Principles and science of stocking sea cucumbers into the wild

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Presentation overview

- Invertebrate stocking: a new era
- Scales of release, different methods and timeframes
- Preserving the integrity of wild stocks
- The dangers of translocation
- Disease screening
- Chemical marking of cultured juveniles
- Use of sea pens
- Surveys to assess the success of sea ranching and restocking
- Likely economic returns?
- Conclusions
Stocking of invertebrates

- Scallops
- Abalone
- Queen Conch
- Shrimp
- Crayfish and Lobsters
- Sea Urchins
- Giant Clams
- Topshell (Trochus)
- Sea Cucumbers
Jumping in too early
Why did enhancement programs have such poor success?

- Restocking and sea ranching are relatively new fields
- Enhancement activities were driven by the ability to produce juveniles
  But…
  1. Goals ?
  2. Cost $$$ !!
  3. Predation?, habitat requirements?, post-release movement?
  4. Animals were rarely marked to prove the success of captive-release

- Poor success in many case studies gave a bad name to stock enhancement and restocking
Marine stocking - a ‘new era’

- Challenges in this ‘new era’ of stocking include the need to:
  - critically assess costs and benefits,
  - conduct research to work out how to release animals so they survive well, and
  - use science to prove the cost-effectiveness of stocking
Sea cucumber management and the role of restocking and sea ranching

- **Stock Enhancement**
  - Increasing stocks and commercial harvests in an existing fishery

- **Restocking**
  - Restoring breeding populations in a depleted fishery

- **Sea Ranching**
  - Growing shellfish in an open area defined by a lease or through property rights

- **Sea Farming**
  - Growing marine organisms in a bounded space – e.g. a fenced off area or in a pond or embayment

Scales of release

**Stock Enhancement**
- Mass release at low density into broad areas

**Restocking**
- Moderate-scale release at moderate to high density in relatively small areas

**Sea Ranching**
- Release at high density into restricted areas

**Sea Farming**
- Release at very high density
Restocking – 7 golden rules

1. It is a management tool - analogous to ‘captive release’ programs
2. Applicable when there are so few animals that you can’t form effective effective breeding populations by aggregating remnant animals in the fishery
3. Survival will be poor unless the release methods are determined and used
4. The released animals must be protected as a nucleus breeding population
5. The protected area (sanctuary/reserve/NTZ) is big enough so that the majority of animals don’t move out of it into grounds where they can be fished
6. At maturity, the animals are in high enough densities to find each other easily to allow successful natural breeding
7. The restocked breeding population is sited such that their offspring can settle in areas within the target fishery
Key steps of restocking

Correct the management system → Nominate existing reserves or create NTZs for restocking sites → Collect broodstock and breed them in a hatchery

Release juveniles in ways to maximise survival to maturity → Larval supply from the restocked breeding population rejuvenates recruitment in neighbouring fishing grounds

Nominate existing reserves or create NTZs for restocking sites → Protect the released animals in the sanctuary for the term of their lives

The offspring from restocked animals can be fished → Breeding populations in local fishery are rebuilt
Sea Ranching – 7 precepts

1. It is an extension of aquaculture - “put, grow, and take”
2. Beneficiaries have full property and access rights
3. Like restocking, the release methods are well founded to give good survival
4. Most animals need to remain inside leased/managed area
5. Harvest efficiency will be high – poaching is minimal and animals can be easily harvested
6. Animals are harvested at a size that maximises economic returns per released juvenile
7. Success = the money made from harvesting the animals far outweighs the cost of producing juveniles

Was more money earned from sea ranching than could have been gained from banking the money to produce/buy juveniles and earning the interest? or investing it in other aquaculture/fisheries initiatives?
Key steps of sea ranching

Gain access rights over an area of optimal habitat for releasing and growing the animals

Produce juveniles in a hatchery or buy them

Release juveniles in ways to maximise survival to maturity

Protect the released animals in the area until they reach an optimum market size

Improved recruitment to neighbouring fishing grounds is a secondary effect

Harvest all animals
Preserving the integrity of wild stocks

- Wild stocks will be needed in future:
  - Broodstock for producing juveniles in hatcheries
  - Rebuilding healthy wild populations resilient to disease, natural disasters, other natural and human-induced disturbances

- This relies on us to:
  - Ensure the **genetic diversity** and genetic structure of each population is not compromised
  - Ensure we don’t introduce, or increase the prevalence of, **disease** into wild populations
Potential problems from translocation

- Can reduce genetic diversity of wild stocks:
  - ‘Introgression’ - introduction of foreign alleles
    1. Interbreeding of introduced stock with wild stock
    2. Out competing native alleles
  - Introgression reduces the genetic identity of stocks and the unique (and potentially advantageous) genetic composition of native stocks
Potential problems from translocation

- ‘Outbreeding depression’ can occur from interbreeding of introduced stock with native stock
  - Disturbs adaptations native stock have to local environment

- Interbreeding of translocated stock have been shown to have long-lasting effects, that tend to be disadvantageous in the long term rather than beneficial

- Translocation problems are more of a risk with species that have limited larval dispersal – e.g. *Holothuria scabra*
Limited gene flow and larval dispersal of sandfish

- On regional scale, genetic differences related to geographic distance
- Restricted gene flow in sandfish at scales <100 km

**Lesson for restocking and sea ranching**

- Juveniles should only be translocated near to the natal sites (where broodstock parents were collected)
- Juveniles cultured from broodstock in one country should NOT be shipped to another country

Minimising introduction of disease

Perform a simple visual disease check in your own hatchery, using established protocols

Lesions?  Discoloration?  External parasites?  White spots or fluffy patches?  Excessive mucus?
Why should we need to mark or tag cultured juveniles?

1. To be able to assess the survival rate of released juveniles \( \Rightarrow \Rightarrow \) cost effectiveness?

2. To show that the animals we later harvest came from the animals we released
   - Provides proof of stock ownership

![Diagram of cultured juveniles with wild recruits](image)
Chemical marking fluorescently colours sea cucumber spicules

Spicules (‘ossicles’)

- In the outer body wall – mainly in the dermis
- Calcareous
- Very small (less than 1/10th of a mm!)
- Produced as the animal grows

Fluorochromes

- Tetracycline (and oxytetracycline)
- Calcein
- Calcein blue
- Xylenol orange
Chemical marking with flurochromes

- The juveniles must be in a period of active growth before immersion marking

Keeping juveniles in a bare tank overnight

Fluorochrome stock solution added to tank with aerated seawater and heater

Tanks shaded and animals left in immersion solution for 24 h
Marker verification - sampling

Taking a sample of outer body wall and bring back to the lab

Digest soft tissue in bleach to get cleaned spicules

Check spicules to see if any are marked with a fluorochrome
Marked spicules under fluorescent microscope

Spicules marked with tetracycline (T) and calcein (C) sequentially

White light only

UV light only

Xylenol orange

Calcein blue
Sea pens – an experimental tool

Gauging the post-release survival of juvenile sea cucumbers: A dilemma
Small sea pens

- Small sea pens (1 m² to 10 m²) are great for short-term work
- Chance of escapement increases with smaller pens
- A netting skirt at the top of the pen significantly reduces escapement
Large sea pens

- Pens need to be open to replicate the natural conditions – so that we can assume similar mortality in and out of the pens
- A strip of antifouling on the mesh should reduce escapement
- Big pens (100-1000 m$^2$) are harder to install
- 500 m$^2$ pen – 2 days to install 3 pens
- Pens are difficult to set up in firm sand – muddy sand is best for sandfish

25 m diam
Field surveys to assess the success of stocking

QUADRAT SURVEYS IN SEA PENS

- Quadrats need to be set randomly – in pre-determined positions
- Need to assess border separately
  - This requires stratified sampling
Assessing the success of sea ranching

- Release the marked juveniles into a core area in a natural habitat
- Allow 1 year for them to attain a size at which they can be seen in surveys
- Assess survival of larger sandfish by using transect surveys within dispersion zones and verifying the origin of the animals using analysis of their spicules
- Juveniles are expected to move further if the habitat is sub-optimal

Random transects for visual surveys
Survival of released juveniles?

- Most of the mortality occurred in the first couple months after release
- At some sites, none of the released animals survived to market size

- If animals are released in the correct habitats, at initial sizes of >3 to 10 g, survival to market size (700 g) was predicted to be 7-20%
- Survival may be higher at other localities where predators are removed or where the animals can grow to adulthood faster
Likely economic returns from sea ranching?

A quick calculation:

- Conservatively, one-in-ten animals will survive to market size

Total cost per juvenile (3-10 g) of production, release and harvest must be **US 24 cents or cheaper**, just to break even.

Maybe you only find 80% of those that survived.

1 adult of 700 g = about US$3.
Lessons for sea ranching and restocking

**Unpredictability**

- Factors beyond those controllable by optimal release strategies can dictate success (e.g., cyclones, predator invasion, flooding)
- Success on one occasion doesn’t guarantee success at that site on another occasion
- Success from short-term experiments is no guarantee for success of large-scale releases over longer time frames – some key causes of mortality occur infrequently
  - Plan on some sites failing – use multiple release sites and multiple times
Lessons for sea ranching and restocking

1. Firstly determine the optimal habitats, sizes and densities to release juveniles.

2. Risks to wild populations (genetic, disease) are real, and should be minimised.

3. Chemical marking of juveniles is cheap and simple. Restocking and sea ranching programs should mark all cultured juveniles to prove cost-effectiveness.

4. A majority of the juveniles you release in the wild will die or be eaten by predators before they reach market size.

5. Sea pens can help assess survival, and visual surveys can be used once the animals are adults.

6. Juveniles need to be produced cheaply for cost effectiveness.

7. Weigh up the costs and expected benefits, and be aware of the timeframes.

8. Sociological issues and constraints will be just as important as biological ones!