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.
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

Example: 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
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 not 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 and 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).

- \( \frac{338,315,003 \text{ g dw}}{82,820 \text{ g dw ac}^{-1}} = 4,085 \text{ acres} \)
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**
\[
900 \times 0.55 = 495
\]

**Bacteria**
\[
495 \times 0.67 \times 0.1 = 33 \text{ g}
\]

**Herbivores**
\[
1,000 \times 0.1 \times 0.1 \times 0.2 = 2 \text{ g}
\]

**Benthic/epibenthic consumers**
\[
25 + 3.3 + 16.3 = 44.6 \text{ g}
\]

**Nekton**
\[
0.2 + 4.0 = 4.2 \text{ g dw m}^{-2}
\]

**Residents**
\[
2.8 \text{ g}
\]

**Migrants**
\[
1.4 \text{ g}
\]
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:

\[43,964 \text{ lbs/ac/yr} \times 0.40 = 17,586 \text{ lbs/ac/yr detritus.}\]

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

\[17,586 \text{ lbs/ac/yr} \times 0.67 = 11,782 \text{ lbs/ac/yr detritus}\]
Step 5: Assume that this organic matter is converted to fish biomass as follows:
Organic matter $\rightarrow$ primary consumers (arthropods) $\rightarrow$ secondary consumers (age 1 fish)

Assuming a 20% conversion efficiency among trophic levels, then the fish biomass produced is given as:
$11,782 \text{ lbs/ac/yr} \times 0.2 \times 0.02 = 471 \text{ lbs/ac/yr}$ 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 marsh per year

Bay anchovy: \[
\frac{1,280,304 \text{ lbs/yr}}{171 \text{ lbs/ac/yr}} = 7,487 \text{ ac}
\]

Weakfish: \[
\frac{127,463 \text{ lbs/yr}}{29 \text{ lbs/ac/yr}} = 4,395 \text{ ac}
\]

Spot: \[
\frac{252,869 \text{ lbs/yr}}{45 \text{ lbs/ac/yr}} = 5,619 \text{ ac}
\]

White perch: \[
\frac{62,350 \text{ lbs/yr}}{50 \text{ lbs/ac/yr}} = 1,247 \text{ ac}
\]
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.