

*Geoduck clam aquaculture on the
intertidal habitats of southern Puget Sound:*

*Assessment of ecological impacts and
mitigation of regional-scale cultural conflict*



Geoduck
Panopeus abruptus

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Geoduck clam: *Panope abrupta*

- Largest known burrowing bivalve on earth;
- Siphon may be >1 m in length;
- Ranges from California to Alaska;
- Filter feeder;
- Life span > 100 yr
- Harvested commercially in Washington and British Columbia;
- Optimal harvest age 5-7 yr (weight 0.5-1.0 kg)



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Harvest history

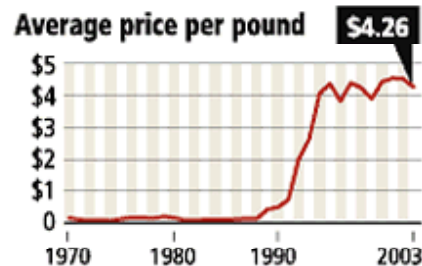
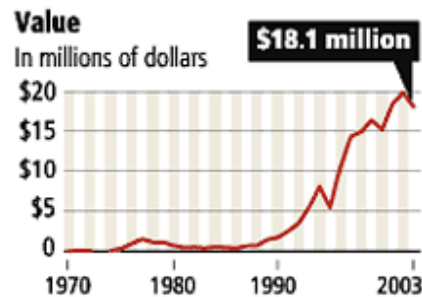
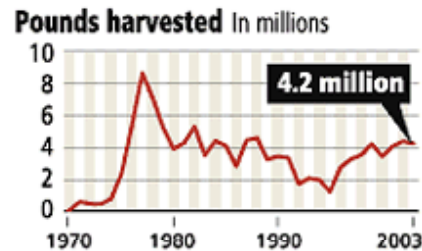
Until recently, geoduck harvest has been dominated by collection of wild clams by divers in subtidal habitats



GEODUCK HARVESTING

More geoducks are harvested from Puget Sound than any other place in the world. In the past 15 years, the price per pound for these oversized clams has skyrocketed, making geoducks one of the state's most valuable fisheries. Now geoducks grown in aquaculture are entering the market and beginning to compete with the more traditional wild harvest.

WILD HARVEST STATS



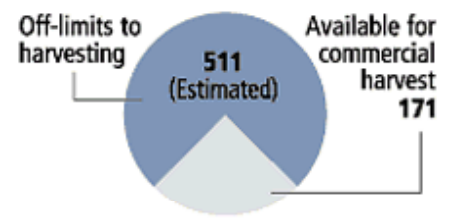
Source: Department of Natural Resources

HARVESTING AREAS



WASHINGTON RESOURCES

In millions of pounds, 2003



SEATTLE POST-INTELLIGENCER



Fisheries & Oceans Canada

Wild harvest: ~85% of value



Chris Fitzgerald

**Cultured harvest: ~15% of value
(projected to reach 40%)**

Primary markets: Asia

Aquaculture cycle



Typical schedule:

- **Year 1: Planting**
 - Placement of anti-predator structures
 - Outplanting of juveniles
- **Years 2-5: Grow out**
 - Removal/replacement of anti-predator structures
- **Years 5-7: Harvest**
 - Liquefaction of sediment
 - Extraction of geoducks



P. Sean McDonald

Aquaculture cycle



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The issues:

1. Geoduck aquaculture activities are viewed as unsightly, therefore undesirable, by shoreline residents.



Save Our Shoreline (both)

The issues:

2. Geoduck aquaculture activities may be causing irreversible ecological damage.



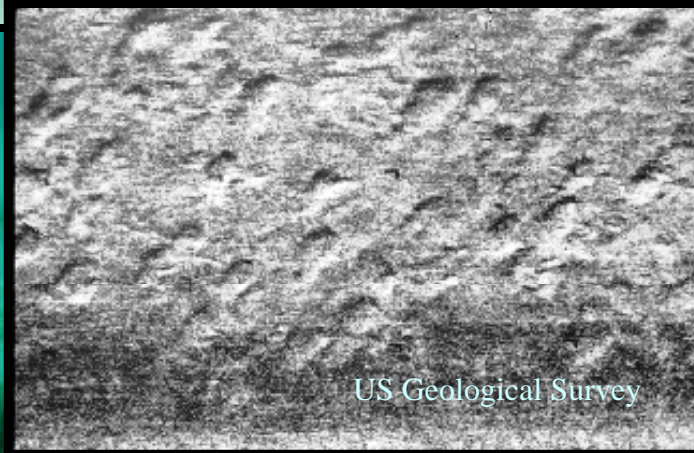
Defining the conceptual context: ecological disturbance:



A disturbance is any relatively discrete event in time that disrupts ecosystem, community, or population structure and changes resources, substratum availability, or the physical environment

[Pickett, S.T.A., and P.S. White. 1985. The ecology of natural disturbance and patch dynamics. Academic Press, Orlando, Florida, USA.]

Natural disturbances on smaller scales



Anthropogenic disturbances



Large scale



Small scale

Operating premises:

1. **Natural disturbances occur in all biological communities;**
2. **The ability of biological communities to resist, accommodate, and recover from anthropogenic disturbances depends on the similarity between anthropogenic and natural disturbances to which the community is exposed.**



Metrics for characterizing disturbances, and for comparing disturbances of different types:

Frequency and duration:

How often and for how long?

Intensity:

How disruptive?

Size:

How big?

Chemical and Physical Attributes:

By what mechanisms does disruption occur?

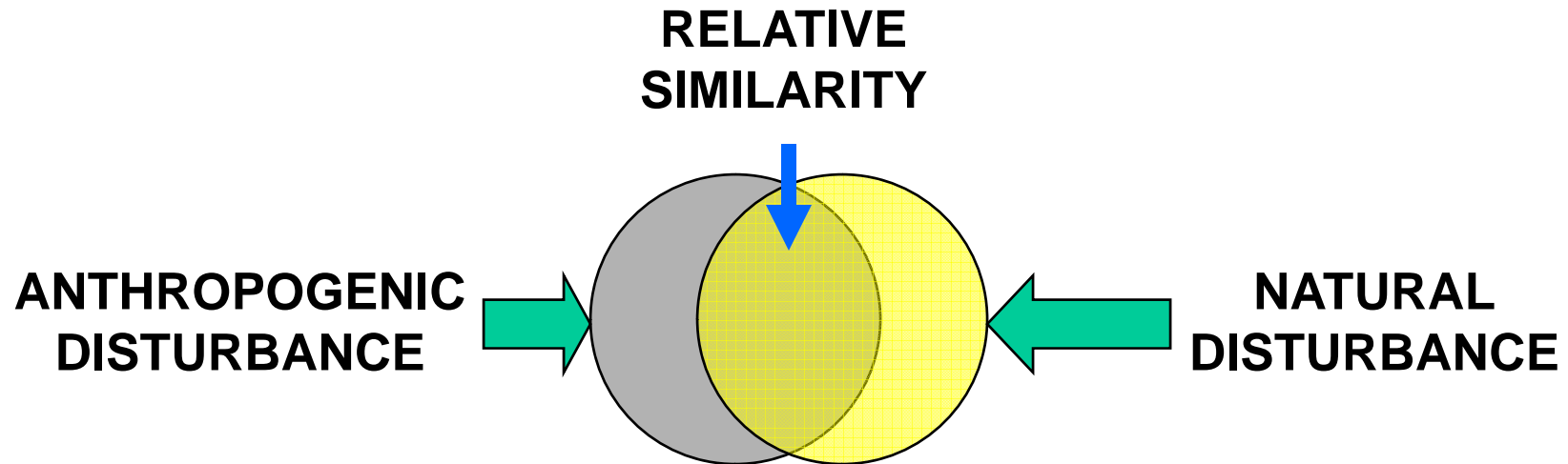
Community resistance/resilience:

What are the spatial and temporal patterns of recovery of the disturbed community to the pre-disturbance configuration?



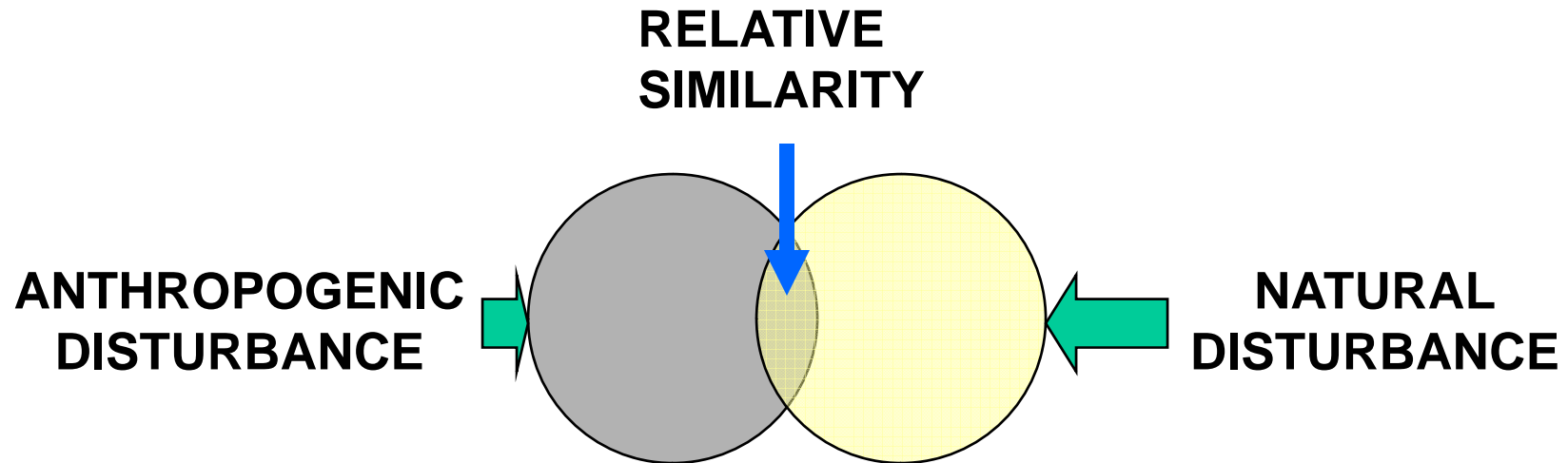
Natural versus anthropogenic disturbances

- Compare similarity of effects and consequences across all disturbance metrics: frequency & duration, intensity, size, chemical/physical attributes, and population response patterns:
- If similarity is **high**, the potential for lasting ecological damage by the anthropogenic disturbance likely is **low**.



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Design foci:

Disturbances:

- a) Outplanting and structural placement;
- b) Removal of structures;
- c) Harvest.

Structural effects:

- a) Infauna;
- b) Mobile invertebrates;
- c) Salmonids and prey.



Effects of structural placement I

1. Deposition of material produced by epibiota, both within *and* adjacent to the culture plot:

- inorganic: alteration of sediment grain size distribution;
- organic: alteration of sediment organic carbon content, and depth of redox discontinuity in the sediment column.



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Effects of structural placement II

2. **Scour associated with water movement at the interface of sediment and structures**

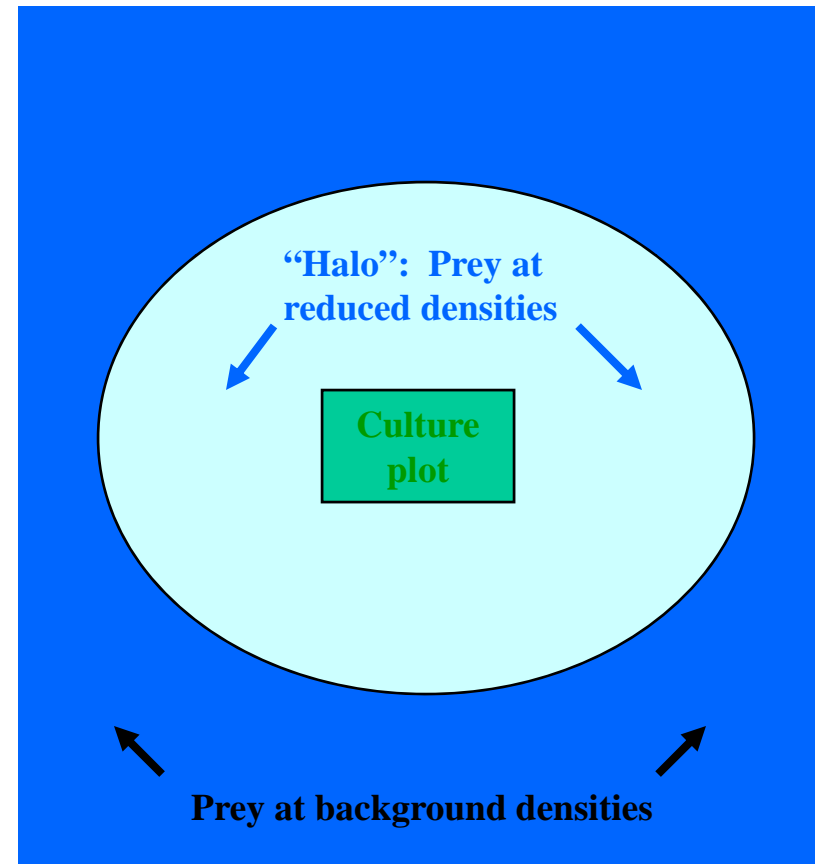


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Effects of structural placement III

3. The “halo” effect:

- Foraging by mobile predators attracted to the structures for shelter;
- Foraging occurs both within and adjacent to the culture plot.
- Results in a “halo” of low densities of selected prey around the structures.



Effects of harvest I

Harvest components:

1. **Liquification of sediment using high-velocity water jets;**
2. **Removal of dislodged clams;**
3. **May be repeated several times over a period of 5-10 days.**



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Effects of harvest II

Biological effects of harvest:

1. Initial dislodgement, injury, or mortality to resident biota;
2. Attraction of predators and scavengers to disturbed site to consume dead or injured biota;

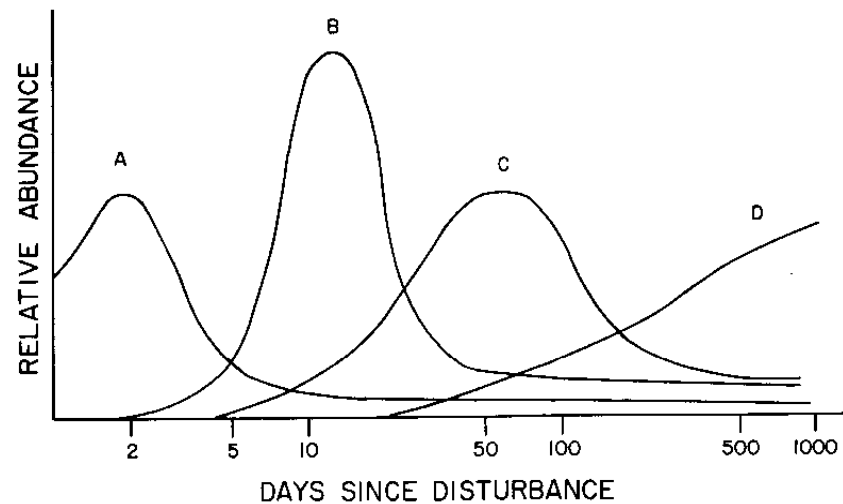


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Effects of harvest III

Biological effects of harvest:

3. Physical modification of habitat;
4. Utilization of modified habitat by opportunistic species;
5. Successional transition over time in the physical characteristics of the disturbed location, and in the composition and abundance patterns of biota in the disturbed location

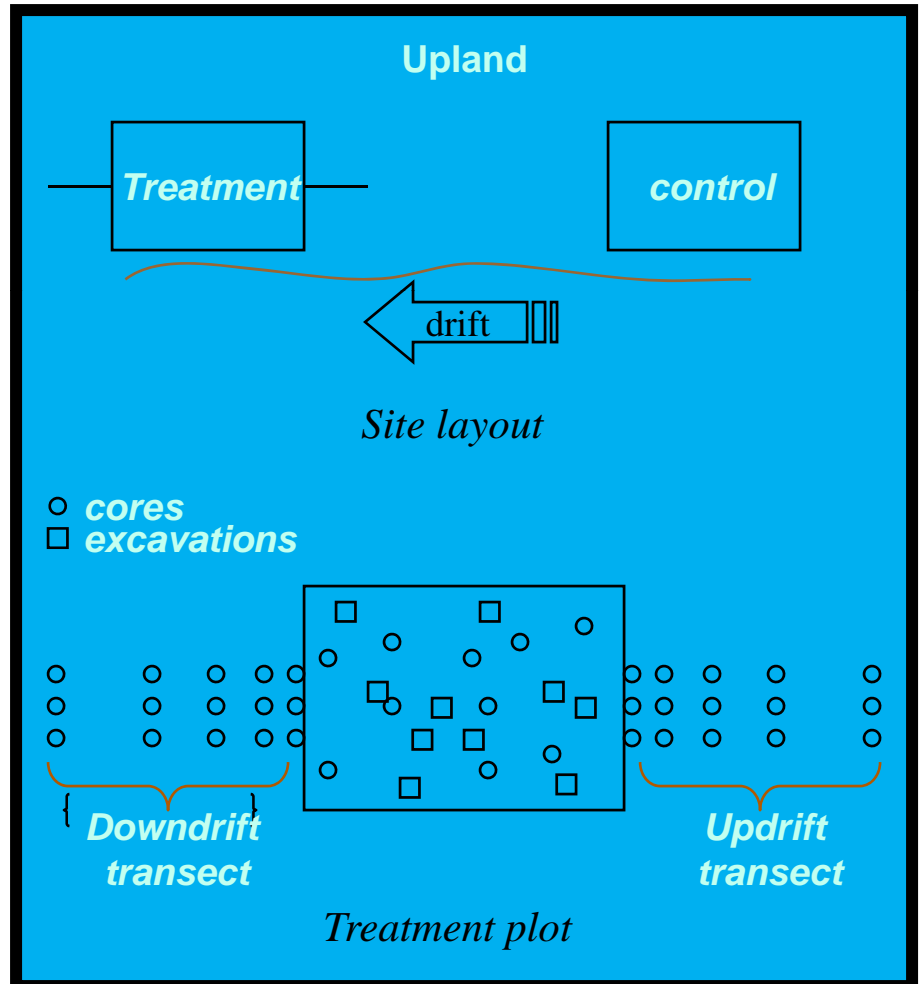


VanBlaricom 1982

Sampling Design

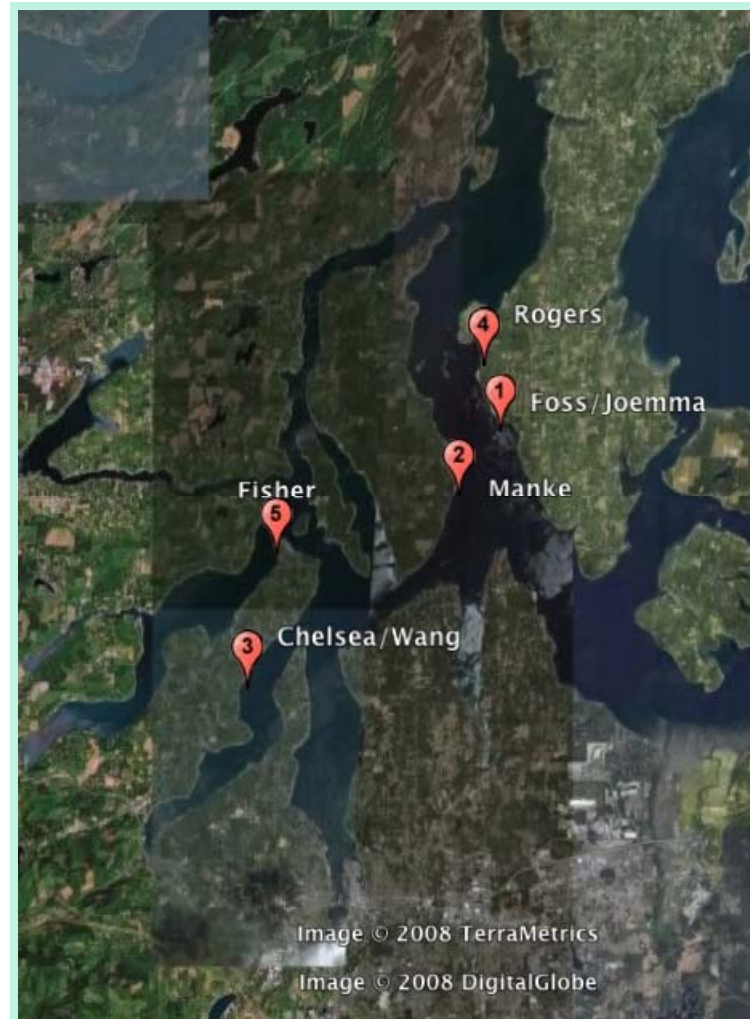


- **Sampling regime**
 - Before-during-after disturbance
- **Data types**
 - 10 randomized cores
 - 10 excavation samples with prior photo-quadrats
 - Extra-limital transects



Courtesy of P. Sean McDonald

Study sites: Emphasis on southern Puget Sound



Courtesy of P. Sean McDonald