ENVIRONMENTAL INFLUENCES ON THE SUSTAINABLE PRODUCTION OF THE SYDNEY ROCK OYSTER

SACCOSTREA GLOMERATA:
A STUDY IN TWO SOUTHEASTERN AUSTRALIAN ESTUARIES

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Declaration

This thesis is my own work and contains no material previously published or written by another person except where acknowledgement or citations have been made in the thesis. The data used in this thesis I have collected personally except where acknowledgements have been made. I also declare that the intellectual content of this thesis is the product of my own work, except to the extent that assistance from others in some of the experiment’s design, data interpretation or in style, presentation and linguistic expression is acknowledged.

Ana Rubio

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Abstract

There has been a continuous decline in both the production and general performance of the SRO in NSW estuaries over the past three decades. The relationship of this decline to both environmental and oyster-density related factors are assessed in this thesis. This question has been examined at different scales: a large scale that compares two different estuaries (Clyde and Shoalhaven Rivers, southern NSW); a regional scale that encompasses variations within an estuary and, at a lease scale that examines processes pertaining to individual or small groups of oysters. Levels of inorganic nutrients were in general very low potentially limiting primary production. The limiting nutrient was nitrogen or phosphorus depending on whether long term conditions were dry or wet, respectively. Only during rain events, through the input of terrestrial material, were conditions favourable for fast rates of primary production. Carbon and nitrogen isotope analysis has demonstrated that both external material and local resuspension of the benthos constitute a major proportion of the SRO diet. The uptake of the various food sources also varied considerably depending on local environmental conditions. Increases in SRO growth were strongly correlated to increases in temperature with a low temperature cut-off at ~13°C. Growth also appeared to reduce considerably when salinities lower than ~15ppt persisted for the order of a month. These factors may alter growth through changes in filtration rates. These processes were modelled in a coupled hydrodynamic-NPO (Nitrogen-Phytoplankton-Oyster) model of the Clyde River. This demonstrated that primary production was more affected by estuarine dynamics and nutrient concentrations than oyster uptake. At the current levels of oyster densities, primary production by itself could not account for the observed oyster growth, however growth became realistic with observed levels of POC added to the model. A set of environmental indices were used to complement the model and to assess the sustainability of the culture system. The combined indices indicated that while the ecological carrying capacity of the Clyde was exceeded the production capacity at an estuarine scale was not. On the lease scale, density experiments showed that while growth was not reduced as a result of current stocking densities, the condition index was significantly affected.
This thesis is dedicated to the Clyde and Shoalhaven oyster growers

‘Oysters may be the food of love,
but it is definitely a labour
of love to produce them’
(Anonymous)

An early morning sampling in the Clyde River…
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Glossary

Adductor muscle – oyster organ whose function is to close both shells tightly

Aerobic – oxygen present

Anaerobic – oxygen absent

Anterior – area of the oyster shell where the hinge is located

ANZECC – Australian and New Zealand Environment and Conservation Council. ANZEEC compiled the ‘Australian Water Quality Guidelines for Fresh and Marine Waters’. Guidelines for sustainable management of the water resources

ASS – acid sulfate soils

Australian Height Datum (AHD) – a reference water level corresponding approximately to mean sea level

Benthos – material and organisms which inhabit the seabed

Biodeposits – oyster depositions which comprised true faeces and pseudofaeces

Bistro grade – oysters that weigh ~40-45g/ each. One bag of bistro has 110 dozen oysters

Bottle grade – oysters that weigh ~35g/ each. One bag of bistro has 130 dozen oysters

Broodstock – a parent shellfish

Catching area – area for the collection of wild juvenile oyster spat which settles onto ‘catching’ substrates such as sticks or plastic slats

Carrying capacity – the maximum oyster biomass sustaining a marketable growth rate, supported by a given area as a function of the water residence time, system primary production time, and oyster clearance rate

Chl-a – Chlorophyll-a, estimate of the phytoplankton biomass (measured in µg L⁻¹)

C.I.—Condition Index measured as the ratio of dry flesh to shell weight

Cilia – small hair-like structures that are part of the gill which create water currents through the mantle cavity and are involved in the removal of particles from the water column

Clearance rate – amount of particles cleared from a volume of water per unit of time (measured in mg L⁻¹)

Culling – the manual division of clumps of oysters into single oysters or the removal of organisms which attach to oyster crops

δ¹³C & δ¹⁵N – ratios of ¹³C/¹²C and ¹⁵N/¹⁴N which are the difference between the sample and conventional standards in isotope analysis e.g. Pee Dee belemnite limestone carbonate for carbon and air for nitrogen.
Depot area – growing area where blocks of catching sticks bound together are used; this structure provides protection enabling the oysters to grow to a size that can withstand predation by fish

Depuration – a cleaning process that requires oysters to be placed in a sterilised recirculation tank for 36 hours. During this period oysters cleanse themselves by filtering bacteria-free water

Detritus – small pieces of dead and decomposing plants and animals

DIN – Dissolved Inorganic Nitrogen, comprises NO₃⁻ and NH₄⁺ (measured in mg N L⁻¹)

DLWC – Department of Land and Water Conservation

DO – dissolved oxygen (measure as percentage saturation or mg L⁻¹)

DOC – Dissolved Organic Carbon (measured in mg C L⁻¹)

DW – dry weight (measure in g or mg)

EC – electrical conductivity (measured in mS cm⁻¹)

Endemic – native to a particular area and found in no other location

Environmental Index – (EI) a functional performance indicator that assesses the environmental potential characteristics of a system

Epifauna – animals living on the surface of the ocean bottom

Eutrophication – water body enriched with nutrients that results in excessive growth of organisms and depletion of oxygen concentration due to uptake in biological processes

Faeces – material that has gone through the digestive system and has been excreted

Filtration rate – amount of water volume and suspended particles taken up by the oysters (measured in L h⁻¹)

Floating cultivation – sub-tidal cultivation of oysters in baskets, pillows or tumblers suspended from tethered, low buoyancy systems that may include lines and/or floats

Flushing time – the amount of time taken on average to turn over an amount of water in a tidal waterbody

GF/F – glass microfibre filters of pore size 0.7μm

Hinge – anterior area of the shell where there is a ligament that functions as a pivot point of both valves

Labial palps – soft flaps at the mouth of the oyster whose function is to select the particles that are going into the digestive system. The rejected material is engulfed in mucus, forming what are called pseudofaeces

Mantle – a flap of flesh that covers the internal organs of an oyster
Microphytobenthos – the microscopic flora community embedded in the first centimetre of sediment that in the interface between pelagic and benthic processes, in particular in aquatic systems

Mudworm – oyster disease caused by the spionid polychaete worm (*Polydora websteri*)

\( NH_4^+ \) – dissolved ammonia (measured in mg N L\(^{-1}\))

\( NO_x \) -- dissolved organic nitrogen, including nitrate and nitrite (measured in mg N L\(^{-1}\))

NSW – New South Wales

ppm – parts per mil

pH- a measure of the acidic or basic (alkaline) conditions in an aqueous solution (a measure of the hydrogen ion concentration H\(^+\))

Phao – Phaeopigments, estimate of the numbers of dead algae cells (measured in \( \mu g \) L\(^{-1}\))

P.I. – Performance Index. Oyster biomass index suitable for comparing oyster production between areas

PIM – particulate inorganic matter (measured in mg L\(^{-1}\))

Plate grade – oysters that weigh ~45-50g/ each. One bag of Plate has 100 dozen oysters

POM – particulate organic matter (measured in mg L\(^{-1}\))

ppt (‰) – parts per thousand, typical unit for measuring salinity

Pseudofaeces – particles filtered from the water column that have been rejected before entering the digestive system

PVC – polyvinyl chloride

Oyster aquaculture lease – an area of submerged Crown Land that is leased for the purpose of oyster culture

QX – ‘Queensland unknown’, a Sydney rock oyster disease caused by the protozoan parasite *Martelia sydneyi*

Raft – sub-tidal cultivation of oysters in trays (generally stacks of 10 trays) suspended from a permanently anchored, rigid, high buoyancy structure

Rejection rate – total pseudofaeces production per unit of time (measured in mg h\(^{-1}\))

Residence time – time taken for an amount of water at an arbitrary location within a waterbody to leave through its mouth to the sea

Salinity (S) – the amount of salt contained in water (measured in ppt)

Seston – suspended material in the water column (organic and inorganic)

Single seed oyster/ cultivation– a single unattached oyster that has been removed at an early stage from catching collectors or produced as single oysters in a shellfish hatchery
SL – Shell Length, measurement from the anterior (shell hinge) to posterior edge at the furthest point of the oyster (measured in mm)

Spat – small juvenile oysters (term used up to c. 1.5 yrs old)

SRO- Sydney Rock Oyster (*Saccostrea glomerata*)

ST – Shell Thickness, measurement at the thickest point between right and left valve (measured in mm)

Stick oyster/ cultivation – 4x4cm wooden stick which provides a substrate for larvae settlement which is transportable when relocating oysters within farming grounds. This cultivation method is suitable for areas subject to wave action. Oysters remain attached to the sticks for approximately 2.5-3 years

Stocking density – number of oysters per given area or volume

SW – Shell Width, measurement at the widest point of the flat or right valve (measured in mm)

TOC – Total Organic Carbon (measured in mg C L⁻¹)

Tray cultivation – growing-out system for single seed oysters. This method is suitable for use in sheltered areas and is often used for the final oyster cultivation stage prior to harvest

TSM – Total Suspended Matter (measured in mg L⁻¹)

TW – Total weight or wet weight (measured in g)

Valves – the two shells holding the oyster flesh; in the SRO the left valve is cupped and the right valve is flat

Winter mortality – oyster disease caused by the proctoctistan parasite *Mikrocytos roughleyi*
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