Strategies to minimize risk of disease and produce resilient quality oysters

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Aug 2018
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

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...

- **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 ...

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 ...

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 ...

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

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 ...

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 ...

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

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?
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

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
What is TOPS Oysters™ (Traceable Oysters Production System) www.topsoysters.com:

- Free suspension
- Controlled spacing
- Unrestricted water flow & food supply to each oyster
- No shell touching = no competition = no “survivorship mode”:
  - Balanced growth
  - High meat (glycogen) content
  - Good shell nacre
Grow-out: TOPS Oysters™

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

- **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

- 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