Strategies to minimize risk of disease and produce resilient quality oysters

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What defines a quality oyster:

Here:

- Single-seed oyster
- High glycogen content
- Good shell shape & nacre
- Uniform looks & performance
- Year-round availability

A selectively bred 3N oyster!

What defines a resilient oyster?

Here:

- Robust to changing environmental conditions & stresses
- Healthy, fit & low mortality
- for Pacific oysters:
  - Resistance to OsHV-1
  - Resistance to ‘adult morality’ (Vibrio spp. ?)

Has emphasis on OsHV-1 or some qualitative traits affected robustness of the adult oyster?

Overview of strategies used to reduce disease risk and get resilient quality oysters

- Selective breeding
- 3N
- Hatchery & nursery procedures
- Grow-out technology & husbandry
- Biosecurity measures

Selective breeding strategies for resilient quality oysters (1)

Important: Focus on key commercial traits & avoidance of inbreeding!

Examples:

- **Disease resistance** for QX and Winter Mortality in Sydney Rock oyster (AU): one-sided, missing growers' expectations
- **Oyster shape** & uniformity in Pacific oyster (AU): at expense of genetic variation?
- **OsHV-1 mortality**, the latest focus of most Pacific oyster breeding: *Could strategies used have led to inbreeding, weakening of overall fitness & contributed to 'adult mortality' problem?*

Selective breeding … (2)

- **Inbreeding**, 1x1 brother-sister crosses, proven v. **negative:**
  - Immediate hatchery difficulties
  - Poor growth
  - Low fitness & poor overall survivorship
- **Line Maintenance Crosses (LMCs),** pool of multiple brother-sister crosses: **safe?**

  LMCs routinely used by breeders, researchers, hatcheries, for:
  - Maintenance of genetic lines over generations (example: 'R'-lines)
  - High uniformity, a quick expression of qualitative traits (shape, colour, etc.)
  - Overcoming broodstock shortages of select lines (commercial hatcheries)

Selective breeding … (3)

Experiences with Inbreeding & LMCs in NZ:

- Inbred/ down-selected families: always worst performers!
- LMCs for OsHV-1 mortality: Can slower growth of inbreeding benefit OsHV-1 survivorship? Yes, but is 'real' *genetic gain?*
- LMC tested in commercial batch: reduced OsH-1 mortality, but otherwise poor performer, compared to out-bred

Could the use of LMCs create unwanted genetic effects?

- LMC: a form of inbreeding leading to reduced growth, fitness & survivorship (?)
- What effects have multiple generations of LMCs on oyster fitness & adult survivorship?

Selective breeding … (4)

Hatchery trend towards use of 'seed lots' (family pooling):

Benefits for hatcheries:

- Large numbers of families grown mixed - environmental effects minimized!
- Easy & fast during hatchery & grow-out

Down-sides & risks:

- Parentage testing: huge cost & effort
- Hatchery broodstock needs: 1,000s per select line not provided for
- **LMC**: intermediate step to satisfy hatchery broodstock needs

Selective breeding … (5)

Breeding test sites & their relevance (G&E):

- Atlantic coast-based ‘generalist lines’: how suitable for rest?
- Mediterranean: extremely different, own programme needed

Selective breeding, an ongoing effort:

- Adapt to constantly changing environments & demands
- Target: Provide continued genetic gain without risk of inbreeding. Large base population needed = big effort & cost!
- Re-focus on ‘adult mortality’: new strategies needed with long assessment timing (3 yrs +)
- Who can provide?
  - Commercial hatcheries alone?
  - Other institutions?

Triploid strategies for resilient quality oysters (1)

Benefits of 3N:

- Year-round supply of quality oysters (glycogen)
- Lock-in genetic gains from breeding work (competitive advantages hatcheries)
- Not contributing to build-up of wild populations:
  - Maintain diverse genetic make-up 2N
  - Lesser spat over-catch problems
- Lower OsHV-1 infection pressure & mortality (?)

Triploid … (2)

Most used Induction strategy: 4N x 2N

Some issues with 4N-based inductions:

- Use of highly fecund 3N broodstock for 4N: contra-intuitive!
- With 4N induction, both from 3N or 2N: low %-age of induced larvae meet 4N target
- Passing on breeding gains difficult:
  - Little control (see above!): typically, half of genetic variance comes from within family selection
  - Some: holding on to same 4N batch for many years (sex issue)
- “Laboratory” animals (for biosecurity reasons): entire life-cycle spent in artificial non-challenged environment

Triploid … (3)

continued …

- Typically, 4N based on multi-generations of “R-line” **LMC**: inherent problem with oyster fitness and robustness (?)

- 67% of genetic make-up of Triploids based on 4N parent: implication of combination of effects (LMC, low induction efficiency, lack of genetic selection, lab animal)?

- 4N-Triploids: Selection for resilient quality traits largely restricted to 2N component (33% of genetic make-up)

Alternative 3N methods, how would they compare?

Hatchery strategies for quality resilient oysters (1)

Genetics, the key point of differentiation for hatcheries!

Hatchery-own breeding & selection:

- **Selection criteria**: Focus on OsHV-1, or beyond? Is key issue of adult mortality addressed?
- **What approach:** Single-family or 'seed lot'? How can cope with effort? What scale of programme?
- **Selection sites**: Where? G&E representative site for grower's needs?
- **Inbreeding**: Is strategy to avoid inbreeding in place?
- **LMCs:** To what extent are LMCs used? In context of 'seed lot' breeding? To meet broodstock demand? Implications?

Hatchery … (2)

Selection & hatchery screening - AU:

No natural recruitment. Generations of mass selection from farmed stocks. High intensity of hatchery screening:

- Great shape (key selection trait)
- Great uniformity & looks!
- But ~ 20% smaller larvae, higher background mortality, slower grow-out compared to NZ
- Q.: Signs of inbreeding? With **LMC**, over time, get the same?

Screening in hatchery & nursery

- Minimum intensity: higher variability
- High intensity: lesser variability, more uniformity

Grow-out strategies for resilient quality oysters (1)

Glycogen content, the key to oyster quality & resilience!

- Main market attribute
- Energy reserves: fitter, more resilient oysters

How to build glycogen content:

- → Controlling shell growth
- Target: balanced growth between shell and meat

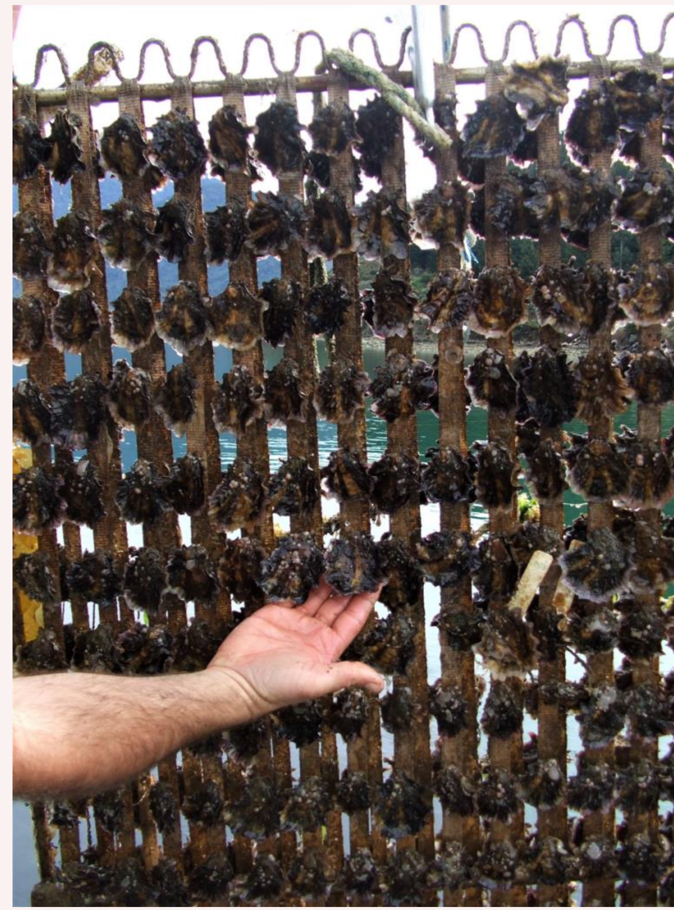
Common strategies:

- Use upper inter-tidal, productive sites (environment)
- Tumbling growing systems (technology)
- Density, grading, bag turning, etc. (husbandry)
- Combinations of above

Grow-out: TOPS Oysters ™ (2)

What is TOPS Oysters ™
(**T**raceable **O**ysters **P**roduction **S**ystem) www.topsoysters.com:

- Free suspension
- Controlled spacing
- Unrestricted water flow & food supply to each oyster
- No shell touching = no com-petition = no "survivorship mode":
  - Balanced growth
  - High meat (glycogen) content
  - Good shell nacre



Grow-out: TOPS Oysters ™ (3)

Benefits:

- No handling from spat
- Quality meat, shell & nacre
- Uniform performance
- High resilience, v. low mortality (NZ trials!)

Optimal growing conditions for **each** individual oyster!

Grow-out … other important aspects (4)

- **Productivity of sites**: estuarine sites better than oceanic
- **Sites affected by catchment run off**: risk of pollutants
- **Fouling**: hard & soft fouling, importance of control
- **Stocking rate & carrying capacity**: moderate approach important for sustaining good performance
- **Feral oyster populations**: sites with excessive wild stock more prone to food competition, over-settlement, disease
- **Beneficial use of OsHV-1 "pre-challenged" oysters**:
  → Lower infection pressure, safer!
- **Production area sharing with other producers**: higher risk of cross-farm effects

Biosecurity measures to minimize disease risk (1)

Recent Biosecurity decisions- oysters:

- **NZ, in 2017**: Ministry decision to eradicate all flat oyster farming (B. ostreae)
- **AU, in 2016:** Ministry decision to stop all oyster spat movement to SA (OsHV-1 risk)

  → Not only science & industry, but often also politically driven

Ideal: Minimize stock & gear movements between regions!

- But commercially viable?
- Practically implementable (growers & other users)?
- Enforceable (Authorities, industry organizations ..)?

Biosecurity … a few practical aspects (2)

- **Risk of transferring OsHV-1 with spat source:**
  - Wild-caught spat: high
  - Hatchery spat, ‘open’ nursery system: medium
  - Micro-nursery, ‘closed’ nursery system (water ageing) spat: v. low to none
- **Use of OsHV-1 ‘pre-challenged’ oysters** (based on specialized challenge & grow-out sites): mortality can be contained (important for TOPS Oysters)
- **Use of 3N**: beneficial to control build-up of wild populations

Conclusion

- Spat source important: selective breeding & 3N important for resilient quality oysters
- Strategies applied during different production steps (from sel. breeding, 3N induction, hatchery, grow-out) provide desired outcomes, but not all effects may be positive
- Could problem of ‘adult mortality’ to some extent be related to some of highlighted strategies & practices?
- Cause-effect relationships are complex & not well enough understood: Answers require coordinated effort between all stakeholders