Ecological Issues in Scaling Restoration to Offset Unavoidable Entrainment

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Background

- Even the best technology available (BTA) cannot eliminate all impingement and entrainment (I&E)
- Whatever the final 316(b) regulation, CA may seek habitat restoration to offset I&E losses that continue to occur even after implementation of BTA
- To increase the likelihood of restoration success, agencies need reliable methods to quantify the production of organisms in restored habitats

Project Objectives

- Provide an overview of restoration scaling
- Evaluate the HPF/APF method
- Recommend ways to improve scaling methods
- Discuss restoration costs in the context of cost-effectiveness analysis.

Restoration Scaling

- Goal of habitat restoration is to offset a loss
- Loss is usually quantified
- But few restoration projects quantify the potential ecological benefits
- Restoration scaling seeks to answer the question "how much" – how much restoration is needed to offset a given magnitude of loss

HPF Method

- HPF method uses results of ETM modeling to express entrainment in terms of habitat:

  $$HPF = PM_{AVG} \times SWA_{AVG}$$ for target species

<u>Example</u>: if PM is 0.11 (11%) and SWA is 2,000 acres, then

$$HPF = 11\% \times 2{,}000 = 220 \text{ acres}$$

- 220 acres is then taken as an estimate of the area representing the quantity of larvae entrained

HPF (cont'd)

- The next step involves using the HPF to estimate the amount habitat restoration needed
- Problem: HPF is based on the density of entrained larvae in the SWA -> a measure of standing stock
- Standing stock gives the fish per unit area at a single point in time.
- But the measure needed to estimate gains of fish in a restored habitat is a rate – fish per unit area per unit time

HPF (cont'd)

- Restored habitat must be capable of producing an ***increase*** in fish production above the baseline
- Need to know how many new fish will be produced and over what time frame

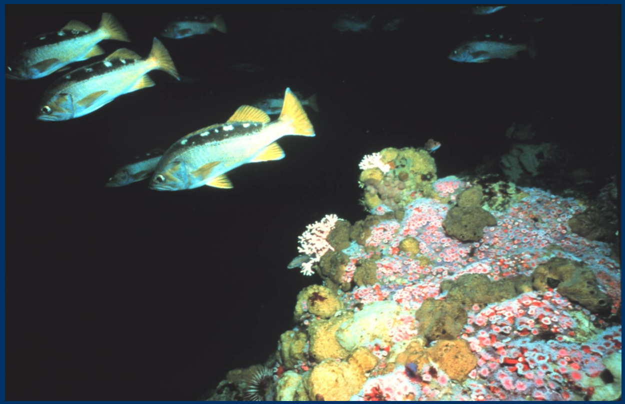
Calculating Scale of Restoration

- To determine the ecological benefits of restoration: need measure of *recruitment* (the addition of new recruits to the population) or *productivity* (the rate of biomass production)

- The density of organisms in the water column (and the area associated with this quantity of organisms, the HPF) is <u>not</u> a measure of recruitment or productivity

Can Standing Stock be Used as a Proxy?

- Standing stock can only be used as a “proxy” for production under limited circumstances:
  - Sampling is of habitat where larvae are produced
  - Sampling program captures all larvae that will be produced that year
  - There is no emigration or immigration

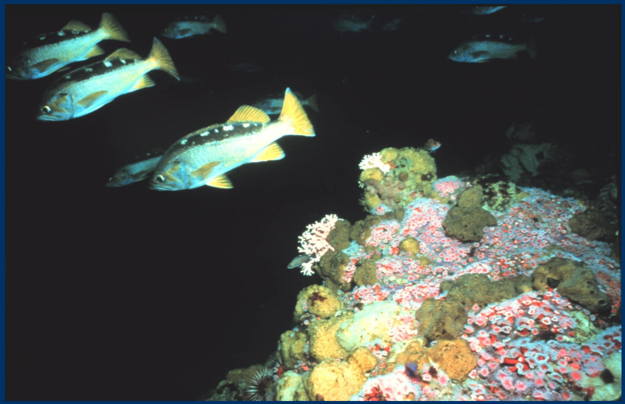


Time Considerations

- Need to account for restoration trajectory
  - Time lag from beginning of restoration action until benefits begin to accrue
  - Maximum life span of restoration benefits
  - Point of maximum benefits

Present Value

- Convert losses and gains to present value to account for fact that resource now is worth more than resource in the future (as in a bank account – a $1 now is worth more than $1 later)
- Discounting is used to convert losses anda gains into present value equivalents

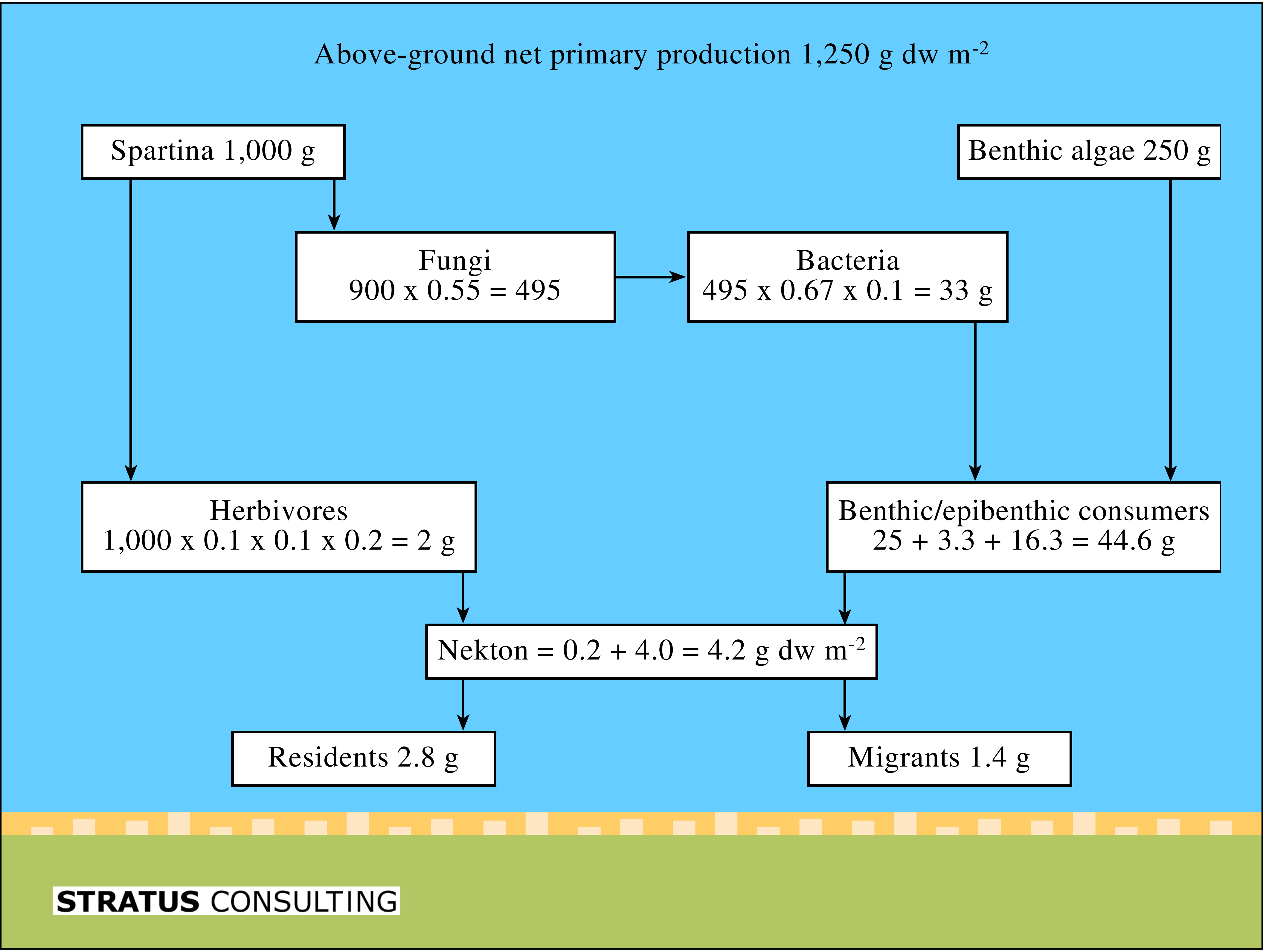


Example:

- Goby entrainment is 338,315,003 g dw NPV of loss over a 10 yr period
- Goby production is 0.2026 g dw m^{-2} yr^{-1} (Allen, 1982), or 820 g dw ac^{-1} yr^{-1}. The present value equivalent 82,820 g dw ac^{-1}.
- To determine the restoration needed to offset the loss: divide entrainment loss (338,315,003 g dw) by restoration gain (82,820 g dw ac^{-1}).
- 338,315,003 g dw / 82,820 g dw ac^{-1} = 4,085 acres

Example (cont'd):

- Based on the cost used for HPF estimates of $75,444 per acre, and our estimate of 4,085 acres, the cost would be $308,182,883
- the HPF estimate for goby by the facility's consultant was: 15.35 acres and $1,158,065
- the HPF estimate for all species by agency consultants was of 104 acres and $7,956,000



Above-ground net primary production 1,250 g dw m-2
Spartina 1,000 g
Benthic algae 250 g
Fungi
900 x 0.55 = 495
Bacteria
495 x 0.67 x 0.1 = 33 g
Herbivores
1,000 x 0.1 x 0.1 x 0.2 = 2 g
Benthic/epibenthic consumers
25 + 3.3 + 16.3 = 44.6 g
Nekton = 0.2 + 4.0 = 4.2 g dw m-2
Residents 2.8 g
Migrants 1.4 g
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Trophic Model Used to Scale Restoration for Salem Power Plant, Delaware Bay

Step 1: Determine total annual marsh primary production by adding estimates of primary production by marsh plants and by benthic algae:

72,790 lbs/ac/yr (plants) + 7,145 lbs/ac/yr (benthic algae) = 79,935 lbs primary production/ac/yr

Step 2: Assuming that about 45% of this annual primary production is transported out of Delaware Bay, primary production within the bay is given as:

79,935/lbs/ac/yr × 0.55 =

43,964 lbs primary production/ac/yr

Step 3: Most biomass of marsh plants passes through a detrital food web. Assuming that 40% of plant primary production is converted to organic detritus, then:

43,964 lbs/ac/yr × 0.40 = 17,586 lbs/ac/yr detritus.

Step 4: Allocate the detritus among invertebrates (33%) and fish (67%). Then, on this basis, the amount of detritus consumed by fish is:

17,586 lbs/ac/yr × 0.67 = 11,782 lbs/ac/yr detritus

Step 5: Assume that this organic matter is converted to fish biomass as follows:
Organic matter → primary consumers (arthropods) → secondary consumers (age 1 fish)

Assuming a 20% conversion efficiency among trophic levels, then the fish biomass produced is given as:
11,782 lbs/ac/yr × 0.2 × 0.02 =
471 lbs/ac/yr of fish biomass produced

Step 6: partition biomass among species based on mortality rates of age 1 fish

Step 7. Determine area of salt marsh needed to offset each species loss by dividing the biomass of each species lost per year (lbs/yr) by the biomass of that species produced per acre of salt march per year

Bay anchovy:	1,280,304 lbs/yr / 171 lbs/ac/yr	= 7,487 ac
Weakfish:	127,463 lbs/yr / 29 lbs/ac/yr	= 4,395 ac
Spot:	252,869 lbs/yr / 45 lbs/ac/yr	= 5,619 ac
White perch:	62,350 lbs/yr / 50 lbs/ac/yr	= 1,247 ac

Step 8: Use the acreage for the species requiring the maximum as the total area to be restored - 7,487 acres

Cost Effectiveness Analysis

- Even if restoration is not implemented, cost information is useful
- Provides context for cost of technology
- From the point of view of public trust resources, what is cost-effective?

Evaluating Technology Costs – Brayton Point

- EPA R1 considered the cost of restoring organisms lost compared to cost of technology to avoid losses
- Restoration costs - $28M per year, Closed Cycle Cooling – $41M, with cost to ratepayer of $0.03 to $0.13 per month
- CC cooling was permit requirement

Conclusions

- Methods and data exist for quantifying amount of restoration needed to offset a given magnitude of loss
- Important to estimate restoration gains, not just resource losses
- Cost of restoration is useful information even if restoration is not feasible or the preferred mitigation