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History, Status and Future of Oyster Culture in Australia

Greg B. Maguire[1*] and John A. Nell[2]

1. Research Division, Department of Fisheries, Western Australia, PO Box 20, North Beach, WA 6920, Australia.
2. New South Wales Department of Primary Industries, Port Stephens Fisheries Centre, Private Bag 1, Nelson Bay, NSW 2315, Australia
   * Corresponding author Email: maguirewa@iinet.net.au

INTRODUCTION

Oyster farming is one of the oldest aquaculture industries in Australia, dating back some 120 years (Nell, 2005). While farming methods, particularly for Sydney rock oysters, changed little for several decades in the twentieth century, the Australian industry in recent decades has been a very dynamic industry with new farming areas and additional Australian states becoming involved in oyster production while some traditional farming areas have experienced long term declines (Smith and Maguire, 1988). Additional changes include the commissioning of oyster hatcheries, industries based on exotic oysters progressively becoming larger than those based on native oyster species, new environmental challenges being met, and better technology being developed by farmers, companies and researchers. For earlier reviews of oyster farming industries in Australia see Holliday et al. (1988), Maguire et al. (1988), O'Meley (1992), Nell (1993, 2001, 2002a, 2005), Holliday (1995), Brown et al. (1997), and Love and Langenkamp (2003) several of whom provide useful photographs.

PRODUCTION STATISTICS

The major industries for edible oysters in Australia are based on production of native Sydney rock oysters (*Saccostrea glomerata*) and introduced Pacific oysters (*Crassostrea gigas*). The major areas of production, based on 2003-04 financial year data (ABARE, 2005), are New South Wales NSW (approximately 6000 tonnes worth A$37.9 million predominantly Sydney rock oysters but with 5% of total value from Pacific oysters), South Australia (4,382 tonnes worth A$21.2 million, almost all as Pacific oysters) and Tasmania (3,243 tonnes worth A$12.0 million, almost all as Pacific oysters). (1A$ = about 83 Yen at time of preparation of the abstract for the 1st International Oyster Symposium). Smaller quantities of Sydney rock oysters and the closely related Western rock oyster are grown in Queensland and Western Australia respectively. At times there has been some production of native flat oysters (*Ostrea angasi*) and native tropical oyster species, chiefly blacklip oysters (*Striostrea mytiloides*) and milky oysters (*Saccostrea cucullata*).

Excluding Western Australia, the total value of Australian edible oyster production was A$71.8 million for the 2003-04 financial year (ABARE, 2005). Most sales are for the high value, half shell market rather than just as bulk sales of shucked oyster meat. This total production of over 13,000 tonnes is considerably higher than the 1999-2000 financial year estimate provided by Nell (2001) who indicated total production of about 9,000 tonnes. The most dramatic growth in production has occurred in the South Australian industry. Oyster production in NSW has been relatively static in recent years and has not returned to its peak of about 8,400 tonnes in the mid 1970s (Nell, 2001) or 9267 tonnes if production of Sydney rock oysters in Queensland is included (Nell, 1993).

In Australia, oysters are sold by number eg per dozen, and not by weight although different size categories attract different prices per dozen. Regardless, the above data imply that Pacific oysters grown in South Australia are more valuable per kg than Tasmanian Pacific oysters. This is not necessarily the case. Industry sources suggest that the value estimate is a better indicator of the size of the Tasmanian industry than the tonnage estimate.

SYDNEY ROCK OYSTERS

Taxonomy

At the 1st International Oyster Symposium it was apparent that there was some confusion over the appropriate nomenclature for Sydney rock oysters.

It was known for many years as *Crassostrea commercialis*. In a review of oyster taxonomy in 1971 it was incorrectly considered to be *Saccostrea cucullata*, which is in fact the tropical milky oyster (Nell, 2001) and dual usage of the two scientific names occurred eg Wisely et al. (1979). Subsequently, the Sydney rock oysters was again considered to be of the genus *Saccostrea* and the name *Saccostrea commercialis* was used by many authors eg Holliday et al. (1993). The similarity between Sydney and New Zealand rock oysters led to their being considered as subspecies (Buroker et al., 1979) and Holliday (1995) proposed that the Sydney rock oyster be called *Saccostrea glomerata commercialis*. Because of the genetic similarity of the Sydney and New Zealand rock oysters, as indicated by DNA sequencing (Anderson and Adlard, 1994), the name *Saccostrea glomerata* is now widely used for both Sydney and New Zealand rock oysters eg Nell (2002a). The specific name *glomerata* had been used prior to the name *commercialis* for Australasian rock oysters and hence it was, by taxonomic convention, preferred. The importation of New Zealand rock oyster spat around 1888 to replenish depleted Sydney rock oyster stocks (Nell, 2001) may have contributed to the genetic similarity.

<u>Historical development of production systems</u>

Collecting and farming of Sydney rock oysters have a long history in Australia (Nell 1993). Indigenous Australians fished for both Sydney rock oysters or flat oysters, depending on locality, and middens (collections of old shells presumably accumulated after removal of meats) for these species occur widely along the Australian coastline. After European settlement, Sydney rock oysters were collected from rocks and mangroves in NSW the 19th century and were often just for lime (calcium carbonate) production. Middens were also excavated for this purpose. Dredging for oysters occurred and specific rock and shell bed areas were established for oyster production.

The combined effects of siltation and mudworm commensals (spionid polychaetes especially *Polydora websteri* – see Skeel, 1979) forced farmers to develop off-bottom, timber post and horizontal rail intertidal systems (racks). These supported various types of horizontal timber oyster sticks with tarred hardwood sticks (25 mm x 25 mm x 1.8 m) becoming the preferred material. The tar inhibits shipworm (*Toredo* spp.) and assists with detaching of oysters at harvest (O'Meley, 1992; Nell, 2001, 2002a). These are initially arranged in three-dimensional bundles of five layers of 20 sticks to catch spat, with the layers helping to deter predators, and are then nailed out in single layers of 20 sticks for growout. The appropriate choice of intertidal height also assists with reducing losses due to winter mortality (*Bonamia roughleyi*) and some farmers raise the intertidal growing height in winter (Smith et al., 2000). Oysters, detached from the sticks but too small for sale, can be grown to larger sizes in large, intertidal trays. A range of alternative substrates to tarred sticks and trays were developed (Holliday et al., 1993; Nell 2001). The use of tar and tar pits for coating wooden surfaces has become less acceptable from an environmental perspective and many farmers now catch spat on plastic slats (2-3 mm thick, 104 mm wide) (Holliday et al., 1993). Increasingly, the oysters are detached as spat, and grown in enclosed mesh trays and then in baskets or mesh cylinders developed interstate for Pacific oysters (see below).

Modern subtidal growout systems were also introduced. Interestingly, given the hosting of the 1st International Oyster Symposium in Japan, these subtidal systems evolved from initial work using Japanese techniques (scallop shells with oyster spat attached were separated by spacers on longlines (Wisely et al., 1979). Subsequently, in the limited number of locations that can be used for multi-layer subtidal culture, a range of cage and stacked tray systems evolved (Holliday et al., 1988). A subtidal system, called a pontoon, uses long, capped, PVC pipes for flotation and supports a single layer of oysters below. It has become popular in the key farming area of Wallis Lake about 65 km north of Port Stephens (Fig. 1). Given the use of intertidal baskets and cylinders and subtidal cages and trays, there has been a major shift to single seed culture (the farming of unattached oysters typically contained within mesh containers).

<u>Other diseases and genetic strategies</u>

Apart from mudworm and winter mortality, the latter of which usually affects oyster farms in the southern half of NSW through to the Victorian border, the major biological problem has been QX disease (*Marteilia sydneyi*). This paramyxean protozoan can cause very high losses in warmer months in the northern half of NSW and further north in southern Queensland. It appears to affect the host's defence mechanisms by inhibiting enzyme (phenoloxidase) activity (Peters and Raftos, 2003). Unfortunately, its impact has spread further south in recent years and has contributed to a severe reduction in oyster farming in areas around Sydney (120-180 km south of Port Stephens). (Note that the oyster diseases discussed above do not affect consumers of oysters.) Predators can cause significant losses of Sydney rock oysters grown in systems that are not fully enclosed by mesh that can exclude predators such as flatworms, fish and crabs (Nell, 1993).

Most Sydney rock farms have relied on wild caught spat, traditionally from Port Stephens, although hatchery produced oysters have allowed for lines of Sydney rock oysters that are selective bred for growth rate and resistance to QX disease (Nell and Hand, 2003). This breeding program has been based on mass selection and fortunately genetic diversity has been conserved well through the use of large numbers of broodstock initially used to create the mass selected line (English et al., 2001). Growth rate has continued to improve with successive generations and growout time has been reduced by 11 months (Nell and Perkins, 2005a). Survival rate, in response to exposure to QX disease, has also improved greatly with each generation (Nell and Perkins, 2006).

Chemically induced, triploid Sydney rock oysters (3N; three sets of chromosomes per cell instead of two), also produced in hatcheries, confer improved resistance to winter mortality (Hand et al., 1998) and grow faster than diploids, although this advantage varies with farming site (Nell, 2002b). However, as with triploid Pacific oysters (Nell and Perkins, 2005b), there can be meat discolouration problems at times (Hand and Nell, 1999; Nell 2002b). In contrast to Pacific oysters, “natural triploid” Sydney rock oyster production, achieved by obtaining sperm (2N) and eggs (1N from female after meiosis) from tetraploid (4N) and diploid (2N) lines respectively (Guo et al., 1996), has not been successful because of the lack of success with producing tetraploid lines. This is despite the wide range of techniques that were assessed with Sydney rock oysters (Nell et al., 1998). One of the problems is the low number of high quality eggs produced by chemically induced triploid Sydney rock oysters. “Natural” triploids are almost all triploids, as opposed to a mixture of triploid and diploid individuals as occurs with batches of chemically induced triploids. This is a major advantage and further work should be undertaken with Sydney rock oysters as new techniques for tetraploidy induction in bivalves become available.

It is important to note that that Pacific oysters have become established in NSW but it was not through introductions approved by the NSW government. While they have the advantage of growing much faster than Sydney rock oysters and are resistant to some of the above diseases, spatfall of this exotic species is considered undesirable in NSW estuaries from a conservation perspective. High levels of spatfall on farmed oysters are also undesirable from husbandry and marketing perspectives and, while techniques are available for killing the overcatch, they increase labour costs (Nell, 2005).

While triploid, or selectively bred, or triploid, selectively bred Sydney rock oysters may be useful in helping to restore oyster industries around Sydney, farmers in these areas will further evaluate “natural triploid” Pacific oysters as supplies from Tasmania increase. An additional advantage of “natural triploid” oysters is the minimal risk of spatfall because of greatly reduced gonad production and likelihood of viable offspring when all of the oysters are triploids (Nell, 2002b).

Profitability

While Pacific oyster farming can be very profitable (see below for Tasmania), some less widely available economic analyses have cast doubt on the profitability of more traditional Sydney rock oyster farming methods (Holliday et al., 1988; Maguire et al., 1988). Clearly, losses due to disease are a serious problem, as is the slow growth rate of this species (3.5 years to 50 g size for unselected, diploid Sydney rock oysters in intertidal culture in NSW (Nell, 2001) compared to 17-18 months from spawning for diploid Pacific oysters in intertidal culture in Tasmania (Maguire et al., 1994)). The choice of production system may also be influential. Growing Sydney rock oyster on sticks is a relatively low yielding farming system, partly because of variable coverage of sticks by oysters, whereas standing crop may be at least double with the use of single seed Pacific oysters in baskets, at least in Tasmania. This estimated difference is based on data in Maguire et al. (1994) and also from Holliday et al. (1988) who estimated yields for a range of production systems including culture of Sydney rock oysters on hardwood sticks, i.e. 5-8 kg of whole oysters per m^2 of oyster rack area in two years. Because single seed techniques allow adjustment of density through the production cycle, lease space can be more efficiently utilised than with growout on sticks. The latter technique requires relatively little labour input, after the sticks are rearranged as single layers on intertidal leases, until harvest. However, processing clumps of oysters into marketable individual oysters as whole oysters or in the half-shell is labour intensive.

There is an ongoing need to promote this small oyster as a gourmet product and to maintain high product standards. However, the tendency towards sales of smaller size grades of Sydney rock oysters is of concern to the NSW industry because it can reduce profitability (Nell, 2005).

<u>Hatchery issues</u>

Some of the technical innovations (triploidy and selective breeding) should help greatly with profitability however they rely on hatchery production. The Sydney rock oyster industry in NSW is still heavily reliant on natural spatfall and the hatchery sector has struggled to produce this species reliably because of anorexia in 2-8 day old larvae and sudden gaping and death of spat below 2 mm (Heasman, 2004). There has been some success with producing Sydney rock oysters in a hatchery in Queensland and the very closely related Western rock oyster in Western Australia (WA) can be produced reliably in a hatchery near Albany on the south coast of WA. Fortunately, there has been recent success with large-scale hatchery production of Sydney rock spat in NSW. The use of single seed culture systems for Sydney rock oysters may also improve profitability and this is not necessarily reliant on hatcheries.

<u>Public health issues</u>

As with many bivalve industries worldwide, the Sydney rock oyster industry in NSW operated in many estuaries that experienced little human impact but which subsequently were subject to coastal urbanisation. After serious cases of gastroenteritus occurred near Sydney that were linked with oyster consumption, land-based oyster depuration technology was introduced in the late 1970s. In the 1980s and 1990s there were several episodes of gastroenteritus caused by Nowalk virus associated with oysters. In 1997 another major outbreak of gastroenteritus occurred which was linked to hepatitis A and often was associated with consumption of Sydney rock oysters. A shellfish quality assurance program was formally implemented later that year (Jackson and Ogburn, 1999). This has involved classification of waterways and not just reliance on land-based oyster depuration technology (Nell 2002a). Oysters can also be relocated to "cleaner" finishing sites within estuaries but this increases costs. These developments should engender greater public health confidence in the consumption of Sydney rock oysters produced in NSW and promote exports. In a major literature review by C. Burke and G. Maguire in 1998, which was further developed by Jackson and Ogburn (1999), the key conclusion was that bacterial indicators eg *E. coli*, are not necessarily good indicators of viruses that are pathogenic to humans. While viral monitoring is carried out in NSW, the development of more cost-effective techniques for monitoring specific viruses, including Nowalk virus and hepatitis A viruses, is a worldwide challenge.

<u>Environmental issues</u>

The Sydney rock oyster is a robust species in terms of environmental tolerance but can be vulnerable to extended exposure to very low salinities (to less than 10 ppt for 2 weeks) and acute exposure to high air temperatures when out of water (Nell, 1993). As such, Sydney rock oyster farms could be vulnerable to climate change although some researchers consider that the natural range of this species extends north through tropical areas of Australia (Nell, 2005). Changes in rainfall patterns could also affect nutrient input into estuaries. Urbanisation of coastal areas can lead to a range of other environmental changes including eutrophication and the associated risks of algal blooms. Fortunately, toxic algal blooms that impact on the health of consumers have been much less of a problem for bivalve industries in Australia than in many other countries. Unfortunately, not all members relocating to coastal areas are favourably disposed to the perceived visual and navigational impacts of oyster farms and sea-based aquaculture in general.

PACIFIC OYSTERS

<u>Origin of stocks</u>

Pacific oysters were introduced Tasmania from 1947-52 (from Sendai, Hiroshima and Kumamoto regions of Japan). Such introductions were unsuccessful in other Australian states and the industry expanded in northern Tasmania, based on natural spatfall. There are still locations in Tasmania where Pacific oysters have become naturalised, periodically setting on rock structures even though commercial farms are not operating in those areas. Deupree (1993) concluded that deep-cupped Pacific oysters in Tasmania were not derived from Kumamoto strain oysters (*C. sikamea*). However, English et al. (2000) showed using allozyme techniques that nine groups were very similar genetically. These included four naturalised groups, three of which were Tasmanian and one was from Port Stephens, three hatchery-derived groups from Tasmanian farms and two groups obtained from Sendai and Hiroshima in Japan. These results were confirmed by English (2001) using microsatellite techniques. Overall, the results confirmed the origin of the Tasmanian stocks and indicated that sound hatchery practices had allowed the Tasmanian industry to avoid major losses in genetic diversity. It is likely that the deep-cupped shape of many Tasmanian Pacific oysters partly reflects the high degree of shell abrasion that occurs during grading of oysters on vibrating or rotating screens during routine stock management of single seed oysters (O'Meley, 1995).

Development of production systems

Because natural spatfall did not prove to be reliable, the Tasmanian industry moved to a hatchery-derived spat supply and new growout areas about 25 years ago (Ward et al., 2000). Modern production in Tasmania is based on single seed oysters produced, by relatively standard international techniques, in indoor larval tanks and then in land-based upwellers before being moved into intertidal, plastic mesh nursery trays. Growout is typically within units of two plastic mesh, open baskets supported by two timber stakes that pass through the length of both baskets. The sticks are then arranged across intertidal post and rail systems (Nell, 2002a) and are secured with strong rubber ties than can be easily detached for stock management. Significant quantities are also grown out in subtidal cage systems. Subsequently, spat were provided to South Australian farmers and a Pacific oyster industry was established in South Australian with government approval, and has outgrown the industry in Tasmania. A significant innovation was the "horizontal longline" system in which tensioned wire replaced timber rails on intertidal leases and enclosed individual plastic mesh tubes or cylinders were hung from a single wire with two simple, detachable clips (see Nell, 2002a). This allowed farming in areas where wave action was excessive for more traditional systems. Variations to the cylinder design have emerged and the technology has been introduced to most Australian oyster producing states. These Tasmanian and South Australian systems are lightweight and allow oyster boats to be loaded with large numbers of baskets or cylinders for grading or sale of oysters on-shore.

Diseases and genetic strategies

Pacific oyster farming has been particularly successful in Tasmania and South Australia largely because of the absence of significant diseases. Apart from sacrificial sampling, overall mortality of diploid and triploid Pacific oysters at two good farming in Tasmania were <1% during the 22-23 months the oysters were held in intertidal mesh baskets (Maguire et al., 1994). Losses can occur in nursery systems if overcrowded or if food levels in the seawater supply are severely limiting. (Saxby, 2002 reviewed food availability at bivalve farming sites internationally, including at Pacific oyster farms in Tasmania and South Australia.) Losses, by displacement or to predators, can be minimised by placing a cover over the top of open baskets or by complete enclosure of oysters within the cylinders or tubes.

Pacific oyster farming in Australia have benefited from selective breeding programs involving mass selection for faster growth and use of family lines (Maguire, 1997a; Ward et al., 2000; Thompson and Ward, 2004). Progress has also been made with full sib crosses (to remove deleterious recessives) and with using microsatellites to help interpret performance of family lines (McGoldrick et al., 2000). The results of much of this research program have been commercialised and while initial demand was highest for mass selected oysters, farmers are now more inclined to purchase specific family lines (R. Pugh, pers. comm. 2004).

Research on triploid Pacific oysters in Tasmania and South Australia was aimed primarily at inhibiting spawning so that the oysters remained saleable in summer months. This was achieved with chemically induced triploids although the more rapid shell growth of triploid oysters after they reach about 60 mm in Tasmania can reduce meat weight to shell cavity volume ratio (condition index) (Maguire et al., 1994). There have been examples of large growth rate advantages of triploid oysters of various species (31-81%), often commencing at sizes much less than 60 mm (Nell, 2002b). However, the growth advantages at the two better sites in Tasmania were only 23.4%, on a whole weight basis, at age 27-28 months (Maguire et al., 1994). Subsequently, no growth advantage was recorded at one site in South Australia (Ward et al., 2000). Meat discolouration can be an occasional problem with triploids in Tasmania.

The development of "natural triploids" has led to increasing demand for triploid Pacific oysters. Tetraploids produced by the first author, using techniques developed by Guo and Allen (1994), have been used for several years in Tasmania to produce "natural triploids" but fortunately a new tetraploid line has now been produced there, using eggs from "natural triploids", to help replace this ageing line of tetraploids. Moreover, there has also been success in Tasmania with a tetraploid x tetraploid cross to produce another tetraploid line (G. Kent, pers. comm. 2005). Interviews with oyster farmers in Tasmania and South Australia indicate that they prefer the natural triploids because of the almost 100% triploidy level and ongoing success with avoiding spawning in summer but again growth rate advantages with triploids were considered to be relatively small. In contrast, Nell and Perkins (2005b) obtained "natural triploid" Pacific spat from Tasmania and achieved high growth and survival rate advantages in Port Stephens. These spat reached 55 g whole weight in 13 months instead of 20 months with unrelated diploid Pacific oysters. It seems likely that a combination of warm water temperatures and adequate food supplies is necessary to achieve a large growth advantage with triploid Pacific. Meat discolouration again occurred but the "natural triploid" Pacific oysters reached market size before this was evident (Nell and Perkins, 2005b).

Profitability

Pacific oyster farming can provide an excellent and highly predictable return on capital (27% per annum) at good farming sites in Tasmania (Treadwell et al., 1991). Subsequently, marketing pressures have been placed on Tasmanian farmers because of the rapid growth in production of Pacific oysters in South Australia. Increased exports of Australian oysters would assist the domestic market and South Australian Pacific oysters are being exported to Japan during the northern hemisphere summer.

Earlier research by the first author showed that it was not necessary to grade oysters so often to prevent excessive size variation (Maguire, 1997b) and this is being adopted by some farmers in Tasmania. O'Meley (1992) indicated that Pacific oysters may be graded 5-7 times during growout in Tasmania (excluding grading operations in the nursery phase). Reducing the frequency of size grading should lower production costs for Pacific oysters as grading operations, including moving oysters to and from leases, are labour intensive and labour costs are highly significant to the economics of oyster farming in Tasmania (Treadwell et al., 1991; Maguire, 1993). While selectively bred or triploid spat attract a price premium, better performance of these oysters should also assist with maintaining profitability.

Hatchery issues

In contrast to NSW, Tasmania now has more than adequate hatchery capacity particularly with the move towards smaller, high density, flow through larval rearing systems. Increased demand will largely be for genetically selected lines and natural triploids. In contrast to some Pacific oyster hatcheries overseas, it has not been necessary to rely on antibiotics in Tasmanian hatcheries.

Public health issues

In contrast to NSW, the relevant coastlines of Tasmania and South Australia are not very heavily urbanised and these states have had few public health problems due to oyster consumption. They rely on oyster growing area classification and appropriate closures after substantial rainfall rather than land-based depuration systems.

Environmental issues

In terms of impacts of the environment on oysters, "heat kill" can occur particularly on South Australian leases if hot weather coincides with very low tides. Some leases in Tasmania had to be relocated because of extended exposure to freshwater after heavy rainfall.

The environmental impact of oyster farming in Tasmania and South Australia has not been a major problem although not all community members are comfortable with perceived visual and navigational impacts of oyster farms (Maguire, 1992). Pacific oyster spatfall has at times been contentious in Tasmania but in general the degree of "overspatting" in much lower than in NSW. While some spat do develop on oyster cylinders in South Australia, it is generally a very minor problem in these hypersaline areas. Intertidal culture in Tasmania does lead to biodeposition of organic wastes on the seabed.

Attempts to grow venerid clams below the oyster racks, as a way of minimising organic buildup, were unsuccessful (Maguire, 2005). To meet Australian government requirements for export, both Pacific oyster industries have to demonstrate that they meet sustainability principles (Fletcher et al., 2004).

OTHER ISSUES FOR OYSTER FARMING IN AUSTRALIA

Forms of aquaculture that use inshore coastal waters do attract criticism from communities and it is important that these industries minimise environmental impact. For example, quality assurance programs for bivalve aquaculture industries in Western Australia require shoreline surveys to ensure that farming debris, such as displaced oyster baskets, is not evident.

Conversely, it is also appropriate to highlight the benefits associated with these industries. Typically, these are economic and social benefits that accrue from increased employment and investment. In the case of oyster farms there are additional environmental benefits. At least in Australia, where quality assurance programs require monitoring of oyster growing areas for a range of attributes including water quality and types of phytoplankton, oyster leases represent one of the most significant sources of estuarine water quality monitoring. This can be augmented by periodic checks on any heavy metal or pesticide contamination in seafood (not a significant problem so far with oysters in Australia). As bioaccumulators of contaminants, oysters are sentinels for any estuarine pollution. Moreover, oyster farmers visually inspect their oysters quite regularly and poor growth or unexpected mortality can be observed and investigated. Some years ago in NSW, chambering in oyster shells highlighted a problem with tributyl tin from antifouling paints on boats (Batley et al., 1989). This led to restrictions, on the use of such paints, that probably also benefited non-commercial bivalve species. It is clear that oyster farmers can be effective lobby groups for environmental protection (Maguire, 1991). In the absence of oyster farms, oysters, which are not subsequently released for human consumption, have been deployed in NSW specifically for environmental monitoring purposes (Avery et al., 1998).

Given the environmental protection role that oyster leases can have, it is important that where oyster industries have declined in waterways around Sydney, efforts be made to rejuvenate them.

Finally, the ongoing commitment to public health and product quality standards with Australian oysters is important both for promoting exports and for encouraging younger consumers in Australia to purchase oysters so that the domestic market remains strong.

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DEDICATION

This paper is dedicated to the outstanding contributions made by the late Drs Baughan Wisely and John Holliday. They and several other key researchers played major roles in making the research facility, currently known as the Port Stephens Fisheries Centre, one of the world's major oyster husbandry research centres for over 30 years.

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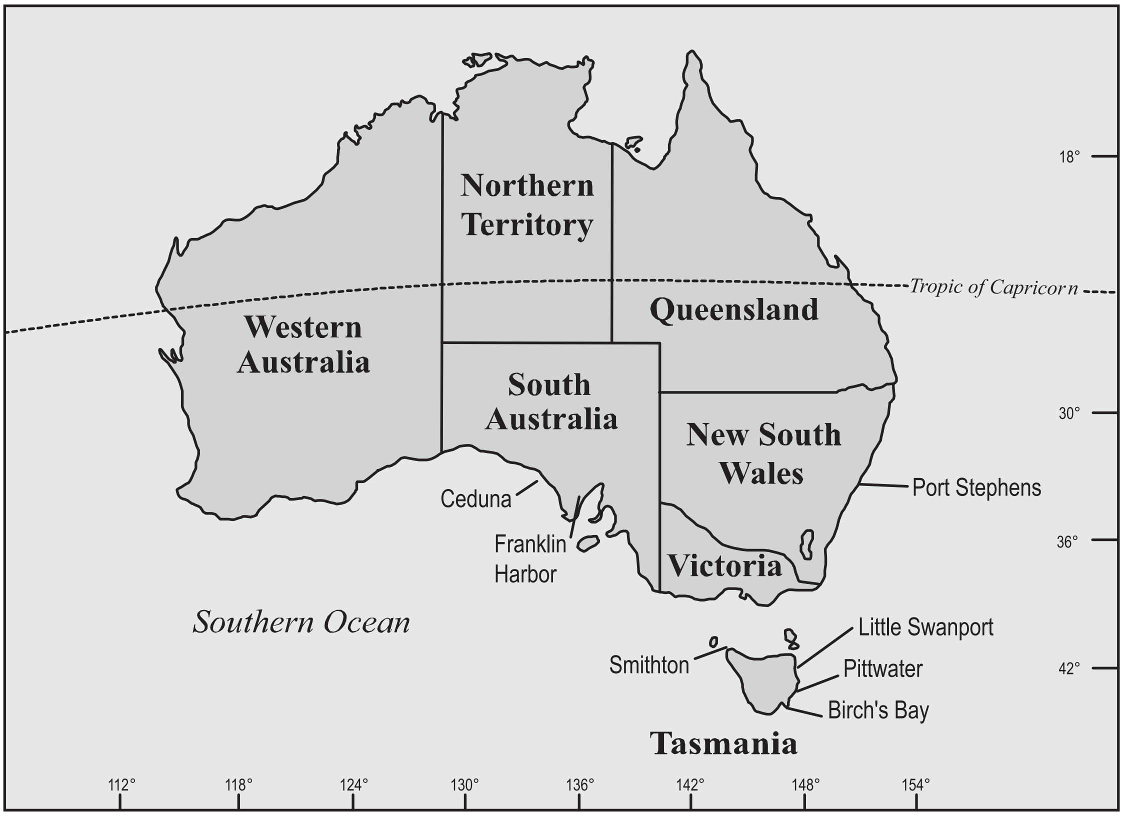

Fig. 1
Map of Australia showing some of the individual oyster growing areas where triploid oyster research has been undertaken by the authors.