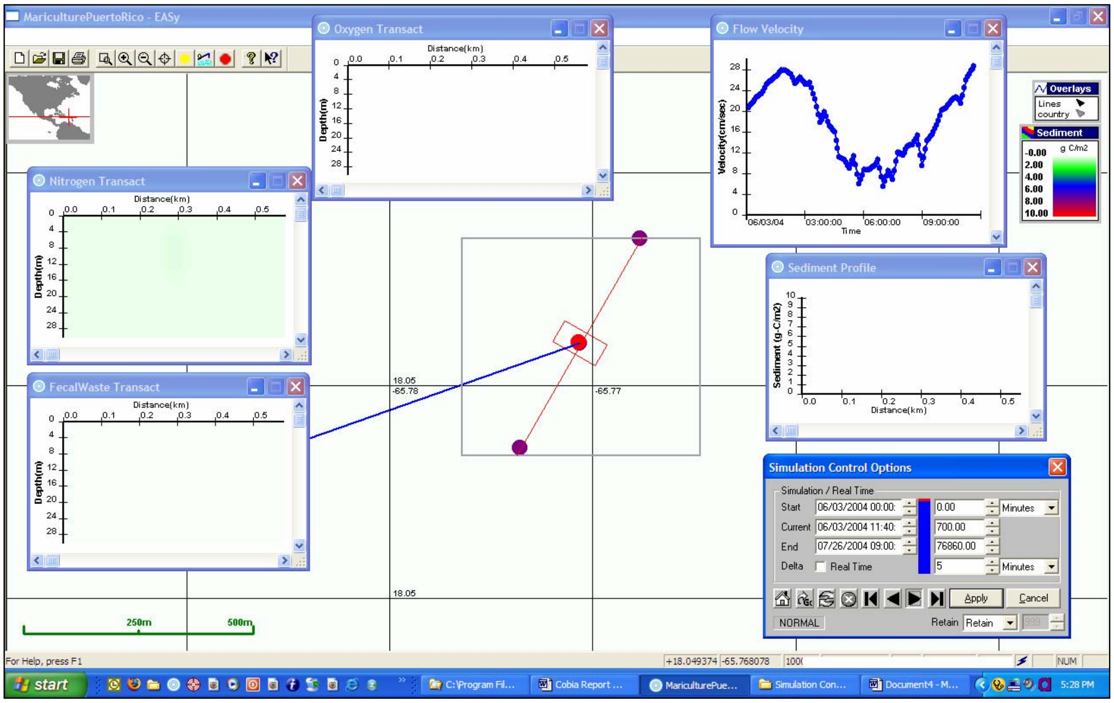
This document is an analysis of potential water column and benthic cumulative effects of a proposed offshore, submerged fish farm to be located off the east coast of Puerto Rico. Ten individual, submerged SeaStation cages would be used to rear about 900,000 pounds (405MT) of cobia (*Rachycentron canadum)*. The fish has an extraordinarily-fast growth rate and reaches a size of 5 kg about 9 months after hatch. This feature and other characteristics make cobia an excellent farmed-fish candidate.

The proposed fish culture area may be characterized as exposed, well-flushed coastal shelf remote from sensitive habitats such as coral reefs. Extensive current meter, acoustic Doppler current profiler and other studies have been conducted in preparation for the fish farm. A proprietary modeling program known as AquaModel was used to simulate water and sediment quality effects of the proposed fish farm. It is the first comprehensive model for net-pen aquaculture that simultaneously accounts for both water column (dissolved oxygen, nitrogen, plankton) and benthic (particulate carbon sedimentation) effects.

AquaModel is composed of interlinked submodels of fish physiology, hydrodynamics, water quality, solids dispersion and assimilation all with roots in the scientific literature and prior model that have been verified and used by others. The system provides the user a 3-dimensional simulation of growth, metabolic activity of caged fish, associated flow and transformation of nutrients, oxygen, and particulate wastes in adjacent waters and sediments. AquaModel resides within a Geographic Information System (GIS) program designed for oceanographic use but is compatible with other common 2-dimensional GIS software.

The results of the modeling work indicated that at steady state conditions relatively minor amounts of carbon will be deposited on the sea floor immediately under and near the cages. Mean current velocity at the proposed site is relatively modest (about 10 cm s^{-1}) but current direction is highly variable and peak current velocity reaches ~ 50 cm s^{-1} (1 knot). These features afford a great deal of dispersion of particulate and dissolved wastes. Organic and inorganic wastes are not merely diluted, but are readily available for uptake and growth of marine invertebrates, fish and plankton. Many regulatory jurisdictions worldwide have decided this is the best means to manage marine fish farms, i.e., proper siting and avoidance of habitats of special significance in the immediate vicinity. The reader should not confuse fish farm effluent with municipal or industrial treated waste effluent as there are fundamental differences of composition, persistence and degree of risk to the marine ecosystem. Weston (1986) was the first to point out some of these differences, i.e., that fish farm particulate effluent is much larger in size, more biologically available to the food web, sinks rapidly and not spread in a freshwater plume over large distances, does not contain the myriad of drugs, chemicals, heavy metals, PAHs and other contaminants found in domestic and industrial point and non-point source discharges, etc.

AquaModel applied to site specific conditions in Puerto Rico predicts levels of carbon-containing particulate wastes that may be easily assimilated by the benthic ecosystem. Current velocity is great enough to facilitate regular resuspension and aeration of the particulate matter, so that anaerobic conditions experienced under fish farms that were poorly sited in the past may be avoided. Perturbations of the water column will include slight reduction in dissolved oxygen in and very near the fish cages and slightly elevated dissolved nitrogen concentrations within the cages. The probability of stimulating a plankton bloom was shown to be essentially none, as phytoplankton cells have population doubling rates that are slow (days) compared to the advective properties of the site. In every case we used conservative to very conservative model calibration coefficients or constants to purposely investigate worst-possible-case conditions and to offset any limitations or inaccuracies of the model.



Simulation Control Options

Simulation / Real Time

Start 06/03/2004 00:00: 0.00 Minutes

Current 06/03/2004 11:40: 700.00

End 07/26/2004 09:00: 76860.00

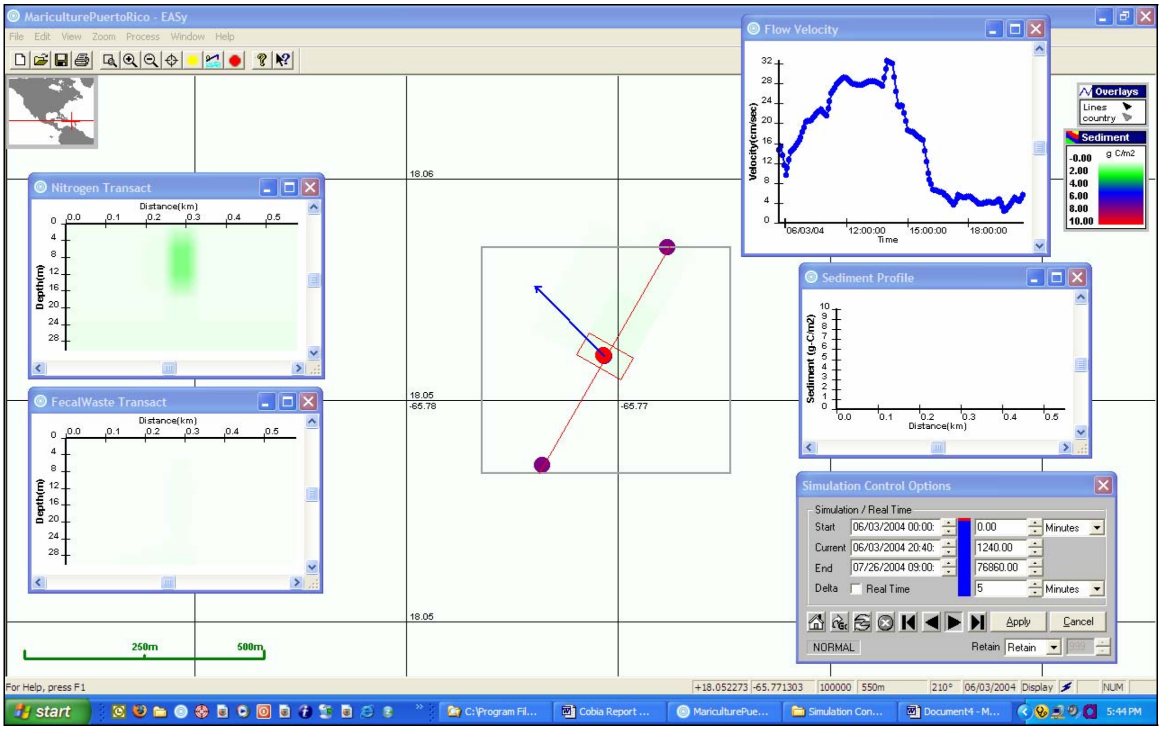
Delta ☐ Real Time 5 Minutes

Apply Cancel

NORMAL Retain Retain 999

Figure 1. Typical higher current velocity screen print.

Top right velocity plot at 28 cm s^{-1}; no carbon being deposited on bottom (right center plot) and very slight localized nitrogen plume along center of transect (left center plot). Blue line from center is a current vector (speed and direction) indicator.



Start 06/03/2004 00:00: 0.00 Minutes

Current 06/03/2004 20:40: 1240.00

End 07/26/2004 09:00: 76860.00

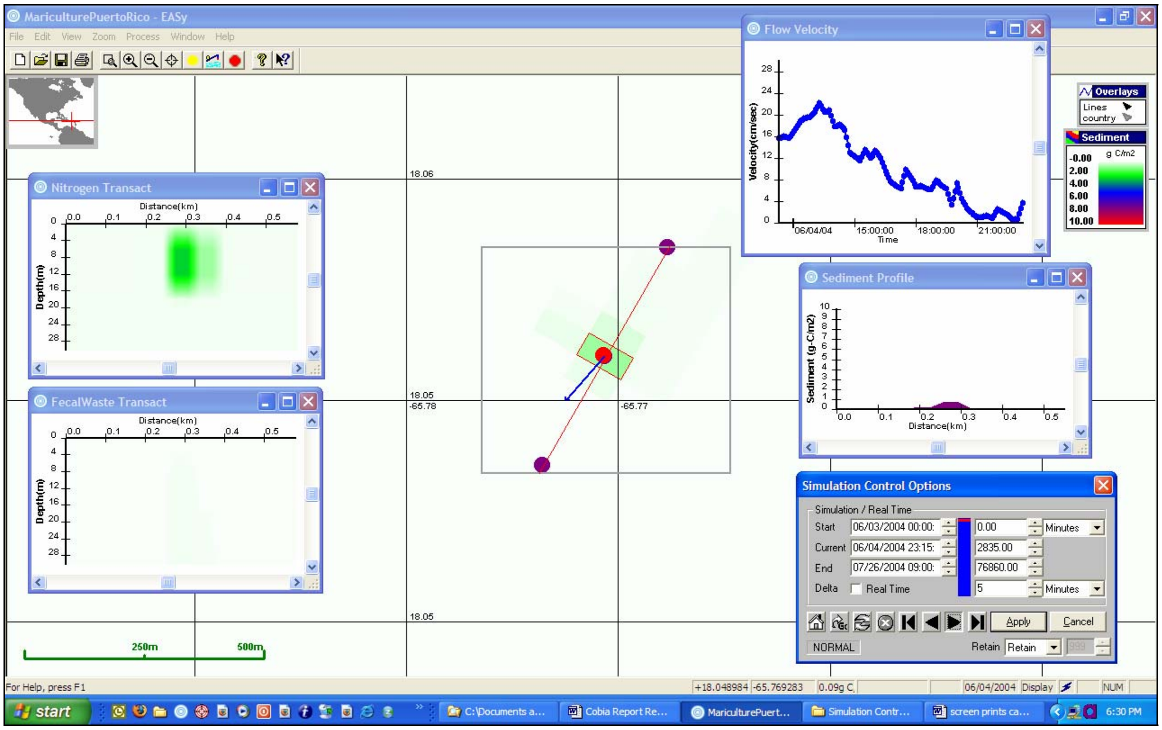
Delta ☐ Real Time 5 Minutes

+18.052273 -65.771303 100000 550m 210° 06/03/2004 Display

Figure 2. Later in same time series after a sustained period of slow velocity

Note faint shadow to NE indicating low level <0.2 g C/m2 deposition graded toward edge of mixing zone.

\



Start 06/03/2004 00:00: 0.00 Minutes

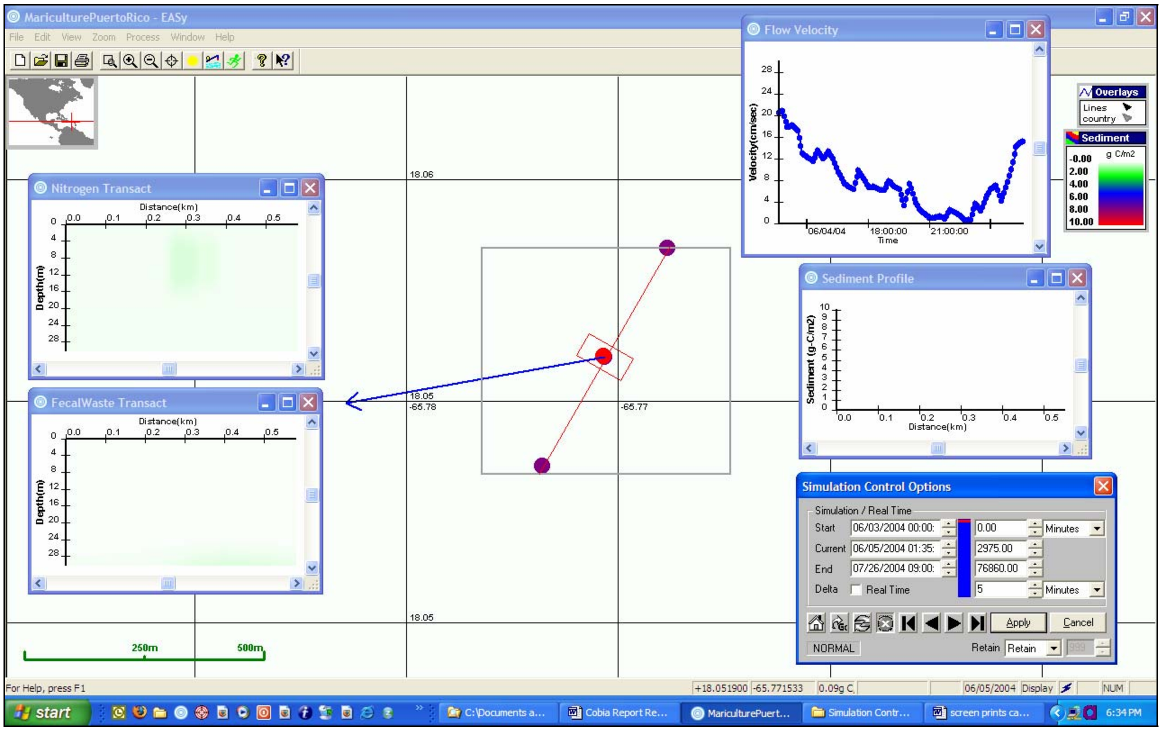
Current 06/04/2004 23:15: 2835.00

End 07/26/2004 09:00: 76860.00

Delta ☐ Real Time 5 Minutes

+18.048984 -65.769283 0.09g C 06/04/2004 Display

Figure 3. Much later in same time series with current direction reversal and maximum carbon deposition showing in main plot and in profile in right center (scale 1 to 10, purple mound indicating < 1 g C m^{-2} beneath simulated cage.



Simulation Control Options

Simulation / Real Time

Start 06/03/2004 00:00: 0.00 Minutes

Current 06/05/2004 01:35: 2975.00

End 07/26/2004 09:00: 76860.00

Delta ☐ Real Time 5 Minutes

NORMAL Retain Retain 999

+18.051900 -65.771533 0.09g C 06/05/2004 Display NUM

Figure 4. Stronger currents resuming and resuspension having removed temporarily deposited solids from the bottom.
