FINAL Report

Oysters

Independent Review of the Relationship between Healthy Oysters and Healthy Rivers

March 2003

Healthy Rivers Commission – Inquiries and Status

Inquiry	**Completion Date**	**Status**
Williams River	December 1996	Statement of Intent June 1998
Hawkesbury Nepean River	August 1998	Statement of Intent March 2001
Shoalhaven River	July 1999	Statement of Intent May 2001
Clarence River	November 1999	Statement of Intent March 2002
Strategic Coastal Rivers	April 2000	Statement of Intent November 2002
Bega River	May 2000	Statement of Intent November 2002
Georges River / Botany Bay	September 2001	Statement of Intent November 2002
Coastal Lakes	April 2002	Government decisions to be announced
Hunter River	May 2002	With Government awaiting decision
North Coast Rivers	March 2003	With Government awaiting decision

Addendum: Following the March 2003 election, the names and responsibilities of a number of NSW agencies have changed. The Government Statement of Intent, to be issued in response to this Final Report, will reflect the new administrative arrangements.

Preface

The oyster industry is important to New South Wales from social, economic and environmental perspectives. Oyster growing occurs in 30 estuaries, and is one of the state's most valuable agricultural enterprises per hectare. Oysters have also been referred to as the 'canary of the estuary' as a decline in their health presents an early warning sign of river health problems. The hepatitis A outbreak in early 1997, which resulted from people eating contaminated oysters grown in Wallis Lake, highlighted the susceptibility of oyster cultivation to river health problems.

The NSW Government has requested that the Healthy Rivers Commission review the relationship between river health and the cultivation of oysters that are safe for human consumption. Many of the Commission's recommendations in previous river and lake specific Inquiries have been made in recognition that they would create conditions conducive to improved oyster cultivation, and the NSW Government has initiated two key programs relating to the oyster industry. The Commission is, however, convinced that there are a few critical gaps to be filled to create a comprehensive strategy for safe oyster cultivation.

This Final Report contains five recommendations that the Commission considers are essential to the maintenance of healthy oyster growing catchments. These recommendations relate to all waterways where oyster cultivation for human consumption occurs or might be expected to occur in the future.

The recommendations have been informed by submissions received to earlier Inquiries by the Commission, a report prepared by Professor Ian White for the Commission, an oysters workshop, submissions on the Draft Report and other available information.

Submissions on the Draft Report were received from individuals, community groups, oyster growers, local councils, and state and Commonwealth agencies. Many comments were received about the continuing pressures facing the oyster industry related to declining river health. All submissions were supportive of the general approach recommended by the Commission, with many proposing enhancements for the Final Report.

I thank everyone who has been involved in this review, and encourage citizens to seek early Government decisions and actions in response to this review. I look forward to auditing the responses two years following the announcement of decisions.

Peter J Crawford
Commissioner

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1 Introduction

1.1 The Healthy Rivers Commission and Oysters

Oysters are critical indicators of river health because they are filter feeders, extracting phytoplankton, bacteria, suspended solids and inorganic particles from the surrounding water as their food source (SafeFood NSW 2001). Oysters have been referred to as the 'canary of the estuary'[1] as a decline in their health presents an early warning sign of river health problems.

As requested by the NSW Government, the Healthy Rivers Commission has undertaken a number of Inquiries into specific river and lake systems over the past eight years. A list of public Inquiries undertaken by the Commission and their status is presented on the inside cover page of this Report.

The NSW Government also requested that the Commission review the specific relationship between river health objectives (including water quality specifically) and the cultivation of oysters that are safe for human consumption. In undertaking this review, the Commission has made recommendations as to how desirable objectives for river health should be achieved.

In response to some submission makers who questioned the undertaking of a specific review relating to oyster cultivation and river health, it is emphasised that Government initiated this review because of the relationship between a healthy, valuable oyster industry and river health. It is noted that oyster growing for human consumption does not occur in all waterways, but, where it is undertaken, the health and safety of the oysters provides one valuable indicator of river health.

In past Inquiries, many of the Commission's recommendations for improving river health generally, and NSW Government decisions, have been made in recognition that they would also create conditions conducive to improved oyster cultivation for human consumption. For example, implementation of previous recommendations relating to improved sewage, coastal floodplain and riparian management would directly benefit oyster cultivation for human consumption.

Additionally, the NSW Government has endorsed, in response to the Coastal Lakes Inquiry (HRC 2002a), the recommendation for specified lakes[2] that minimization of risks to safe oyster production should be an explicit intended outcome of planning and management decisions and actions. Some submissions stressed the importance of implementing Government decisions in response to past Inquiries, to ensure river health, and correspondingly oyster health, are protected.

This Final Report represents the culmination of the Commission's investigations into oyster growing and river health. The Commission's review suggests that implementation

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[1] Related to the historical use of canaries in coalmines to indicate safe air quality.

[2] Wallis, Wagonga, Tuross, Merimbula, Conjola, Queens/Watson Taylor, Wonboyn and Pambula lakes.

of Government decisions in relation to previous Inquiries (together with two recent government initiatives in relation to oyster growing areas, to be discussed later in this Report) would provide some increased security for oyster cultivation. However, it considers that development of a *comprehensive* strategy for the maintenance of healthy oyster growing catchments requires a few remaining critical gaps to be filled. These relate to the determination of areas where oyster growing is a priority intended outcome, improved management of land and water, implementation of decisions and actions, and viability of the oyster industry.

1.2 Views from Submissions

In the course of its Inquiries into many coastal rivers and lakes, and in response to the Draft Report for this review, the Commission has received several submissions and heard commentary linking healthy coastal rivers and lakes with sustainable oyster cultivation. (Appendix 1 contains a list of submission makers to the Draft Report.)

For example, the important link between land and water management has been identified in statements from oyster growers, such as ***"the Quality Assurance program will have no meaning if our Coastal Lakes continue to be contaminated through uncontrolled development".***

The social and economic importance of the oyster industry to numerous communities around many coastal rivers and lakes has also been highlighted in commentary such as ***"Clean, unpolluted waters capable of sustaining and producing products acceptable to the domestic and overseas market are an asset of inestimable value to an area."***

Similarly, many submission makers acknowledged ***"the importance of healthy oyster catchments generally, in particular their invaluable ecological, social and economic benefits to the community".***

However, oyster growers have also expressed their frustration to the Commission, asserting that if improved management does not occur they will ***"continue to suffer death by a thousand cuts".***

In light of such frustration and past land and water management decisions, many have requested that the Commission ensure that ***"real and effective measures be introduced to halt degradation of water quality that occurs due to poor urban and rural land practices".***

In response to the draft recommendations submission makers noted that ***"if enacted effectively by government, the five recommendations made should assist the industry to exist beyond 2020".***

1.3 Wallis Lake Incident

The hepatitis A outbreak in early 1997[3], which resulted from people eating contaminated oysters grown in Wallis Lake, again highlighted the susceptibility of oysters (in terms of their suitability for human consumption) to river health problems.[4]

A NSW Government task force was convened following this incident. The task force produced recommendations aimed at securing conditions necessary for a healthy and productive oyster industry. These recommendations included the development of sewage management strategies for local government areas where oyster growing occurs; the identification of priority works (primarily related to the Environment Protection Authority licensing program and the Department of Land and Water Conservation's Country Towns Water Supply and Sewerage Program); and the evaluation of the application of dynamic models of estuarine flows to assist in water quality predictions.

The length and intensity of the legal proceedings in relation to the Wallis Lake incident, and the diversity of views expressed, highlight the complexity of this case. While the issue of responsibility for the incident was a central consideration, the case clearly identified the importance of the direct link between catchment and estuary management and oyster health, and resultant human health.

1.4 Independent Expert Advice

To improve its understanding, and to test the relevance to oyster growing catchments of the findings of its Coastal Lakes Inquiry, the Commission engaged an independent expert in the field of oyster health and land and water management, Professor Ian White (Australian National University), to provide advice on oyster cultivation and river health. This assessment included review of the environmental conditions conducive to oyster growing, threats to the growth of healthy oysters and trends in oyster production.

In brief, White (2001) found that oyster production has been declining over the period 1968-2001. The trend is attributed to socio-economic and physical[5] factors. The physical factors are influenced by population growth and agricultural land use, which affect downstream environments, and ultimately, oyster production in the estuaries. Also relevant are the increased occurrence of disease and changing hydrologic regimes (such as more frequent intense rainfall). Further information about these issues in included in Section 2 of this Report.

White (2001) notes that the market for live seafood is still developing in Australia, and there is the potential, with strategic advertising and promotion, to expand domestic sales of oysters, as well as venturing into the large Asian market. He notes that in comparison with products sold overseas, NSW oysters are grossly undervalued in the local market.

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[3] In which 450 people contracted hepatitis A.

[4] The most well known being the major contamination incident in 1978 related to oysters grown in the Georges River in which 1000 people suffered viral gastroenteritis.

[5] This includes environmental issues related to growing conditions.

However, he stresses that maintenance and expansion of the oyster industry will require an improvement in industry performance, an increase in confidence in the product and a greater acceptance by government of its responsibility for the health of estuaries.

The report includes a number of proposed strategies that have informed the Commission in its consideration of issues related to river health and oysters. Professor White's report is attached as Appendix 2. Further details about many of the issues discussed in this Report can be found in that Appendix.

1.5 Oysters Workshop

As part of this review the Commission conducted a workshop, involving a number of people who collectively represent the interests of the oyster industry, development industry, environment groups, local councils and state agencies. A list of participants is attached in Appendix 1.

The workshop examined issues relating to oyster growing catchments, particularly relating to land and water planning and management, cost sharing and strengthening of the oyster industry's involvement in decision making.

Several participants noted the importance of the oyster industry, and the value of linking oyster health to river health. The need for improved management of land and water uses was highlighted, particularly in relation to existing uses where resources are limited and changed practices harder to achieve. While it was agreed that urban development and oyster growing are not *necessarily* mutually exclusive, the benefits of good site selection at the outset of an activity and effective development planning and management were identified as crucial.

Views expressed at the workshop have informed the Commission in its preparation of this Report and in the development of recommendations.

1.6 Next Steps

The Commission's Final Report will be presented to Government and the community. The Commission expects that government decisions on the recommendations of the Final Report will be incorporated in a publicly released 'Statement of Intent'. The NSW Government has assigned the Commission a responsibility to audit implementation of such Statements of Intent, with formal audit reports to be delivered two years after the public release of the decisions.

2 Oysters and River Health

Oysters that are safe for human consumption are critical indicators of river health because they are filter feeders, extracting phytoplankton, bacteria, suspended solids and inorganic particles from the surrounding water as their food source (SafeFood NSW 2001).

The ANZECC and ARMCANZ (2000) water quality guidelines for the production of healthy oysters, safe for human consumption, are the most stringent of any estuarine water use because oysters bioaccumulate pathogens and toxins and are typically eaten raw, with their gastrointestinal tract intact.

Not only are the water quality guidelines the tightest, but adverse water quality impacts on oysters present an almost immediate gauge of river health. Oysters have been referred to as the 'canary of the estuary' as a decline in their health, and human contamination incidents, present an early warning sign of river health problems. Such river health problems relate to general aquatic ecosystem health, and are likely to influence other desired recreational and commercial uses of a waterway, such as swimming, fishing and tourism activities.

Oyster cultivation occurs, to a varying extent in 30 NSW estuaries. During their growing life, oysters may be translocated between a series of estuaries for different growth periods. Additionally, some estuaries are used solely for spat collection.

The general conditions required for growing healthy oysters are well oxygenated, clear, brackish to saline waters, with pH in the range 6.75 to 8.75, suitable tidal exchange, adequate phytoplankton supplies and control of upstream sources of runoff and pollution (see ANZECC and ARMCANZ 2000 for further details). In addition to the threats presented by human modifications to land and water, natural conditions, including climatic patterns, can have a major influence on the suitability of a site for oyster cultivation (further details are contained in White, 2001). Discussion at the Oysters Workshop suggested that information is available to allow the selection of sites where natural characteristics present the best conditions for highly productive oyster cultivation.

White (2001) identifies the principal threats to oyster production as being human faecal contamination of oyster growing areas; the oyster diseases QX and winter mortality (direct linkage between disease and environmental degradation is not established,

however, stressed oysters are prone to disease); runoff from acid sulfate soils; turbid waters; marine biotoxins; agricultural and industrial pollutants; and prolonged freshwater flooding.[6]

Additionally, oysters are just one of many organisms in an estuary competing for seston[7]. Food supply and stocking density is therefore a critical issue. A number of growers, particularly in southern NSW are concerned about their apparent inability to grow oysters to plate size. This has been attributed to overstocking. (In its submission on the Draft Report, the NSW Farmers Association, Oysters Committee notes that stocking density should be determined at an estuary level and be based on thorough research, taking seasonal and climatic fluctuation into account.)

[6] Submissions noted other issues affecting oyster health, such as the presence of algal blooms resulting in the ingestion of toxic organisms, and the occurrence of toxic algae such as pfiesteria.

[7] All material, both organic and inorganic, suspended in a waterway.

3 The Oyster Industry

The oyster industry is important for New South Wales from social[8], economic and environmental perspectives and aquaculture is being promoted strongly at the national[9] and state level. Planning for both land and water uses must, therefore, take particular account of the special requirements of this industry.

The oyster industry is the most valuable aquaculture industry in NSW, producing 80 percent of the total value of aquaculture. The average gross value of oysters at market is $8,000 per year per hectare of lease area, with some areas returning as high as $35,000/ha/yr[10]. Oyster cultivation is also one of the state's most valuable 'agricultural' enterprises per hectare, and the farm gate value in 1999/2000 of oyster production was approximately $30 million (White 2001). There are more than 380 permit holders, 2400 leases and it is estimated that there are 1226 people employed in the industry (NSW Fisheries 1999).

In contrast to what may be expected from the above figures, the NSW oyster industry has been described by some as a 'cottage' industry (Brown et al 1994) with growers operating in an open market. There does not currently appear to be an *industry-wide* promotion of oysters in NSW, with many growers adopting a 'selling' rather than 'marketing' approach. It is encouraging to note, however, that the Bellinger-Kalang-Nambucca Oyster Growers Group, in conjunction with local councils and relevant state agencies arranged for the preparation of a 'Report on Coffs Coast Oyster Industry Development Plan' (Ruello & Associates Pty Ltd, 2002). This plan, which is currently being implemented, includes promotion and strengthening of the group business.

A high percentage of growers produce relatively few oysters, and there are many estuaries in which a very small number of oysters are produced. In 1997/98, 26 percent of permit holders did not produce any oysters, while in the same year, 33 percent of the permit holders produced 89 percent of NSW oysters, and the 10 most productive estuaries produced 80 percent of the state's oysters (NSW Fisheries 1998).

Given the importance of this industry on a number of fronts, its decline over the past 30 years is a cause for concern. In a report to the NSW Oyster Industry Plan Steering Committee, ACIL (1997) stated that from a peak production of nearly 150,000 bags (15 million dozen) of Sydney rock oyster in the mid 1970s, production has dropped by over 45

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[8] Social value relates largely to the oyster industry and connected interests. Some participants at the Oysters Workshop argued that there is scope for increased valuation of the oyster industry by the *general community*. This would also result in an increased understanding of the wider need for improved river health.

[9] A National Strategy on Aquaculture was developed in 1994. This was reviewed in 1997, and a National Aquaculture Action Agenda is currently being developed (Department of Agriculture, Fisheries and Forestry – Australia 2001).

[10] Assuming a gross value of $4.00 per dozen oysters.

per cent to 78,000 bags (8 million dozen) in 1995/96 (worth approximately $28 million at the farm gate)[11]. ACIL concluded that the primary reason for this decline is degradation of water quality generally and specific problems at Port Stephens related to the introduction of the Pacific oyster[12].

White (2001) nominates a series of further impediments to sustainability of the oyster industry in NSW, including the institutional arrangements for the management of estuaries, the availability of finance and the structure of the industry. He notes with concern the significant challenge of attracting younger farmers into the industry, with success largely dependent on how the real and perceived threats to the industry are dealt with. (White (2001) notes however, that at present many NSW oyster farmers are third, fourth or fifth generation producers, and that as such they are custodians of much valuable information about estuaries.)

[11] The Aquaculture Production Report for 1999/2000 (NSW Fisheries 2001) indicates that production levels of the Sydney rock oyster have remained at the 1995/96 level.

[12] The aggressive nature of the Pacific Oyster resulted in the failure of Sydney rock oyster leases.

4 Current Initiatives by the NSW Government

The NSW Government has signalled an intention to encourage and support a sustainable oyster industry, and, as outlined below, it has recently launched two specific initiatives in that regard. Many other government initiatives and programs, such as those related to PlanFIRST, sewage (including sewage from vessels and on-site wastewater management systems), water, vegetation, estuaries and catchment management also have scope to influence the oyster industry, as have the Statements of Intent encompassing Government decisions on the recommendations of previous Commission Inquiries into coastal rivers and lakes.

4.1 NSW Shellfish Program

SafeFood NSW is implementing the NSW Shellfish Program[13] which is designed to protect the health of shellfish consumers. This Program provides for assessment of the risk of shellfish contamination by pathogenic bacteria and viruses, biotoxins and chemicals derived from the growing area, for control of the harvest of shellfish in accordance with the assessed risk, and for protection of shellfish from contamination after harvesting. Shellfish growing areas are being classified using information from comprehensive sanitary surveys of existing growing areas. Those surveys comprise a shoreline survey, periodic bacteriological examination of water samples and bacteriological and chemical examination of shellfish. The Program requires periodic review of the classification assigned to each growing area.

The primary classification categories are:

- approved – for direct shellfish consumption;
- restricted – shellfish must be purified naturally (that is, by relay to an 'approved' site) or artificially (via depuration tanks); or
- prohibited – shellfish harvesting not permitted at any time (SafeFood NSW 2001).

Classifications of growing areas has been completed for three areas within Wallis Lake (Cape Hawke, Long Island and Wallis Island), Corrie Island at Port Stephens, the Brunswick River and Nelson Lagoon. The process is well advanced in the Hawkesbury River and Twofold Bay and intensive sampling will soon commence in Brisbane Water, other Port Stephens harvest areas and the Clyde River. Shoreline surveys have been

[13] Established in December 2001 to replace and expand the NSW Shellfish Quality Assurance Program (SafeFood NSW 2001).

completed in all other harvest areas and in most other significant production areas the process of determining the exact harvest areas to be classified is underway. The program is being implemented in accordance with a prioritisation schedule which is primarily based on risk and production (Derwent, A, 2002, pers. comm., 18 September).

The classification process is clearly intended to facilitate safe oyster production, and will contribute valuable information in that regard. However, in the Commission's judgement it is a matter of significant concern that there is no explicit requirement for other land and water planning and management decisions to have regard to the classification categories. This means that the real potential of the classification system to create long-term gains may be seriously undermined.

4.2 SEPP62 – Sustainable Aquaculture

State Environmental Planning Policy 62 aims to encourage aquaculture development throughout NSW and to streamline assessment processes in preferred areas and in line with regional aquaculture industry development plans (developed pursuant to the *Fisheries Management Act 1994)*. As components of these plans, maps are being prepared to indicate areas suitable for aquaculture production (at a first level of assessment), based on existing environmental conditions, site and other factors. The consideration of environmental factors in plan development addresses both the potential impact of the surrounding environment on sustainable aquaculture and the potential impacts of aquaculture on the environment.

A land-based aquaculture industry development plan has been prepared for the North Coast of NSW (Stone et al 2000). The Oysters Workshop was advised that plans for water-based extensive aquaculture are also being prepared (Ogburn, D 2002, pers. comm., 22 August).

As is the case for the NSW Shellfish Program, there is at present no explicit link between aquaculture industry development plans and other land and water planning and management. Neither the potential risks nor measures to mitigate these risks are required to be identified. Consequently, no mechanism exists to recognise and resolve any trade-offs between safe oyster production and other present or future land and water use goals.

4.3 Statements of Intent related to Healthy Rivers Commission Inquiries

As noted in Section 1.1, the Commission's recommendations and the associated government decisions focus on river health. These decisions are directed at much improved land and water management, so in a number of cases implementation will have direct benefits for oyster cultivation.

For example, the Government decision (NSW Government 2002b) in relation to the Clarence River Inquiry to prepare a partnership agreement for the Clarence floodplain and its interface with the estuary presents a significant initiative towards maintaining and achieving healthy rivers and estuaries for activities such as oyster cultivation. The

Statement of Intent notes that the agreement will incorporate mechanisms by which compliance with the agreement will be audited and the benchmarks against which the management outcomes will be assessed. The Integrated Catchment Management Plan for the Upper North Coast (Upper North Coast Catchment Blueprint) acknowledges that development of such a partnership agreement is a priority. The Commission has been informed that a government and community task force has been established by the Department of Land and Water Conservation to progress this work.

In relation to the Commission's Hawkesbury Nepean River Inquiry, the NSW Government (2001) took decisions that state agencies are to work with local councils to assist them in developing the environmental management component of their council management plans. This will help create a more predictable and sustainable context for catchment and river health, generally, and for oyster production, specifically. The Commission has recently begun its formal audit of implementation of the Hawkesbury Nepean Statement of Intent.

Significantly, in November 2002, the NSW Government released a Statement of Intent for Coastal Rivers – A Strategic Perspective. This document includes a number of general principles and strategies that will guide agency approaches and action along the NSW coast. These include managing rivers as whole systems, ensuring that management plans are rigorous and directive and that they create obligations on the entities that possess powers and resources, and the implementation of explicit processes by agencies for the objective evaluation of implementation actions and results. Importantly, the document states that the audit process to be undertaken by the Commission will be designed to facilitate agency understanding through progressive communication and feedback, leading to the preparation of an audit report two years after the making of the statement of intent. The Commission will adopt such an approach in all audits.

5 The Way Forward

While supportive of the NSW Shellfish Program, and the Sustainable Aquaculture policy (SEPP62), the Commission is convinced that the lack of an explicit link between these two initiatives and other land and water management and planning processes represents a significant threat of conflict and failure. It is a particular concern that the two initiatives focus only on the *existing* conditions, rather than considering and taking into account future land and water use planning decisions. This is a critical limitation, which, if not specifically addressed, may, in the light of increasing pressures for coastal development, result in river health degradation and greater impediments to healthy oyster growing.

The approach to managing catchments and waterbodies in ways that protect oyster growing conditions is presently quite ad-hoc. For example, a reading of the recently prepared catchment blueprints reveals that scant attention is paid to the needs of the oyster industry.[14] A draft catchment management plan (this is a separate process from the current preparation of catchment blueprints) has, however been prepared for Wallis Lake that acknowledges the value and needs of the oyster industry (Wallis Lake Catchment Management Plan Steering Committee 2001). This is not the case in all areas where oyster cultivation occurs *at present*, and it is certainly not the approach in areas where it might be expected or desired to occur in the future.

The Commission therefore considers that additional steps are needed – involving both government and the industry - to ensure the viability of the industry and the safety of human consumers of its product, as well as protecting river health. These relate to protecting areas where oyster growing is a priority intended outcome, ensuring land and water planning and management is timely and in accordance with nominated priorities, ensuring that actions are implemented and costs internalised and working through these and other means to increase the viability of the oyster industry.

5.1 Oyster Growing as a Priority Intended Outcome

Given the importance of the oyster industry, as discussed in the foregoing, and given the already considerable investment made in its management, the Commission considers there would be benefit in the NSW Government specifying areas where commercially viable cultivation of oysters is a priority intended outcome from a state perspective.[15]

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[14] Differing views were expressed on this issue in response to the Draft Report. One catchment board noted that whilst the oyster industry was not singled out for attention in the blueprint they prepared, effort was made to address water quality issues. In contrast, an environment group noted that the needs of the oyster industry were not included in a particular blueprint.

[15] It should be recognised that whilst this review has focused on healthy oysters and healthy rivers, other processes exist for the selection of other intended outcomes or values for a waterway, catchment and region. For example, the NSW Government has determined interim water quality and river flow objectives for many waterways (EPA, 1999). In a similar light, SEPP14 designates coastal wetlands that are afforded an additional level of protection in the planning process, and NSW Fisheries has recently designated areas where commercial fishing cannot occur.

Some commentators on the Draft Report have questioned the term 'priority intended outcome' in relation to oyster production in certain areas. The Commission has applied that term to highlight the fact that in any given location there will be, inevitably, a hierarchy of *targeted* outcomes, resulting from decisions (whether implicit or explicit) that are made about the relative priorities of the many *desired* outcomes that will generally prevail. In those locations where objectives such as urban growth are deemed to be of highest importance, it may be impossible to achieve *optimal* oyster growing conditions, and the trade-off in favour of urban development and 'against' oyster production is likely to be accepted. Conversely, however, in those places where oyster growing is deemed most important, it must be designated as the 'priority intended outcome' *from the outset,* and other decisions, such as those concerning various land uses, must defer to the decision to produce oysters for human consumption in those areas. The Commission's intention is to emphasise that *explicit* recognition of oyster growing as a priority intended outcome in relevant locations is needed to ensure that the necessary constraints on other activities are adequately recognised.

The specification of areas where oyster cultivation is a priority intended outcome could encompass entire estuaries or part thereof, and there may need to be some differentiation in terms of end use. For example, some areas may be designated as ‘spat collection’ or ‘growing’ areas for later translocation, others as ‘fattening areas’ for harvesting. As an adjunct to such designation, there must be more explicit recognition, from the outset, of the resulting implications for the management of surrounding land and water.

The absence of such decisions in the past have resulted in oyster growing areas not being clearly recognised or protected. Land and water use changes over time have often created incremental river health degradation with progressive damage to and alienation of oyster growing and production. Given increased development pressures along the NSW coast, further degradation of river health and future threats to the oyster industry can be expected, even if there is a much more proactive approach to land and water management and planning.

As is the case for the protection of prime agricultural land, management and planning relating to oyster production areas should ensure that activities upstream (and downstream, where there is influence) of ‘prime’ current and potential future oyster leases are consistent with the desired downstream uses. Decisions as to the priority to be assigned to oyster production, and the resulting need for other activities to be curtailed or modified should, of course, be made with regard to environmental[16], social[17] and economic considerations. Citizen views about future land and water use are clearly critical. Decisions may be difficult to make, but they cannot be avoided if explicit protection is to be provided for important oyster cultivation areas.

Much of the information needed to make such decisions is available at present, or is in preparation. For example, the NSW Government decided, in response to the Coastal

[16] Achievement of environmental conditions necessary for healthy oyster cultivation should not be dependent on further modification of natural ecosystems. For example, new training walls or dredging of estuary entrances to increase tidal regime is not seen as an appropriate mechanism to achieve necessary environmental conditions. In some cases, however, rectification (at source) of river health related to past human induced land and water changes may be necessary. Factors such as carrying capacity and optimum stocking density of a waterway must also be considered.

[17] This includes the social benefits of oyster growing in a region, as well as consideration of the decreased recreational amenity due to oyster leases within waterways.

Lakes Inquiry (HRC 2002a) that Wallis, Wagonga, Tuross, Merimbula, Conjola, Queens/Watson Taylor, Wonboyn and Pambula lakes be protected for oyster cultivation. Outputs and results from the NSW Shellfish Program, aquaculture industry development plans and the Comprehensive Coastal Assessment will increasingly provide information for the NSW coast that should be used in making such decisions. Additionally, regional directions, priorities and actions, such as those contained in catchment blueprints, estuary management plans, interim water quality and river flow objectives and regional and local plans provide further information. Views of citizens, industry, local councils and agencies should be considered in making such decisions.

The specification of areas where oyster cultivation is a priority intended outcome would provide direct and explicit signals to all state government agencies, local councils, industry and the community as to where oyster cultivation is being encouraged from a *state-wide* perspective, but would not necessarily restrict oyster cultivation in other areas. Regional or local decisions may include additional areas to be protected for oyster cultivation. Similarly, the designation of areas as 'primary' oyster cultivation areas would not imply that degradation of river health in other areas is more acceptable. The proposed approach does, however, highlight that river health goals should be aligned to specific areas and circumstances. Such an approach was adopted by the Commission in the determination of management orientations within the Coastal Lakes Strategy (HRC 2002a) and in recommendations for the Hunter River Inquiry (HRC 2002b).

To ensure that local, regional and state agency actions are in accordance with, and assign appropriate regard to the state-level priorities for oyster growing as an intended outcome, such intended outcomes should be formalised via inclusion in a relevant policy/statutory instrument. At present, *SEPP62 – Sustainable Aquaculture* appears to represent the most appropriate mechanism, but it would require some minor amendments. Inclusion of areas, where oyster cultivation for human consumption is a priority intended outcome, in such an instrument, with appropriate supporting clauses, would provide similar protection and planning controls as that provided to coastal wetlands subject to SEPP14.

5.2 Management of Land and Water

As previously noted, the Commission considers that there is a critical gap in land and water planning and management processes, in that they often fail to draw together the requirements of oyster cultivation for human consumption with those of other land uses (for example, urban and agricultural development) and water uses (for example, siting of sewage treatment plant discharges and management of sewage from boats). Discussion at the Oysters Workshop tended to confirm such concerns with statements that the impacts of sediment, human sewage and other runoff on oyster growing areas are not usually explicitly considered in the *land* use planning framework. Participants at the Workshop particularly emphasised the need to better manage *existing* land uses.

State-level priorities, in terms of safe and productive oyster cultivation are highly unlikely to be secured without commensurate anticipatory action to protect, and rehabilitate where necessary, catchments and waterbodies for oyster growing. This requires recognition up-front of the interrelationships between the management requirements of land, water and aquaculture resources. Clear decisions need to be taken and implemented from the

outset, with the various values and views well-explored and trade-offs made in transparent ways.

In some circumstances, oyster cultivation and other forms of development or resource use could occur without additional restrictions on either activity[18]. In other circumstances, additional conditions or restrictions would be required for the proposed land and water development and/or on oyster cultivation[19]. In yet other circumstances the various forms of resource use will *not* be compatible. In each case, the site-specific circumstances, as well as cumulative impacts, must be considered to ascertain appropriate resource uses and conditions.

Clear decisions taken at the outset relating to future land and water uses will decrease long-term problems that compromise both river health and safe oyster production, and thus also decrease the conflicts and social and economic problems, which will otherwise inevitably arise.

Credible assessments of the capability and limitations of a catchment and waterway, as endorsed by the NSW Government for coastal lakes (see HRC 2002a for details), and all coastal rivers (NSW Government 2002c), would provide information necessary for sound decisions about compatible land and water uses and the controls needed to contain risks to oyster growing. Individual assessment of specific proposals would remain necessary, although it is expected that there will be a greater degree of certainty about the likely acceptability of proposals, generated by the higher-level capability assessments and planning decisions.

The undertaking of priority applications of the PlanFIRST (DUAP 2001) approach to regional planning along the NSW coast presents a significant opportunity to adopt a process based on selected outcomes and the capacity of the system to sustain such outcomes. The Commission understands that these priority applications will result in the preparation of regional strategies and local plans, incorporating as well as influencing natural resource management plans (as an iterative process) and other issue specific plans. To be effective, feedback loops and regular review mechanisms between all such plans must be ensured.

As well as statutory land use plans, there are many natural resource management plans that govern activities (both upstream and downstream) that may influence oyster growing areas. These plans include catchment blueprints, interim water quality and river flow objectives, national park plans of management, species recovery plans, estuary management plans, water sharing plans, native vegetation management plans and habitat management plans. Such plans, as they are being made, or subsequently reviewed and amended, must give explicit recognition to priority areas for oyster cultivation and tune actions to achieving the river health required. State and local government programs should also be aligned with specified priorities and required actions.

Some submissions from state agencies, local councils as well as individuals discussed the difficulties of determining the impacts and costs of proposed development on river

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[18] For example, where oyster cultivation occurs in a very well flushed area of an estuary, and the development is minor.

[19] For example, stricter levels of sewer overflow control may be required and/or longer periods when oyster harvesting areas are closed.

health generally, and the needs of healthy oyster cultivation specifically. Assessments of costs and impacts should be undertaken at a catchment-wide scale (and/or region-wide), as well as at a development-specific scale. Application of the various processes described above, including the preparation of sustainability assessments, regional strategies pursuant to PlanFIRST and the undertaking of actions specified in various natural resource management plans, particularly catchment blueprints, should provide greater guidance and models for resource managers to allow for better decision making.

The known development pressures facing the NSW coastline, and their implications for safe oyster production, promote a focus on planning for future land uses, but this should not detract from the need to manage *existing* land and water uses that already impact on oyster production[20]. Significant concerns have been expressed to the Commission regarding the impact of *existing* uses and the lack of a clear framework for their effective management. Many of the above mentioned plans could and should provide the opportunity to address such issues.

As a specific issue relating to land and water management, some submissions from oyster growers called for dredging of estuary entrances or permanent entrance opening. The Commission has not considered this issue in this review, and directs readers to its *Independent Inquiry into Coastal Lakes Final Report* (HRC 2002a) and its *Independent Inquiry into the North Coast Rivers Final Report* (HRC 2003). The NSW Government has endorsed classifications of coastal lakes into one of four classes, with corresponding indicative actions, including in relation to estuary entrance management. The latter has recommended that future dredging of estuaries and entrances be managed in accordance with principles and priorities established by a coast-wide review of the goals and implications of such activities.

Several submissions discussed the valuable contribution of the Shellfish Quality Assurance Program to the oyster industry, and the need to utilise fully information collected via this Program. Many councils stated that limited financial resources have restricted their ability to undertake river health monitoring, but that benefits were likely if they were provided with access to water quality monitoring undertaken by oyster growers. The Commission considers that where such information is provided to SafeFood NSW as part of regulatory requirements, these data should be available to entities with river health responsibilities. SafeFood NSW should investigate and develop mechanisms to allow for the sharing of these data.

5.3 Cost Sharing and Implementation of Decisions and Actions

Water quality requirements for oyster cultivation for human consumption are more stringent than for other estuary uses, such as safe swimming. Because such requirements have rarely been *explicitly* recognised and addressed in land use decision making processes, costs incurred by oyster growers are higher than they would be if the land use planning processes had better provided for safe cultivation. Additional costs arise from the need to close harvest areas, the requirement to undertake food and water

[20] Currently the only option when such impacts threaten consumer health is for the oyster grower to be forced to close harvest areas, either temporarily or permanently, and to be the sole bearer of the financial loss from such action.

quality monitoring, and the harvest of smaller grade oysters due to uncertain river health and increased risk of disease.

In future, the maintenance of conditions suited to safe oyster cultivation in specified areas, where existing or proposed development will impact upon river/estuary health will involve a mix of preventative costs (in the case of new development) and remediation costs (for existing developments).

As recommended by the Commission in its previous Inquiry reports, the costs of maintaining required standards of river health in the face of *new* development (whether in industrial, urban, agricultural or other forms) should be explicitly recognised and 'internalised' in the cost of the proposed development. Requirements upon new developments, including ongoing maintenance and monitoring and the use of bonds, must be clearly specified using enforceable mechanisms. This principle is generally applicable in all areas, but its application would be of particular importance in areas identified for oyster production, at either the state or regional level.

Where modification of *existing* land and water uses is required to provide river health consistent with safe oyster production, remediation costs will be involved. In such circumstances, adequate time must be allowed, given funding limitations, for these actions to be undertaken by the appropriate individual, company or government authority.

Management will need to deal with the reality that while controls may be imposed on *new* developments *relatively* easily, it is far more difficult to require changes to existing activities, particularly agricultural practices. This difficulty relates to a number of interrelated factors including the historical limited regulation of such activities, the diffuse nature of the activity, and the small-scale, large number, and financial position of many farm enterprises upstream of oyster growing areas.

The Commission has investigated sustainable farming in detail in its Hunter River Inquiry (HRC 2002b). The Commission also engaged the Institute for Rural Futures (Reeve et al 2002)[21] to investigate links between sustainable farming practices and farm productivity and profitability. The Commission concluded from this consultancy and other evidence, that the adoption of sustainable land management practices can enhance both economic and environmental outcomes. In the short term, there is a need to promote and facilitate the adoption of such practices. The Commission has made a recommendation in this regard in its Hunter River Inquiry Report, and now notes that where oyster growing is important the potential benefits of such approaches warrant particular efforts.

The Commission therefore recommends that in exploring how government incentives and market-based mechanisms might be applied to promote sustainable resource use, NSW Agriculture and the Department of Land and Water Conservation pay particular attention to the oyster growing areas where farming practices have a direct impact on oyster production. It is encouraging that some of the catchment blueprints include actions aimed at developing and applying incentives for better land management.

[21] A copy of the report is available from the Commission on request.

Similarly, there should be special consideration of the possible applications of green offsets, as recommended in the Commission's Georges River – Botany Bay Inquiry (HRC 2001) and proposed by the NSW Government (2002a), to contribute to improved land management that would benefit river, estuary and oyster health.

The Commission notes that the introduction of such mechanisms, including 'green offsets' as instruments of environmental protection will require carefully tailored applications that consider economic, social and environmental costs and benefits. However, it is clear that the more traditional instruments have not been effective, and the Commission is therefore convinced that there is a continuing need to explore the design of innovative mechanisms that can be applied effectively.

In making these recommendations, the Commission stresses that the use of incentives for sustainable farming and resource use practices does not obviate the need to recognise a developer's or farmer's 'duty of care' that is created by the obligation to meet agreed public standards.

The costs of maintaining a secure environment for oyster cultivation will, and should, be distributed among the resource users in the catchment (including farmers), government (in recognition of the 'public good' nature of positive environmental outcomes) and the oyster growers themselves, whose productive activities necessitate a higher standard of river protection than may otherwise have been required. As noted above, the oyster growers are at present bearing what appears to be a disproportionate share of the costs.

Whilst an optimal distribution of costs, reflecting appropriate levels of 'duty' and 'benefits' may be difficult to quantify, recognition and discussion of the issues would, at minimum, generate greater understanding between the various primary producers, as well as other entities about the impacts of various activities, and the value of rivers as assets.

In that context the use of innovative cost distribution mechanisms such as contractual arrangements and partnerships (involving land users, oyster growers, other beneficiaries, local, state and federal government) should be considered by the responsible entities. The Government decision in relation to the Clarence River Inquiry, to develop a partnership agreement for the Clarence floodplain and its interface with the estuary provides an example of the use of such mechanisms (NSW Government 2002b). Any such agreement must involve clear responsibilities and accountabilities, as well as cost-sharing arrangements.

Another opportunity could be provided by using trust funds managed by NSW Fisheries, such as the Recreational Fishing Saltwater Trust Fund. These funds contain licence fees collected from various activities that NSW Fisheries regulates, such as aquaculture and recreational fishing. Such funds could be used to undertake habitat improvement, such as restoration of floodplain wetlands to improve overall estuary health and thereby increase the fishery resource.

5.4 Viability of the Oyster Industry

The Commission believes that government moves to promote and protect the aquaculture industry should be complemented by a greater effort by the industry itself to assure its long-term productivity and commercial viability. The 1997 ACIL report stressed the need for the oyster industry itself to progress *further* along the commercial and professional path. Some government initiatives may assist in this regard - for example, government programs may create incentives for the transfer of leases to high priority areas, and may encourage value-adding within the industry and the more productive use of leases. However arguably, some of the most important steps need to be taken by the industry independently of government.

While industry structure, and issues such as marketing and business planning are matters for the industry itself to determine, the Commission suggests that the industry should give consideration to how it may achieve a much more active and organised involvement in natural resource management, in order to promote river/estuary health[22] and wider industry interests.

The Commission notes that the oyster industry is increasingly becoming involved in estuary management processes, where a more direct link to oyster health can be seen.[23] It encourages the industry to build on that involvement in order to maximise the leverage it may enjoy from exploiting more fully the links between oyster health and whole-of-catchment processes. This may include providing one message at an industry wide level[24], speaking with a clear voice on major river health issues, participation at a local, regional and state level on natural resource management related committees and programs, and involvement in policy and decision making. One state agency noted that increased industry, rather than individual, activity would improve lines of communication between state agencies, local councils and oyster growers.

Such expanded industry involvement in natural resource management may provide the industry with a positive feedback loop that is likely to increase consumer confidence and community desire for a sustainable oyster industry, including the relationship between a sustainable industry and sustainable river health.

The Commission believes that government specification of areas where oyster growing is an intended priority outcome for the long-term, as it has recommended, would give oyster growers confidence to invest their time and resources in estuary management processes.

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[22] This may include integrating river health data collected by the oyster industry with data collected by local and state entities.

[23] It is also encouraging to see the industry improving its own environmental performance. White (2001) notes that the industry has initiated a four-year program to phase out tar and arsenic-copper-chromium treated timber.

[24] Providing one message at an industry wide level relates to the content and policy of commentary, *rather than* the number of peak industry groups. The Commission acknowledges the value of different groups, and notes that at present there are two peak industry groups in NSW, related to differences in scale and structure of individual members.

6 Recommendations

From its analysis of submissions to previous Inquiries and the Draft Report, expert advice on oyster cultivation, stakeholder information from the Oysters Workshop, other discussions and consideration of available information, the Commission has concluded that implementation of the following recommendations would contribute significantly to the maintenance of a sustainable and viable oyster industry.

This Final Report and the recommendations it contains will be presented to the NSW Government and the community. Government decisions are typically recorded in a public Statement of Intent. The Healthy Rivers Commission has an ongoing role to undertake independent audits of implementation of Government decisions. The audit process will be designed to facilitate agency understanding through progressive communication and feedback, leading to the preparation of an audit report two years after making the Statement of Intent.

Recommendation 1

The NSW government should identify areas (estuaries or parts thereof) where oyster cultivation for human consumption[25] is a priority intended outcome from a state-perspective.

The decisions should be taken in light of *available* information relating to environmental, social and economic factors, as well as relevant agency, local government and citizen values and views. This includes government decisions on the Coastal Lakes Inquiry (HRC 2002a), information and strategies incorporated into aquaculture industry development plans prepared pursuant to SEPP62, the classification of oyster growing areas pursuant to the NSW Shellfish Program, the Comprehensive Coastal Assessment, regional and local plans, catchment blueprints, water sharing plans and estuary management plans.

Decisions on areas where oyster growing for human consumption is a priority intended outcome should be formalised via inclusion in a statutory instrument, such as *SEPP62 – Sustainable Aquaculture.*

Lead responsibility: PlanningNSW

Joint responsibility: NSW Fisheries

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[25] 'Oyster cultivation for human consumption' includes the collection of spat and growing of oysters prior to selling for further growth in other areas.

Completion time: 1 year (from Government decision in relation to the Final Report)[26]

In addition to state-level priorities, regional or local processes may also identify priorities to maintain areas for oyster growing. Similar to state-level priorities, such decisions should be formalised within relevant documentation, such as regional strategies and local plans.

Recommendation 2

For areas where cultivation of oysters safe for human consumption is a priority intended outcome at the state-level, regional and local planning processes for land and other resource uses (particularly PlanFIRST processes) should be specifically directed to achieving this outcome.

Natural resource management plans such as catchment blueprints, estuary management plans and water management plans should be designed or amended to be consistent with and give effect to achieving that outcome.

The application of state and local government programs should be aligned so as to give effect to these decisions and actions, and the prioritisation of these programs should be informed by the intended outcome.

Lead responsibility: PlanningNSW, Department of Land and Water Conservation

Joint responsibility: Other relevant state agencies and local government

Completion time: As plans are finalised, and subsequently reviewed

It is important to note that measures to safeguard river health to allow for oyster cultivation for human consumption will also provide river health for aquatic ecosystem protection and primary contact recreation, both typical objectives for estuarine waters.

Recommendation 3

For *new* development (including industrial, urban, agricultural and aquaculture) in areas where oyster cultivation for human consumption is a priority intended outcome, the costs of meeting necessary river health requirements should be internalised from the outset in the costs of the development.

Lead responsibility: PlanningNSW

Joint responsibility: Relevant state agencies and local councils

Completion time: Ongoing

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[26] This timing is essential to allow for incorporation of decisions into the regional strategies being prepared by PlanningNSW.

Recommendation 4

For *existing* land and water uses that impact on areas where oyster cultivation for human consumption is a priority intended outcome, costs to achieve necessary river health requirements should be internalised or explicitly subsidised through incentives, market based mechanisms and other assistance programs. Time scales to undertake actions appropriate to local circumstances should be determined on a case by case basis.

Cost sharing arrangements should at least recognise a farmer's 'duty of care', 'public good' and 'beneficiary pays' elements, notwithstanding the difficulties of quantifying the various obligations.

Innovative cost distribution mechanisms such as contractual arrangements and partnerships (involving land users, oyster growers, other beneficiaries, local, state and federal government) should be considered and facilitated through appropriate mechanisms.

Lead responsibility: Relevant state agencies and local councils

Completion time: Ongoing

Recommendation 5

Government interaction with the oyster industry should promote structural developments *within* the industry that would assure it a viable and sustainable future.

Education and limited incentive programs should promote and facilitate such industry developments.

Lead responsibility: NSW Fisheries

Completion time: 2 years (from Government decision in relation to the Final Report)

The oyster industry itself should move towards a more sustainable industry structure, including speaking with a clear voice and more active and organised involvement in natural resource management and land and water planning.

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White, I., 2001. *Safeguarding Environmental Conditions for Oyster Cultivation in New South Wales.* Centre for Resource and Environmental Studies, Australian National University. Report to Healthy Rivers Commission.

Appendix 1: Consultations

Submissions on the Draft Report

Name	Organisation
Lisa Corbyn	Environment Protection Authority
Steve Dunn	NSW Fisheries
G A Napper	Shoalhaven City Council
Bob Smith	Department of Land and Water Conservation
Lisbet Dean	NSW Department of Sport and Recreation
Dick Persson	NSW Department of Public Works
Anthony Sciacca	NSW Farmers Association, Oyster Section
Ken Exley	Pristine Waters Council
Cherie Everett	Port Stephens Council
Jenny Edwards	The Coastwatchers Association
Kathy Ridge	Nature Conservation Council of NSW Inc.
George Townsend	
Ross McPherson	Hornsby Shire Council
Theo Hooy	Environment Australia
John Powell	The Hawkesbury River Environment Protection Society (THREPS) Inc.
Vicky Sheppard	NSW Health Department
Shannon Finch	Bega Valley Shire Council
Greg Yeates	PlanningNSW, North Coast
Penelope Coleing	National Parks Association, 3 Valleys Branch
Allen Grimwood	Eurobodalla Shire Council
Neil Rose	Central Coast Catchment Management Board
Tom Port	Nambucca Shire Council
Richard Murray	Tweed Heads Environment Group Inc.
Carl Scully	Minister for Transport
Christopher Ruprecht	Oyster Farmer's Association of NSW – Manning Branch
F C Crook	
Daryl Quinlivan	Department of Agriculture, Fisheries & Forestry - Australia
Peter C L John	The Australian National University

Oysters Workshop - Participants

Oysters Workshop, Port Macquarie, 22 August 2002	
Sandy Allan	Waterways Authority
Peter Ayres	(facilitator)
Scott Carter	NSW Fisheries
Bruce Coates	Department of Land and Water Conservation
Ian Crisp	Oyster grower
Andy Derwent	SafeFood NSW
Mary Fien	NSW Health
Tim Gippel	NSW Fisheries
Glenn Handford	Great Lakes Council
Rick Harris	Port Stephens Council
Rob Irvine	Department of Local Government
Klaus Koop	Environment Protection Authority
Laurie Lardner	Oyster grower
Neil Lazarow	Environmental representative
Stephen Nicholson	Hastings Council
Damian Ogburn	NSW Fisheries
Matt Rogers	Hastings Council
Tony Sarks	Australian Tea Tree Industry Association
Yolande Stone	PlanningNSW
Liz Shelly	On-site Management Systems Project Officer (EPA)
Brian Tierney	Urban Development Institute of Australia
Tony Troup	Oyster Farmers Association
Ian White	Centre for Resource and Environmental Studies, ANU
Paul Wilson	NSW Farmers - Oysters

Appendix 2: Safeguarding Environmental Conditions for Oyster Cultivation in NSW

The author was engaged to provide independent advice to the Commission for its public inquiry process. This Occasional Paper presents that advice and is published as an information source to the community. It does not represent advice of the Commission or any person representing the Commission. Any statements made or opinions expressed are solely those of the Paper's author and do not represent views of the Commission or any of its staff. The Commission and staff also disclaim liability to any person for any actions taken or not taken, based on the information or opinions expressed in the Paper.

Note : This report has previously been published by the Healthy Rivers Commission as Occasional Paper OCP 1004.

Report 010801

SAFEGUARDING ENVIRONMENTAL CONDITIONS FOR OYSTER CULTIVATION IN NEW SOUTH WALES

for

NSW Healthy Rivers Commission

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Jack Beale Professor of Water Resources
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The State needs to provide guaranteed water quality standards consistent with high quality shellfish production. **(Rodgers, 2001)**

CRES ANU
August 2001

Contents

Terms of Reference

This report is to undertake the following tasks:

1. Characterise the current situation and provide a broad prognosis for the future (based on continuation of *current* management practices) with regard to the major types of human activities (within estuaries and their catchments), and their impacts on oyster cultivation in NSW estuaries. Particular regard should be given to:
   - the environmental concerns expressed and experience by oyster growers;
   - disease outbreaks in oysters that may be attributable to degraded water;
   - the outcomes of the *Shellfish Quality Assurance Program* in terms of identifying pollution risk potential and growing area classification; and
   - recent oyster production figures over the past 5 years.

2. Identify the environmental factors that should be assessed to determine whether oyster cultivation is a realistic outcome for an estuary. Suggest other social or economic factors that should be assessed.
3. Identify the types of actions that would be necessary within estuaries and their catchments to rehabilitate and/or maintain areas for oyster cultivation. Indicate how the suggested actions may constrain other activities within estuaries and their catchments.
4. Advise on any specific amendments to the Commission's proposed management framework that would make it more effective as a means of assuring safe, commercially viable oyster cultivation in relevant catchments including:
   - Identifying factors that should be assessed in the preparation of Sustainability Assessments; and
   - Identifying any instances in which the Commission's preliminary classification of coastal lakes should be reconsidered in the light of the presence of oyster production and/or threats to that activity.

SUMMARY

The Healthy Rivers Commission of NSW has recognised the vulnerability of coastal rivers and lakes in NSW and is seeking to identify solutions for their sustainable development. A key thrust in its recommendations has been directed at the minimisation of health and economic risks for oyster farming. The overall aim of this report is to provide independent, strategic advice on actions that are necessary within estuaries and their catchments to safeguard environmental conditions for oyster cultivation, where this is realistically possible.

The 130 year-old NSW oyster industry is Australia's oldest, post-European-settlement, aquaculture industry. It is by far most valuable aquaculture industry in NSW, producing 80% of the total value of aquaculture product. The long-term average gross present value of production from oysters across the state is $8,000/ha of lease area. Some estuaries have returns as high as $35,000/ha. This makes oyster production one of the state's most valuable per hectare agricultural enterprise. Oysters are mainly sedentary filter feeders and are extremely valuable, integrative indicators of water quality in estuaries and coastal lakes. A productive and healthy oyster industry reflects our ability to sustain and maintain healthy, coastal waterways.

The general conditions required for growing healthy oysters are well oxygenated, clear, brackish to saline waters, with pH in the range 6.75 to 8.75, with adequate alkalinity, suitable tidal exchange, adequate phytoplankton supplies and control of upstream sources of runoff and pollution. The growing area classification being introduced by the NSW Shellfish Quality Assurance Programme as a result of the recent Rodgers' review provides details on the conditions necessary to grow healthy, safe oysters.

The principal threats to oyster production are: human faecal contamination of oyster growing areas, due to expanding coastal populations, particularly in the northern part of the state; the oyster diseases QX and winter mortality (whose linkage to environmental degradation is yet to be established); runoff from acid sulfate soils; turbid waters; marine biotoxins; agricultural and industrial pollutants; and prolonged freshwater flooding. Stressed oysters are prone to diseases. Major impediments to the industry in NSW are: the institutional arrangements for the management of estuaries; the structure of the industry itself; and the availability of finance. Restructuring is underway in the industry.

Analysis of historic and recent trends in NSW oyster production shows production continues its downward trend from the late 1970's. The Trend in Oyster Production Index shows only 6 estuaries (4 significantly) increased their production over the last 5 years of the last decade, compared with 18 in which production decreased (9 significantly). Only 7 remained stable. Production in two major oyster-growing estuaries, Port Stephens and Georges River, has collapsed due to disease and the introduction of Pacific Oysters. However, even when these estuaries are removed from the states oyster production, the declining trend in oyster production is still apparent.

The decreasing trend in oyster production over the period 1968-2001 follows the decrease in area leased by growers and the decline in permit holders. Both socio-economic and environmental factors have contributed to the decline in lease area held by growers. Data is not available to determine what area has been lost because of environmental degradation. In the period 1968/69 to 1992/93 the state average annual yield of oysters remained remarkably constant at about 21 bags/ha of lease area. Since 1993, state average annual yield has apparently decreased. The highest recorded annual yield in the state was nearly 90 bags/ha at Wallis Lake. The long term average annual yield in Wallis Lake is 250% greater that the long term state

average yield. Because of its importance to the state's oyster production, and its productivity, Wallis Lake requires urgent protection.

The lease area taken up by growers is an important industry sustainability indicator. It is fundamentally important that the area available for growing healthy oysters be protected. Individual estuary oyster yields are valuable for examining estuary trends and comparing estuaries and regions within estuaries.

The maturity of the oyster industry in NSW and the structure of the industry have meant that it has suffered benign neglect from successive governments. The Healthy Rivers Commission Coastal Lake Assessment and Management Strategy, the acceptance by the NSW government of the Rodgers (2001) Report on NSW Shellfish Quality Assurance Programme, and the Draft Aquaculture Industry Development Plan, together represent a major, positive shift in attitude, and one that is long overdue. All recommend classification of estuaries and of zones within estuaries as an essential step in their better management and in the task of producing healthy oysters.

There are significant threats to oyster production in NSW caused by the range of physical and social environments in which oysters are produced. Rapid population growth in the northern coastal region is a significant threat to growing healthy oysters. The diseases, QX and winter mortality, also threaten production. The presence of large areas of acid sulfate soils, and larger, more intense rainfalls in this area also pose threats to oyster production.

The strategies proposed in the Healthy Rivers Commission Coastal Lake Assessment and Management Framework provide clear mechanisms for ensuring that new developments in the catchments of coastal lakes will not increase the threats to oyster production. They also provide important means for addressing and correcting existing problems. These strategies address the principle concerns of oyster growers about human faecal contamination of oysters, increased sedimentation, changes in runoff rates due to catchment development and sources of agricultural nutrients and pollution. **This report recommends that the extension of the Coastal Lake Assessment and Management Strategy to all commercial oyster-producing estuaries in NSW be considered urgently.**

Three things will be needed for the Coastal Lake Management Strategy to be a success. The first is for the NSW government to endorse, and the community to embrace the Strategy. The second is that Lake Sustainability Assessments are adequately resourced. The third is that there is a long-term commitment to the process of reviewing its effectiveness and updating the Strategy. From an oyster industry perspective the Strategy will have been a success if it forces all players involved in the management and use of coastal lakes to consider firstly the impacts on the health of oysters and the livelihoods of growers of any activities in or surrounding coastal lakes.

ADVICE AND RECOMMENDATIONS

2. Identify the environmental factors that should be assessed to determine whether oyster cultivation is a realistic outcome for an estuary.

The growing conditions necessary for healthy oysters are generally well-oxygenated, clear brackish to saline waters, with pH in the range 6.75 to 8.75, with adequate alkalinity, suitable tidal exchange (tidal amplitude >300 mm; tidal flushing time <15 days), adequate phytoplankton supplies and control of upstream sources of runoff and pollution. Classification of oyster growing areas by the NSW Shellfish Quality Assurance Programme, SQAP and Aquaculture Industry Development Plan, AIDP, recommended by the Rodgers' Report and endorsed by the NSW government, will result in the identification of areas from which it is appropriate to produce and sell oysters for human consumption. Classification of growing areas is based on a comprehensive and ongoing sanitary survey of growing areas. Classification of an area depends on:

- actual and potential contamination sources and their quantification,
- meteorological, seasonal and hydrodynamic factors, and
- periodic monitoring of the microbiology (indicators of human pathogens) and hydrochemistry.

Oyster cultivation is not a realistic outcome in areas permanently or predominantly classified as *closed.*

Because the NSW oyster industry is a mature industry, growers, through long experience, have selected growing sites suitable for oyster production. Problems arise where urban and agricultural development has impacted on pre-existing leases or when siltation of estuary mouths occurs. The classification of growing areas, a continuing process, proposed by the Rodgers (2001) for SQAP and by the AIDP will identify areas where continuing safe oyster production is a realistic outcome. In addition, in areas influenced by acid sulfate soil drainage techniques are now being trialed that will reduce or eliminate acid discharge.

✸ It is recommended that the proposed *Lake* and *Site Specific Sustainability Assessments* be carried out in conjunction with the SQAP and AIDP classification of growing areas.

SQA Committees in individual estuaries have collected information on oyster meat and water quality as well as climate data since as early as 1993. At present that data has remained unanalysed. There is an urgent need for that data to be analysed as part of a process of protecting growing conditions.

✸ It is recommended that the analysis of data collected by local Shellfish Quality Assurance Committees be encouraged.

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The NSW oyster industry has a unique characteristic, that of relaying or translocating oysters to other estuaries or other sites within estuaries to maximise production. If a site is temporarily unsuitable for production due to estuary mouth closure, environmental conditions or disease, growers are able to relay oysters to other locations until conditions change. It must therefore be recognised that there is a dynamic nature to the suitability of sites. Low producing areas may serve as reserve sites for growers or may be used by aboriginal communities.

3. Identify the types of actions that would be necessary within estuaries and their catchments to rehabilitate and/or maintain areas for oyster cultivation.

There are increasing threats to growing healthy oysters in NSW from the continued growth in coastal populations, especially in the northern part of the state. The abstraction of freshwater upstream during low flow periods constitutes a threat to growing healthy oysters. Pollution of estuaries from point discharges is of principal concern including broken, leaking or overflowing sewer mains, sceptic tank discharges, industrial and agricultural chemical discharges, urban stormwater outlets, agricultural drains in acid sulfate soils. Diffuse sources of excess nutrients and pollutants, such as agricultural runoff. Land reclamation, engineering works, over-fishing, boating, waste disposal sites, weed infestation and the clearance of catchments, particularly riparian zones all represent major threats to the health of estuaries and oyster production. Urban and agricultural developments in coastal catchments have dramatically altered the character and quality of storm runoff and its subsequent impact on estuarine ecosystems.

The Healthy Rivers Commission has identified most of these issues in the types of broad management strategies it has proposed as part of the *Coastal Lakes Assessment and Management Strategy*. Some of the other strategies proposed under the lake categories that permit commercial oyster production address specific threats to oyster production. These include:

Significant protection

- Limit development of new dwellings to within the boundaries of existing villages and rural residential areas;
- Mitigate (or remove) existing sewerage discharges, overflows and septics (no new discharges);
- Encourage use of best farming and forestry practices;
- Exclude new intensive agricultural or aquaculture development;
- Stringently manage recreational and commercial uses.

Secure healthy, modified conditions

- Enforce stringent controls on new urban, rural residential and intensive agricultural developments (provided these are demonstrated to be sustainable);
- Locate no new assets (such as sewerage, roads, and dwellings in areas subject to flooding/ water logging under natural entrance conditions; and
- Exclude new sewerage discharge or overflows, stringent management of septics.

Given the sensitive of oysters to acid runoff from acid sulfate soils, and the concerns of the industry a specific strategy dealing with the avoidance of their disturbance in areas neighbouring coastal lakes, or, where acid is already discharging, the complete treatment of runoff is important. As well, an overall strategy for those lakes in which oysters are grown, in which any new development proposals should specifically address the increased risks posed by the development on oyster health and growth. A potential amendment to SEPP62 “Sustainable Aquaculture Strategy” is currently being examined which would require consideration of the impacts of all sewerage, stormwater and acid sulfate soil developments.

- ✸ It is recommended that the specific strategies relating to the disturbance/drainage/treatment and rehabilitation of acid sulfate soils be included in the proposed Coastal Lakes Strategy.
- ✸ It is recommended that in oyster producing lakes a strategy be included that specifically requires all new developments (private and public) within the lake catchment identify the risk they pose to oyster production.

The lease area taken up by oyster growers is an important industry sustainability indicator and the yield trends provide valuable information on the efficiency of production in estuaries.

- It is recommended that lease area taken up by growers and yield of oyster be used as indicators of the success of the Strategy in oyster producing lakes.

The Commission has raised a concern about the impact of oyster production on sensitive lake ecosystems. The policy of NSW Fisheries is to only allow the farming of species indigenous to a locality. Species competition due to oyster farming, therefore, will not be a threat to sensitive lake ecosystems. Oysters in NSW estuaries are farmed under extensive aquaculture. That is, oysters are not feed artificially but rely on the natural seston occurring in waterways. It follows that there is no threat to sensitive ecosystems from introduced feeds.

Farmed and native oysters and shellfish coexist in estuaries and there is competition for food. In locations with adequate tidal exchange and where carrying capacity has not been exceeded this poses no threat to local ecosystems. The draft Aquaculture Industry Development Plan proposes to set estimated sustainable yields for estuaries. This will ensure that farmers do not exceed carrying capacity.

A potential threat to local ecosystems may come from the materials on which oysters are grown. In order to protect wood used in farming activities, growers have traditionally used tar coatings. More recently, Arsenic-Copper-Chromium impregnated timbers have been employed. While there is no evidence in NSW that, in approximately 100 years of growing oysters on treated timbers, oysters or neighbouring species have been contaminated in anyway, the industry has voluntarily agreed to a four-year phase-out of tar and treated timber. Work has commenced to assess suitable, alternate materials and practices.

- It is recommended that where oyster farming is carried out in areas designated with sensitive lake ecosystems, the replacement of tar and ACC-treated timbers be facilitated.

Institutional arrangements will play an important role in the success of the Strategy. For oyster growers, a “one-stop-shop” would remove many of the institutional impediments to maintaining healthy estuaries. While the Strategy provides a unifying framework, institutional barriers will still persist. It appears inevitable that at least three departments, NSW EPA, NSW Fisheries and NSW Safefood Production will be involved in matters relating to oyster-producing estuaries.

- It is recommended that mechanisms for establishing a “one-stop-shop” for managing estuaries or the simplification of procedures be further explored.

4. Advise on any specific amendments to the Commission’s proposed management framework that would make it more effective as a means of assuring safe, commercially viable oyster cultivation in relevant catchments.

The Healthy Rivers Commission Coastal Lake Assessment and Management Strategy represents a major, positive change in the management of estuaries and one that has considerable potential benefits for the oyster industry. Unlike the draft AIDP, it makes a specific commitment to ensuring water quality for healthy oyster production. The proposed Strategy represents a unique opportunity to protect the quality of estuarine waters in coastal lakes for oyster production. There would be great benefits to the oyster industry in NSW if the Coastal Lake Assessment and Management Strategy were extended to all commercial oyster-

producing estuaries in NSW. The establishment of the coastal lakes strategy will mean that oyster farmers in coastal lakes will be advantaged relative to their colleagues elsewhere.

- **It is recommended that the extension of the Coastal Lake Assessment and Management Strategy to all commercial oyster-producing estuaries in NSW be considered urgently.**

The Strategy is essentially a practical approach to a complex problem. The strategy would be strengthened by included as a first step a formal process of identifying, and clearly stating the basic ethical principles underpinning the sustainable management of estuaries and promoting their common acceptance. These include equity, environmental justice, sustainability (rates of regeneration and assimilative capacity), and the protection of livelihoods.

While not explicitly stated, from the listed strategies that oyster farming may not be possible in lakes classified under the *comprehensive protection* category. For lakes under the *significant protection category*, one strategy is to minimise intervention in natural entrance behaviour. Since oysters require adequate tidal exchange, this would appear to limit commercial cultivation to those lakes that are either always open to the sea or mostly open to the sea. Another strategy within this category calls for an exclusion of new, intensive aquaculture development. This would appear to limit any future expansion of oyster production in lakes within this category. It is, noted however, that a listed possible outcome for this category is *minimal risk to existing oyster growing.* Under the *secure healthy modified conditions* category, a proposed strategy is to adjust entrance intervention to protect critical ecological processes such as bird feeding events. Current oyster farming is mostly practised in lakes with entrances that are normally open. It is envisaged that in most cases this strategy would cause no change. The central point of the proposed lakes' strategy is that actual actions carried out in a specific lake will be resolved by the lake specific Sustainability Assessments. From the oyster industry perspective, any further loss of the suitable area available for leasing for oyster production must be avoided.

- It is recommended that the consequences and options for oyster production be explicitly identified under each lake category.
- It is recommended that the maintenance of all lease areas suitable for healthy oyster production is considered a fundamental objective of the strategy.

Given the priority assigned by the industry to the disturbance of acid sulfate soils the strategy should include particular reference to them.

- It is recommended that the liaison with ASSMAC and DUAP take place over the inclusion of strategies specific to the disturbance/drainage/treatment and rehabilitation of acid sulfate soils in the proposed Coastal Lakes Strategy.

The Strategy suggests the formation of an independent Coastal Lakes Expert Group appointed and overseen by the Coastal Council of NSW. It is intended that the Group would specify the criteria and methodology for Sustainability Assessments, professionally validate the findings and actions proposed by councils and agencies and provide advice on the content of educational material. It is envisaged that the Group would have expertise in ecological, social, economic and planning issues related to coastal lakes. Because of the significant pressures on such experts, careful consideration will need to be given to how this group is supported and resourced.

The provision of incentives and the resourcing of councils' planned activities in Sustainability Assessments are critical issues. The Commission suggests that the Coastal Lakes Expert Group will assist councils with high-level advice. Sustainability Assessments and hence the whole management framework will only be successful if attention is paid to the resourcing of the assessment process including the involvement of the Coastal Lakes Expert Group, councils and the Coastal Council. It is important that a strategic approach to funding by the state be developed. The decision by the NSW government to fund the coastal lake assessment under its Comprehensive Coastal Assessment is a welcomed decision

- It is recommended that a strategy be developed for providing adequate financial resources and incentives over sufficient time for the involvement of councils and the proposed Coastal Lakes Expert Group.

The resolution of disputes over Sustainability Assessments is seen an important and it has been proposed that the Coastal Council could mediate in such disputes as an independent, knowledgeable body. Multi Agent Systems may help in the resolution of disputes.

- It is recommended that the use of Multi Agent Systems in helping resolve disputes be explored.

It has been proposed that the Strategy will employ adaptive management to estuaries. Adaptive management is a practical response to the complexities of managing complex situations. Estuaries appear to behaviour in a hysteretic manner. This means that the impacts of incorrect management decisions may not be easily reversed.

- It is recommended that the risks of using adaptive management in estuaries be explored.

1 INTRODUCTION

The Healthy Rivers Commission of NSW (HRC) has recognised the vulnerability of coastal rivers and lakes in NSW. Through a series of Independent Inquiries on coastal rivers and a discussion paper on coastal lakes, the Commission has sought to identify solutions for the sustainable development of coastal rivers and lakes (Healthy Rivers Commission, 1996; 1998; 1999a; 1999b; 1999c; 1999d; 2000a; 2000b). A key thrust in its recommendations has been directed at the minimisation of health and economic risks for oyster farming.

1.1 Ethics, Sustainability and the Management of Estuaries

There are fundamental issues concerned with how we manage our estuaries. These underlie many of the issues raised at HRC coastal river Inquiries. At their centre are ethical issues concerning equity, environmental justice, sustainability, and the protection of livelihoods, in same cases maintained for the past 5 generations[1]. These are difficult, often long-term issues. Too often these ethical issues have been brushed aside in favour of short-term, transitory gains (Galbraith, 1993).

In some quarters, sustainable development is out of favour, partly due to disappointment, partly due to the suspicion that process was about rhetoric rather than outcomes, or the process has been hijacked, or more frequently to the pressures of seemingly more concrete and pressing day-to day concerns. Sustainable development must be recognised as a complex, long term process rather than the culmination of knowledge, or instant outcomes. Vojnovic (1995) identified two basic principles to achieve intergenerational equity:

- renewable resources should not be consumed faster than their regeneration rate, and
- waste discharge should be maintained at or below the assimilative capacity of the environment.

Vojnovic's principles, at first glance, would seem powerful guidelines for the management of estuaries, however, caveats are necessary. Local government boundaries are seldom, if ever, based on whole river basins, catchments or groundwater provenances. Upstream communities often have different water 'regeneration rates' than those downstream. Additionally, where water is diverted for upstream use or storage at the regeneration (rainfall) rate, there is no capacity to supply the environmental flows necessary to maintain downstream aquatic biodiversity. Vojnovic's second principle seems widely applicable to stormwater and sewerage discharges into estuaries.

Questions involving rates of regeneration and assimilative capacity and our ability to estimate them are complex and difficult but central to the stewardship of estuaries. These are linked to issues of education, information availability and provision, institutional capacity and community involvement. These principles ought to be incorporated in guideline formulation and research on them should be encouraged. The Provincial Resource Policy, May 1993, of the Ministry of Agriculture, Fisheries and Food of British Columbia, discussed in Section 3.7 below, provides an excellent policy model of how these principles can be incorporated. It would appear fundament that regeneration and assimilative capacity should be central planks in how we manage and use estuaries. Our response to these issues will be a measure of our civilisation.

[1] R.Drake, oyster farmer Grorges River (pers. com. June, 2001).

1.2 Oysters as Indicators of Estuarine Health

Oysters are filter feeders that extract food from particulate and dissolved materials in brackish water. They take from between approximately two to four years to reach market size in NSW. During that time the average oysters will filter an estimated 0.5 to 1ML of estuarine river water. The approximate average suspended matter concentration in estuarine waters is around 0.02 g/L. If the farmed oysters in NSW remove only half that concentration, they are removing over 1 million tonnes of suspended material, chiefly phytoplankton, in their lifetime. They have therefore an important role as purifiers of estuaries.

Oysters are mobile as larvae for only a brief period in their early life, after which they settle and are sedentary, unless translocated or relayed to other estuaries. Their feeding habits and life-style therefore make oysters extremely valuable, integrative indicators of water quality in estuaries and lakes zone[2]. Oysters therefore transcend their simple, resale and social values. A productive and healthy oyster industry reflects our ability to sustain and maintain healthy, coastal waterways.

Oyster farmers in NSW have been increasingly concerned about water quality and its management. The issue initially gained prominence after Australia's largest food-related incidence of gastroenteritis in mid 1978, which was traced to contaminated oysters from the Georges River. Recent incidents on the Tweed River (August, 1996) and Wallis Lake (February, 1997) in which hundreds of people contracted gastroenteritis or Hepatitis A, were traced to the consumption of contaminated oysters (Wilcox, 1999). In a recent priority setting exercise for the NSW Oyster Research Advisory Committee (ORAC), the oyster industry ranked water quality amongst its highest priorities (ORAC, 2001). Their concerns are based on the loss from production of once-important, estuary systems, such as the Tweed, Clarence, Georges and lower Maria Rivers and the seeming inability of governments and their agencies at all levels to stop or reverse this trend, despite a plethora of seemingly adequate legislation.

1.3 Oyster Farming in NSW

Commercial farming of the Sydney rock oyster (*Saccostrea glomerata*)[3] has been carried out for over 130 years in NSW and is Australia's oldest aquaculture industry. Shell-middens, however, show that oysters have been harvested in Australia for more than 8,000 years. The Sydney rock oyster is reputed to be the most flavoursome oyster in the world, and its ability to survive out of water for periods up to 3 weeks in wet hessian bags makes it a unique product and highly suited for export. Sydney rock oysters are found from Moreton bay in southern Queensland to Flinders Island in Bass Straight (Mitchell *et al.*, 2000). An apparently related variety occurs in southern Western Australia.

The NSW oyster industry has been the state's most valuable fishery for over 100 years and is one of Australia's major aquaculture producers. The NSW industry currently produces annually approximately 90 million oysters worth around $30 million/year at the farm gate. Oysters are produced in 31 estuaries from the Tweed River, in the north to Eden in the south. Wallis Lake, Hawkesbury River and Brisbane Waters are the main producing areas.

[2] The NSW EPA in assessing water quality along the coast adjacent to Sydney's then planned ocean-outfall used rafts of oysters as integrative indicators of water quality to depths of up to 80m.
[3] Previously *Saccrostrea commercialis*

Since the early 1900's, oysters have been grown in NSW using an intertidal stick and tray culture system and the majority of oysters are still grown using this technique. A subtidal system using rafts or pontoons was introduced in the 1970's and produced faster growth rates[4]. In the 1980's a single seed system was developed. In this systems oyster spat caught on plastic strips or tarred sticks[5] are removed from the capturing medium and grown as single, unattached oysters inter-or subtidally in trays, cylinders, baskets or bags.

The two main commercial oyster species grown in NSW are the Sydney rock oyster and the introduced Pacific oyster (*Cassostrea gigas*) together with small quantities of the native Flat oyster (*Ostrea angasi*). The Pacific oyster is very robust and is the most ubiquitous in the world, having been introduced widely in both Northern and Southern hemispheres. In NSW, The farming of Pacific oysters is restricted to Port Stephens where they were introduced in 1984 and first harvested in 1991. Production of the faster growing Pacific oysters in NSW is about 1/30 that of the total Sydney rock oyster production. Pacific oysters in Australia are also extensively farmed in Tasmania and South Australia. Flat oysters grow from the Swan River in Western Australia along the southern Australian coast (including Tasmania) and up the east coast as far as the Clarence River. Flat oysters reach market size within 1.5 o 2 years and offer the chance for growers to diversify. There appears to be potential for increasing farming of flat oysters. Flat oyster spat are currently hatchery produced by NSW Fisheries.

Production of the Sydney rock oyster increased steadily in the early 1950s. In the early 1970s, production leapt, as farmers adopted the practice of moving or translocating oysters (relaying) between different estuaries, to take advantage of different growing and fattening conditions and to minimise the risk of diseases[6]. While oyster production fluctuates due to climatic and disease factors, production has dropped systematically from its peak in 1978, by over 40%. This production decline is the result of the interaction of many factors. Some are demand-side driven, while some are supply-side driven. Of the supply-side factors, the most important are diseases, competition between different species and the degradation of water quality in coastal rivers, estuaries and lakes.

The market for live seafood is still developing in Australia, and there is the potential, with strategic marketing and promotion to expand domestic sales of oysters and to increase prices. Comparison with overseas products shows that quality NSW oysters are currently grossly undervalued in the local market. Additionally, there is great potential for the expansion of the present, diminutive export market in oysters by promoting Australia's "clean green" image. The market in Asia for quality products is enormous. Before that can happen, however, there is a need for improvements in industry performance, an increase in confidence in the product and a change in culture in government agencies responsible for the health of estuaries, at all levels.

1.4 Economic Value and Social Character of the NSW Oyster Industry

The farm gate value of the 1999/2000 total oyster production in NSW was $30.1 million. Of this Sydney rock oysters made up $25.8 million while Pacific oysters were valued at $1.7 million[7]. The approximate capital investment in the industry is $268 million. The oyster industry is a significant regional employer, with around 1600 employees and is a key

[4] This system is not suitable to all growing conditions.
[5] Or for Pacific Oysters as spat from a hatchery.
[6] Older farmers claim that, after 9 months in a particular location, oysters slow down in growth rate. Relaying them to a new location increases growth rates. Some oysters may be relayed up to three times before harvest.
[7] Mean market value for Sydney rock oysters was approximately $3.60/dozen and for Pacific oysters was $4.25/dozen.

contributor to coastal, regional economies. It has been estimated that the oyster industry creates 1 job in regional NSW per $140,000 gross production directly and up to 3 jobs indirectly. In NSW, Oysters are farmed on about 2,886 leases occupying 3,702 ha by 466 permit holders (NSW Fisheries, 2001). The average capital invested per permit holder is $575 thousand.

In recent ears there has been a trend for increased production of smaller, lower value oysters[8]. The production of plate grade Sydney rock oysters now constitutes only 31% of the total production. This is a decrease of 20% since 1994/5 and has been attributed to a combination of market forces, cash flow and disease management strategies (NSW Fisheries, 2001).

About 75% of all oysters grown are sold within NSW. Almost all the rest are sold interstate with only 1% exported at present (NSW Fisheries, 2001). There is significant potential for increasing exports. An economic model for the oyster industry *Oyster Profit: Decision Tools for Farmers and Investors* has been developed as part of a joint Oyster Research Advisory Committee-NSW Fisheries-NSW Department of State and Regional Development-Queensland Department of Primary Industry initiative. It will be released in October 2001 and is designed to assist the industry in identifying costs and increasing efficiencies.

There is the potential for the industry to diversify into other species. The projected production potential for flat oysters in NSW by 2006/7 is 10 million oysters valued at $7 million. This would create over 50 regional jobs directly and an additional 150 jobs indirectly.

Like many primary industries, the oyster industry has been an '80/20' industry, with approximately 80% of the yield produced by 20% of the growers. In 1997/98, two thirds of the growers produced only 11% of production and over 25% produced no oysters at all. Mandatory costs, such as those associated with the Shellfish Quality Assurance Program, make it difficult for small, part-time producers to remain within the industry. Because of this the industry is undergoing structural changes with permit holders leaving the industry over the last decade.

Many NSW oyster farmers are often third, forth and some even fifth generation oyster growers. They are part of oyster-producing family companies. They are the custodians of valuable historical information about estuaries and have intimate knowledge of estuaries and even particular lease areas.

1.5 Healthy Rivers Commission and Oyster Production

The NSW Healthy Rivers Commission has been instrumental in highlighting and clearly identifying issues in coastal river and catchment management that affect the quality and productivity of coastal streams. It is seeking to have the themes central to its findings and recommendations used as a management framework, by agencies, councils, industries, communities and individuals, for improving the condition of specific river systems for oyster farming. These themes are consistent with other recent inquiries into wastewater management, disease outbreaks and water-supply quality. Recommendations that are particularly relevant include those that aim to improve the management of wastewater, patterns of urban and rural development, coastal floodplain use, canal estates, dredging and boating.

The Commission's completed assessments have highlighted actions necessary to improve river health for oyster growing within broad strategies that agencies and oyster growers need to take

[8] The largest grade of oysters is plate followed by bistro and bottle grades.

in planning, risk management and standards setting. It intends to examine and to recommend to government strategies for:

- aligning decisions on the reduction of impacts of other resource uses within river systems with the necessity to protect oyster growing areas;
- balancing the needs of the river system, oyster farming and other resource uses through state and local government instruments, actions and standards;
- creating effective government-community partnerships in which responsibilities and accountabilities are clearly defined and fulfilled.

1.6 Overall Aim of this Report

The overall aim of this report is to provide independent, strategic advice on actions that are necessary within estuaries and their catchments to safeguard environmental conditions for oyster cultivation, where this is realistically possible. This will be achieved by:

- reviewing the range of environmental parameters necessary for oyster farming, that can be influenced by human activities;
- considering the impact of degraded environmental conditions on oyster production; and
- recommending approaches to address the key environmental concerns for oyster growing within a catchment management framework.

2 GROWING HEALTHY OYSTERS: ENIRONMENTAL CONDITIONS

There are two important aspects to growing healthy oysters. The first is securing conditions in which the oyster flourishes as an organism. The second is ensuring conditions that lead to a product that is safe for human consumption of the raw product. We are somewhat hindered in identifying the precise biophysical conditions for optimising oyster growth, despite local experience in the commercial production of Sydney rock oysters for the past 130 years. The Sydney rock oyster behaves differently to other oysters. Surprisingly, there are gaps in knowledge on the oysters basic physiology and ecology (Nell *et al.*, 1990; Nell, 1993). A comparison with the Eastern oyster (*Crassostrea virginica*), where there is a detailed 734 page compendium of fundamental information (Kennedy *et al.*, 1996), demonstrates what is necessary. There is a considerable need for a similar compendium for Australian native oysters, to attract new growers, to inform investors, agency staff and researchers and to summarise the vast experience in the industry.

The most critical factors influencing all stages of oyster development in well-oxygenated waters[9] are water temperature, salinity, seston (suspended material) concentration, and pH (Shumway, 1996).

2.1 Temperature

Temperature critically determines the growth rate of oysters. Mean annual air temperatures along the NSW coast range from 19.7°C in the north to 15.2°C in the south. Mean water temperatures are 2-3°C higher than this, although the mean temperature difference is still 4.5°C. That temperature difference translates into an approximately 35% increase in biological rates in moving from south to north. It follows that the time to commercial harvest of oysters grown in northern NSW can be over a year shorter than that of oysters grown in the south, due to the latitudinal temperature gradient. In relaying oysters, where possible[10], growers take advantage of this gradient to improve production and escape diseases. Currently some farmers in NSW are relaying oysters to Moreton Bay for fattening in warmer regions prior to export. In addition to relaying, spat falls are larger in the warmer parts of the state. These are sources of spat for some farmers in the south.

Temperatures above 40°C cause cessation of pumping and therefore feeding in oysters (Shumway, 1996). Exposure of intertidal oysters, in shallow waters at low tides during heatwaves with temperatures above 30°C, for prolonged periods can result in major oyster kills. This appears particularly so if this period follows flooding with low salinity. Pacific oysters can tolerate temperatures ranging from 1 to 34°C (Coleman, 1996) although survival after intertidal exposure to temperatures as high as 49°C has been reported (Dames, 1996). The optimal temperature growing range for Pacific oysters appears to be 8 to 30°C while that for Sydney rock oysters is 14 to 30°C. Sydney rock oysters appear to be able to tolerate short exposures of higher temperatures. Dipping in boiling water is used as a cultivation technique to reduce overcatch. Prolonged exposure of stick-cultured oysters to the atmosphere during the summer, caused by abnormally low tides can lead to massive oyster mortalities as occurred in Wallis Lake for 3 weeks in 1968/69.

[9] Well-oxygenated waters require adequate tidal exchange.
[10] Translocation of oysters is subject to the occurrence of Pacific oyster and QX disease. Pacific oysters are restricted to Port Stevens only.

Gametogenesis and spawning in oysters are directly correlated with temperature. The condition index (ratio of dry meat weight to cavity volume), however, is strongly influenced by the season and environmental conditions and not just temperature. Condition index is a good measure of the response of oysters to growing conditions. The time taken *D* (days) for the development of mature gametes in Eastern oysters may be predicted from:

$$D = kT^{a+b\log T} \tag{1}$$

Where *T* is the temperature (°C) and *k*, *a* and *b* are constants (Shumway, 1996). Equation has been used to predict when spawning will be initiated and the time of mass spawning in Eastern oysters. It shows that a slight temperature change in the environment at low temperatures causes a more significant change in gametogenesis than at higher temperatures. It is not known whether equation (1) is applicable to Sydney rock oysters. The induction of spawning and loss of condition of rock oysters during depuration, particularly in lower temperature regions is a major concern for growers.

2.2 Salinity

Sydney rock and Pacific oysters have different salinity requirements. The Pacific oyster can tolerate salinities ranging from 11 to 48 ppt and can grow in fully marine waters. Sydney rock oysters grow in fresher conditions than Pacific oysters and salinities below 30-35 ppt appear optimal (Nell and Holliday, 1988). Oysters are faculative anaerobes because they have the capacity to live aerobically or, if conditions are unsuitable, as during flooding, they can close their shells and live anaerobically. Periods of shell closure, however, result in loss of condition and, ultimately, death. Mature oysters are better able to survive closure longer than juvenile oysters. Sydney rock oysters are able to remain closed for periods up to 4 weeks in adverse freshwater conditions during flooding. Large mortalities have been observed in Pacific oysters flooded for 30 days (Allen and Turner, 1989). The ability to remain alive for extended periods under adverse conditions separates the Sydney rock from other oysters.

While prolonged periods of fresh water are a threat to oyster growth, it is important for Sydney rock ousters that some fresh water flow into estuaries is maintained so that waters are at a lower salinity than marine waters. Upstream diversions and extraction of freshwater therefore pose a threat to estuarine ecosystems and optimal oyster production (Healthy Rivers Commission, 1999a; 1999b; 1999c; 1999d; 2000a; 2000b). Cullen (2001) has recently summarised ten steps necessary to return environmental flows to rivers with significant diversions. These include: efficiency dividends (the annual return of 3% of al water used by irrigators); claw back of water in over-allocated rivers (rivers with more than a 1/3 of median flow is extracted); burden of proof (proposals to extract water should bear the burden of proof of the impact on downstream river health); monitoring of river health; protection of undamaged rivers; protecting important wetlands; better technical advice to governments; and integrated management.

Salinity also plays an important role in the distribution of oyster larvae. Larvae tend to concentrate at the top of the halocline and their swimming is more active in more saline waters. It has been found that larvae swim upwards on the flood tide and sink to bottom during the ebb tide in response to both salinity gradients and currents. This permits older larvae to migrate to the headwaters of estuaries at a distance well beyond that of the tidal influence alone (Carriker, 1947). Thus, adequate tidal exchange is important in distributing oyster larvae.

2.3 Suspended Matter

Oysters are filter feeders and consume large quantities of microscopic phytoplankton, detritus and particulate matter. Seston (suspended matter) is one of the least studied environmental variables. Algae are the principal food source and oysters appear to ingest particles preferentially in the range 2 to 30 μm (Newell and Langdon, 1996). The clearance rate of an oyster is the volume of water totally cleared of seston per unit time. Clearance rates, CR, can be described by:

$$CR = aW^{2/3} \quad (2)$$

where a is a constant, and W is the dry tissue weight (Bayne and Newell, 1983). In practice, the weigh exponent in equation (2) is often less than the theoretical value of 2/3. The measurement of clearance rates is an excellent way of studying environmental impacts on oyster health. It has been used only recently to study the impact of environmental conditions on oysters in NSW (Dove *et al.*, 1999)

A sigmoidal relation has been observed between ingestion rate and the concentration of particles indicating that feeding ceases in heavy algal blooms or in turbid waters. Such curves are useful for determining if the carrying capacity of a location has been exceeded. Increased concentration of seston can decrease clearance rates, clog the gill apparatus, lower growth rates and lead to death of oysters. In addition, increased sedimentation may kill oysters by smothering them. In heavily turbid waters (>100 mg/L of silt) the clearance rate of oysters may be reduced by over 50%. Many bivalves have pumping rates that increase and then a plateau after a threshold concentration of total particulate matter has been reached then decrease after a critical concentration has been exceeded. Typically, threshold concentrations occur between 0.03 to 2 mg/L total particulate matter while critical concentrations occur between about 10 and 50 mg/L (Bayne, 1999).

Some studies in eastern USA have shown that oysters suspended in baskets adjacent to dredging activities have no detrimental effect on oyster growth. Indeed, it has suggested that dredging may provide an increased supply of organic detritus. These studies were carried out in generally turbid waters and not under commercial growing conditions. It is clear, however, that even a thin film of silt can reduce markedly oyster settling and it is well known that oyster clearance rates decrease once a critical concentration of total suspended matter has been reached. Pacific oysters appear able to survive and grow in more highly turbid waters than other oysters (Hone, 1996). Oyster eggs and larvae are particularly sensitive to silt. Silt clogs sensitive feeding apparatus in larvae and can lead to infestations of mudworm. In general, oysters feed more efficiently in relatively clear waters (Shumway, 1996).

2.4 Water pH

Oysters will spawn in the pH range 6 to 10. Outside that range, oysters eggs and sperm lose their viability within a few hours. The optimal pH range for oysters appears to be between 6.75 to 8.75 (Shumway, 1996) with growth rates rapidly declining at either side of this range. The pH of estuaries in NSW is of major concern to oyster growers because of the large areas of acid sulfate soils in coastal floodplains in NSW and the drainage of acid waters from them (Sammut *et al.*, 1996; White, 1997; Wilson *et al.*, 1999). A major study of the effects of acidic drainage on the health of oysters has been initiated by ORAC and funded by the FRDC (Dove *et al.*, 1999). It has demonstrated that rock oysters are able to survive for up to 4 weeks in water with pH less than 4. Eventually, holes in the oyster shell occur due to shell dissolution and death

results. A critical issue in drainage from acid sulfate soils is the large volume of iron oxy-hydroxide flocs produced and transported. These smother growing oysters and clog gill structures (Dove *et al.*, 1999).

2.5 Carrying Capacity and Stocking Density

The number of farmed oysters in prime condition that a location can support depends on a range of interacting factors, but food supply and stocking density is a critical issue. Physiological techniques such as the measurement of condition index, ingestion and clearance rates can provide information on whether carrying capacity has been exceeded. In the past, the industry in NSW and the regulating authorities have been reluctant to examine the carrying capacity and stocking density of NSW estuaries. An important issue here is that farmed oysters are but one component of the organisms naturally present in estuaries that are competing for seston.

A number of growers, particularly in southern NSW are concerned about their apparent inability to grow oysters to plate size. This has been attributed to overstocking.

ORAC has recently commissioned a physiological research project on the estimation of carrying capacity. This FRDC-funded project is being carried out by the University of Sydney, using both Sydney rock oysters and Pacific oysters. Three stocking densities have been considered, low, medium and high. The medium density represents 'optimal' stocking densities used by growers in Port Stephens (70% surface area covered). Interim results indicate that stocking density has only a slight effect on oyster growth rates. For both species, total production was lowest at the low stocking density. Highest production for Sydney rock oysters occurred at the medium density. Pacific Oysters, in contrast, had the highest production at the high density. A model for the growth of oysters is being developed in this work.

Historic data on oyster production in NSW and the experience of growers provides evidence that the growing capacity in some areas may have been exceeded. Declines in oyster growth, their failure to "fatten", increased mortality and disease attacks may all be symptomatic of excessive stocking densities. Some farmers, in an effort to control stocking density, have taken up neighbouring leases to prevent encroachment by other farmers. The draft Natural Waters Based Sustainable Aquaculture Strategy (NSWDUAP and NSW Fishers, 2001) has used the historic data for oyster production from 1931 to make first order estimates of the maximum sustainable yield of NSW's 31 production estuaries. This estimates that the NSW's maximum sustainable yield is around 109,000 bags[11] or 130 million oysters, above current production levels.

Despite the gaps in knowledge on the basic physiology and ecology of oysters, the growing conditions necessary for healthy oysters are obvious from the above. Generally, well-oxygenated, clear brackish to saline waters, with pH in the range 6.75 to 8.75, with adequate alkalinity, suitable tidal exchange, adequate phytoplankton supplies and control of upstream sources of runoff and pollution.

2.6 Impact of Oyster Production on Sensitive Lake Ecosystems

In the 1980's, the introduction of non-native Pacific oysters lead to dramatic declines in the production of Sydney rock oysters in Port Stephens. Since then, NSW Fisheries have prohibited their farming into other estuaries. Other than in Port Stephens, growers are legally required to

[11] A bag contains a 100 dozen oysters and is estimated to contain 60 kg.

remove Pacific oysters from their leases. The policy of NSW Fisheries is to only allow the farming of species indigenous to a locality. Species competition due to oyster farming, therefore, will not be a threat to sensitive lake ecosystems. Oysters in NSW estuaries are farmed under extensive aquaculture. That is, oysters are not feed artificially but rely on the natural seston occurring in waterways. It follows that there is no threat to sensitive ecosystems from introduced feeds.

Since farmed and native oysters and shellfish coexist in estuaries, there is competition for food. In locations with adequate tidal exchange and where carrying capacity has not been exceeded this poses no threat to local ecosystems. The draft Aquaculture Industry Development Plan proposes to set estimated sustainable yields for estuaries. This will ensure that carrying capacity is not exceeded by farmers.

A potential threat to local ecosystems may come from the materials on which oysters are grown. In order to protect wood used in farming activities from marine borers and other pests, growers have traditionally used tar coatings. More recently, Arsenic-Copper-Chromium impregnated timbers have been used. While there is no evidence that growing oysters or neighbouring species have been contaminated in anyway due to the use of treated timbers, the industry has voluntarily agreed to a four-year phase-out of tar and treated timber. Work has commenced to assess suitable, alternate materials and practices. Safe, anti-fouling coatings produced by ORAC-initiated, FRDC-funded research at the University of NSW appears to offer promise

2.7 The NSW Shellfish Quality Assurance Programme

Enteric diseases resulting from the consumption of contaminated shellfish can seriously affect local shellfish industry because of decreased sales due to loss of consumer confidence. Lost confidence appears slow to recover and may lead to switch to either non-local or competing products. Because of this shellfish quality assurance programmes have been long been operational in other countries[12]. The main objective of shellfish quality assurance programmes is to ensure that harvested shellfish sold for consumption meet specified quality standards in order to reduce the risk to consumers and to protect the industry from a deterioration in both public confidence and growing conditions in estuaries. Elsewhere these programmes rely fundamentally on cooperation and collaboration between the shellfish industry and the regulating authorities.

The NSW Shellfish Quality Assurance Programme (SQAP) started in September 1996 and became operational in March 1997 with the establishment of the first local committee for Wallis Lake. By December 1997, most of the estuaries producing oysters had formed local committees. The SQAP controls the harvest of oysters from Class A aquaculture leases issued by NSW Fisheries. The SQAP is predominantly funded through levies collected by NSW Fisheries on Class A aquaculture leases.

The aims of the Programme are to:

1. ensure that shellfish are taken from estuaries are to be sold only if;
    - the shellfish meet the standard specified in or under the standard; and
    - those waters meet environmental standards so specified.

[12] The US National Shellfish Sanitation Program was established after the 1923-19925 typhoid epidemics directly linked to the consumption of oysters from contaminated eastern US estuaries.

2. arrange the development of local programmes on each estuary; and
3. ensure that the local programmes meet the objectives specified in 1.

The task of local estuary SQA Committees is to conduct:
Growing area sanitation survey
This survey, carried out with other agencies committees and in collaboration with the coordinator of the SQAP, includes an environmental and shoreline survey to identify and map actual and potential pollution sources that could affect local oyster production within each catchment or estuary. The survey is also designed to identify appropriate sites for monitoring the microbiological quality of water and shellfish.

Water testing includes measurement of salinity, temperature, faecal coliform levels, and a record of weather conditions and local activities. Shellfish testing is also carried out by the local SQAP at harvest with both pre- and post-depuration samples taken for *E. Coli* testing . When an area has been closed for harvesting, shellfish are sampled as part of the process of re-opening the area. If there has been a suspected or actual toxic algal bloom in a harvesting area, the flesh of oysters in the area is tested for marine biotoxins.

The NSW SQAP system is a hybrid of the US and European systems of shellfish quality assurance and differs from the Australian Shellfish Sanitation Control Programme (ASSCP) that was available as model when the NSW system was established. The reasons that ASSCP was not adopted in NSW were largely the small scale of individual operations occurring in many dispersed estuaries with relatively populated and developed catchments, the limited need to establish export markets and the then absence of a dedicated regulator of shellfish sanitation. Currently, there is no classification of growing areas as there is in the US and Australian SQAP. There is some reticence within NSW to its introduction, although the benefits in terms of reduced costs due to minimising depuration, and entry into export markets would appear substantial.

SQA Committees in individual estuaries have collected information on oyster meat and water quality as well as climate data since as early as 1993. At present that data has remained unanalysed. There is an urgent need for that data to be analysed as part of a process of protecting growing conditions.

2.8 The Rodgers' Review of NSW Shellfish Quality Assurance Programme

Rodgers (2001) has recently carried out a comprehensive, operational review of the NSWAQAP. He acknowledges that the programme has only been in operation a brief periods. Throughout his report, he emphasises the point that the condition of growing areas is not the sole responsibility of oyster farmers and that governments have a key role to play in the process. In particular he remarked that… "*the State needs to provide guaranteed water quality standards consistent with high quality shellfish production.*"

His key recommendations for development of the NSWSQAP are:

- increased State level funding for programme expansion (classification and monitoring)[13];
- acceptance of the ASSCP as a basal framework that reflects NSW conditions;
- completion and future update of shoreline surveys, sanitation surveys and classification of commercial shellfish growing areas;

[13] The NSW Government has broadly endorsed the Rodgers' Report and has allocated increased funding to NSW Safefoods to implement the important recommendations including growing area classification.

- use of shellfish meat testing in conjunction with sanitary surveys to determine the classification status of shellfish harvesting areas;
- depuration to be used in areas where it is shown by classification to be appropriate and to be linked to appropriate management strategies;
- implementation of a routine marine biotoxin monitoring programme; and
- improved controls on effluent discharge for boats and a continuation of pollution prevention programmes related to point discharges such as septic tanks.

Under water quality Rodgers (2001) recommended:

- pollution prevention programmes, such as those already applied to the diary industry and septic tanks, should be continued; and
- the polluter pays principle for EPA licences should be maintained as a means of reducing the financial burden on the shellfish industry.

The recommendations under risk management procedures were:

- the associated understanding of waste water treatment processes in relation to the pollution of coastal waters should be used in combination with risk analysis to determine additional potential risk reduction measures targeted towards consumer safety and shellfish consumption; and
- joint cooperative, risk analysis studies should be undertaken at the national/ or international level to address both the common hygiene problems and any more specific local NSW issues.

Finally, amongst the recommendations on future needs were:

- improved methodology for identifying sources of contamination;
- development of better indicator systems in general;
- better support for research on technologies to reduce biotoxin, bacteria and virus loadings in live shellfish; and
- close collaboration should be maintained between the regulatory authorities and the shellfish industry.

Rodgers (2001) has pointed out that there is concern within the industry internationally, that future changes in the standards and criteria for food safety related to shellfish food safety may not reflect the true level of associated risk. Detection levels are becoming more precise in terms of sensitivity and regulatory thresholds could be reduced accordingly. This could occur without any justification based on improved food safety, but could merely reflect improved analytical sensitivity.

Data collected by the NSWSQAP on shellfish meat and its relation to water quality testing and catchment conditions has yet to be comprehensively analysed.

The Draft Natural Waters Based Sustainable Aquaculture Strategy (NSW DUAP and NSW Fisheries, 2001) is, in part, a response to the Rodgers' report. The classification scheme for coastal lakes proposed by the Healthy Rivers Commission (2000b) and the sustainability assessment at the lake specific level have elements in common with Rodgers' recommendation of a growing area classification scheme and with the classification scheme proposed in the Draft Sustainable Aquaculture Strategy. Their advantage is that classification is also directly linked to management strategies for those areas.

Finally, it is noted that growing area classification may involve some hard decisions such as the prohibition of shellfish harvesting from selected areas. In the past, agencies have shown great

reluctance to make such decisions. The reliance on statewide depuration was partly the result of avoiding hard decisions.

2.9 Assessment of Environmental Factors and the Classification of Estuaries

The necessary environmental factors required to assess the suitability of an oyster growing area are essentially covered by systems that classify the suitability of growing areas producing oysters for human consumption. The US has perhaps the longest experience in this. Major outbreaks of enteric diseases occurred in the late 1800s and early 1900s from eating oysters from highly polluted estuaries in the eastern US. Typhoid epidemics in 1923-24 were directly linked to the consumption of contaminated oysters. As a result the US set up the eventually named US National Shellfish Sanitation Program, US NSSP (Rodgers, 2001).

The concept of the classification of growing areas is based on a comprehensive and ongoing sanitary survey of growing areas. Classification depends on a number of critical factors including actual and potential contamination sources and their quantification, meteorological, seasonal and hydrodynamic factors in the area and periodic monitoring of the microbiology and hydrochemistry of the area. In the US NSSP, testing of shellfish for bacterial contamination, biotoxins or hazardous chemicals is only considered following emergency closure of an area or post depuration.

The USNSSP has 6 classification (the ASSCP prefers only 4). The four main criteria (Rodgers, 2001) are:

Approved Areas
Approved areas are areas where the levels of all contaminants and their sources are consistently below the threshold of unacceptable risk to consumers of raw shellfish. Approved areas are closed to harvest only in the event of atypical risks, such as sewerage pipe ruptures or unusual rainfall events. Approved areas are classified as remote areas when there is no human habitation within the catchment, nor any actual or potential sources of pollution.

Restricted Areas
Restricted areas have a limited degree of pollution and shellfish can be harvested from the area provided suitable post-harvest processing such as cooking, relaying to approved areas or depuration is used.

Prohibited Areas
Prohibited areas are areas were there is no current sanitary survey or where monitoring shows that faecal material, pathogenic micro-organisms, poisonous or harmful substances, biotoxins or radionuclides may reach the area in excessive concentrations. Shellfish cannot be taken from these areas for human consumption but can be taken as seed for aquaculture.

Closed Areas
Closed areas are those where the harvesting of shellfish is temporarily or permanently not allowed and can apply to any area except those prohibited.

The US NSSP Manual contains guidelines for patrolling harvesting areas and educational programs and sanctions. It should be pointed out that the US system has evolved in highly developed coastal catchments. The Chesapeake Bay fishery has the largest coastal catchment in the US with 15 million people living within its catchment.

Clearly areas which are prohibited due to the threat of pollution or which are closed due to pollution for a major portion of the time are unsuitable for commercial shellfish production. It would appear that none of the oyster growing estuaries in NSW falls within either of these categories. After 130 years, oyster farmers I NSW are adept at selecting appropriate sites (although there is a clear need to develop a review/response mechanism in areas of increasing urbanisation). There may be some problem areas in coastal lakes where the entrance to the sea is closed for extended periods, such as Tuross Lake. Farmers, however, tend to relay oysters from such situations.

2.10 Advice and Recommendations

Identify the environmental factors that should be assessed to determine whether oyster cultivation is a realistic outcome for an estuary.

The growing conditions necessary for healthy oysters are generally well-oxygenated, clear brackish to saline waters, with pH in the range 6.75 to 8.75, with adequate alkalinity, suitable tidal exchange (tidal amplitude >300 mm; tidal flushing time <15 days), adequate phytoplankton supplies and control of upstream sources of runoff and pollution.

Classification of oyster growing areas by the NSW Shellfish Quality Assurance Programme, SQAP and Aquaculture Industry Development Plan, AIDP, recommended by the Rodgers' Report and endorsed by the NSW government, will result in the identification of areas from which it is appropriate to produce and sell oysters for human consumption. Classification of growing areas is based on a comprehensive and ongoing sanitary survey of growing areas. Classification of an area depends on

- actual and potential contamination sources and their quantification,
- meteorological, seasonal and hydrodynamic factors, and
- periodic monitoring of the microbiology (indicators of human pathogens) and hydrochemistry.

Oyster cultivation for direct human consumption is not a realistic outcome in areas permanently or predominantly classified as *closed* or *prohibited.*

✸ It is recommended that the Healthy Rivers Commission's proposed *Lake* and *Site Speciific Sustainability Assessments* be carried out in conjunction with the SQAP and AIDP classification of growing areas.

SQA Committees in individual estuaries have collected information on oyster meat and water quality as well as climate data since as early as 1993. At present that data has remained unanalysed. There is an urgent need for that data to be analysed as part of a process of protecting growing conditions.

✸ It is recommended that the analysis of data collected by local Shellfish Quality Assurance Committees be encouraged.

3 THREATS TO GROWING HEALTHY OYSTERS

There are a number of threats to growing healthy oysters in NSW. Some are entirely natural but major threats are from anthropomorphic factors.

3.1 Population Growth in Coastal Regions

From 1971 to 1991, the population of the non-metropolitan, Australian coastal zone grew by 95%, from 2.1 to 4.1 million people, compared with a 32% growth for all of Australia. There is increasing development in about 25 to 30 % of the coastal zone. Most of this concentrated in the southeastern section of the Australia (State of the Environment, Australia, 1996). This clumping of population around estuaries and the sea, on one hand, reflects the great value we place on our clear blue waters, our long stretches of almost pristine sandy beaches, our stoic coastal vegetation and superb seafood (Commonwealth Resource Assessment Commission, 1993). On the other hand, it threatens to destroy those very things we value (State of the Environment, Australia, 1996).

There are already clear indications in an increasing number of areas in Australia, that coastal developments are changing the coastal, estuarine and marine ecology. The dramatic decline in Australia's sea grass beds, up to 85% in some areas, due to increased post-European-settlement nutrient outputs and sediment loads, is but one indicator of land-based impacts (State of the Environment, Australia, 1996). Given their fundamental importance in the marine food chain, disappearing seagrasses and their slow rate of recovery are major concerns.

Population growth in the eastern Australian coastal zone, partly through natural growth but particularly through internal migration, will continue disproportionately to the rest of the country, over the next 50 years (Commonwealth Resource Assessment Commission, 1993). This is especially so for northern New South Wales (NSW) and the coastline from Newcastle to Nowra. The latitudinal temperature gradient along the NSW coast means that northern regions are attractive to human settlement and migration. From 1986 to 1993, 5% of Australia's total population growth occurred in northern NSW compared with 1.9% in the south coast (State of the Environment, Australia, 1996). A major portion of this growth was through internal migration to warmer coastal zones. Regions with more rapid oyster growth rates, such as the Tweed River, Wallis Lake and Port Stephens, are also those that are more subject to risks from urban developments. Expanding coastal development, in regions with generally excess rainfall and short resident times for water-transported materials, is a major, potential threat to the health of coastal streams and the viability of their fisheries and aquaculture industries, especially the oyster industry.

A key issue in coastal development is the very large, but short-term gains that can be made from property development. The future value of foregone long-term production, be it on agricultural land or in fisheries that may result from development is often discounted to zero. In addition, the true costs of intensive coastal development, particularly in terms of environmental costs are mostly underestimated and transferred to the public (Health Rivers Commission, 2000a). To coastal councils, the increase in rate base due to property development is an attractive option. State Environment Protection Plans (SEPP), such as the wetlands SEPP 14, although extremely unpopular with landowners, have been an effective way on controlling developments in ecologically sensitive areas.

Land reclamation, engineering works, over-fishing, boating, pollution, particularly from diffuse sources, weed infestation and the clearance of catchments all represent major threats to the

health of estuaries. Approximately 37% of coastal catchments in NSW have had more than half their land cleared. (State of the Environment, Australia, 1996). Additionally, broadacre expansions in the coastal zone formerly have often been at the expense of wetlands and swamps that play a key role in both 'polishing' output water quality and supplying important foods to aquatic flora and fauna. Pollution of estuaries occurs from point discharges, such as broken or leaking sewer mains, urban stormwater outlets, and agricultural drains in acid sulfate soils, and through diffuse sources of excess nutrients and pollutants, such as agricultural runoff. Significant problems occur after runoff producing rains. Both urban and agricultural developments in coastal catchments have dramatically altered the character and quality of storm runoff and its subsequent impact on estuarine ecosystems.

3.2 Oyster Diseases

3.21 QX Disease

Outbreaks of oyster diseases are also governed by environmental conditions, particularly temperature. Prior to 1994, QX disease (paramyxean parasite *Marteilla sydneyi*), the most pathogenic disease of commercial rock oysters, was limited to the warmer estuaries of southern Queensland south to the Macleay. However, QX disease was discovered in the Georges River in 1994, 400 km south of its previous known range, with infections occurring during the warmer months January to March/April. This period also corresponded with periods of infection in southern Queensland (Adlard and Ernst, 1995). Deaths of infected oysters occur from June onwards.

In early studies it was suggested that more saline sites closer to the mouth of the Georges River estuary were free from QX disease, when fresher, further upstream sites were infected. (Adlard, 1996). This led to the suggestion that salinity and the character of the bottom sediments were important in the propagation of the disease. The life cycle of QX disease and the way it infects oysters is currently unknown, despite the fact that it has now forced the closure of the once-thriving Georges River oyster fishery.

An ORAC and Fisheries Research and Development Corporation (FRDC) sponsored research project on a survey of the distribution of QX disease in NSW in 2001 has been initiated recently. In addition, an FRDC and Fisheries Resource Research Fund project has been initiated by the Queensland Museum and NSW Fisheries to develop a zoning policy for QX disease. This project is aimed at reducing the risk of introducing QX disease into disease-free areas and to assist in international export of Sydney rock oysters. Research is also underway at Macquarie University on the effects of QX disease on the defensive response of Sydney rock oysters.

Pacific oysters are resistant to QX disease. NSW Fisheries have been carrying out trials to determine if a strain of QX-resistance oysters can be selected. If successful, a successful hatchery will need to be established to propagate resistant stock. NSW Fisheries have experienced difficulties in establishing a hatchery for Sydney rock oysters, and an ORAC-initiated FRDC-sponsored review on hatchery technology is about to commence. One strategy adopted by growers is to relay half-grown oysters from southern non-infected estuaries to northern infected estuaries to be grown and sold before autumn.

3.22 Winter Mortality

Another protistan parasite disease of rock oysters, winter mortality (*Mikrocytos roughleyi*) is also temperature-dependent and infects oysters between July and September in the cooler estuaries from Port Stephens and south. Although infected in winter, mortalities occur in the in September and October. Evidence suggests that winter mortality appears highest in more saline

waters close to estuary mouths and is less prevalent in fresher areas (Adlard, 1996). Oyster growers in the Hawkesbury River and elsewhere use this to their advantage by relaying oysters to fresher, upstream locations during periods of potential infection. Experience suggests that the probability of a severe kill due to winter mortality is higher after dry autumns and early winters. Mortality is usual extremely variable, both between estuaries and within estuaries. Besides relaying to fresher areas, growers have found that raising the growing position by 150 mm also helps avoid the disease. Farmers try to sell their oysters before winter in infected estuaries. NSW Fisheries has been carrying out selection trials to find faster-growing, disease-resistant oysters.

3.23 Mudword

Mudworm, a spinoid polychaete worm, has been the longest known pest infection of oysters in NSW. Mudworm lives on the inside of the oyster shell and maintains a tube across the lip of the shell. While healthy oysters can cope with mud worm attacks, weak oysters, attacked by many mudworms, may die. Mud worm infestations can cause serious damage in oysters where there has been silt build up. Management strategies include leaving the oysters out of water for 10 days to kill mudworms and washing mud from oysters using boom sprays.

3.24 Bonamia

Bonamia is a parasite disease in Flat oysters[14]. While devastating outbreaks have occurred in South Australia and Tasmania, there have been no recorded outbreaks in NSW.

It seems clear that many of the major vectors for oyster diseases are present naturally in the environment. Healthy oysters can usually ward off infection. Stressed oysters, however, are much more susceptible to disease attacks. Stress in oysters can be induced through the mechanical disturbances of farming practices, by predation, by stocking regimes and by environmental factors that are less than optimal. For example, it has been suggested that some outbreaks of QX disease in NSW may be attributable to exposure to acid drainage from acid sulfate soils (Dove *et al.*, 1999). It is clear, however, that not all QX disease outbreaks are caused by exposure to acid. Knowledge on the relation between diseases and environmental factors is still evolving. It is clear however, that any actions that can be done to reduce stress in oysters will lessen the risk of disease infections.

3.3 Hydrological Setting of Farming Areas

Rainfall excess is a key factor in determining the risk of transport of suspended materials and dissolved pollutants into oyster growing areas. In addition, large rainfall events exposure oysters to periods of fresh water, forcing closure of harvesting and causing loss of condition of oysters.

The NSW Coast generally lies in the moist temperate climatic zone, although the north is subtropical, with hot to warm summers and moderate climatic variability. In the northern part of the state, spring-summer rainfall dominates. Annual mean coastal catchment rainfall varies by a factor of over 2, from about 1700 mm in the sub-tropical north to approximately 800 mm in the south. Mean annual potential evaporation is determined chiefly by solar radiation, which in turn is governed mainly by latitude. Because of that, mean annual evaporation varies less strongly that rainfall and so runoff per unit catchment area is higher in the north of the state than in the south. Annual mean runoff per unit catchment area in the northern part of the state is about twice that in the south. However, large catchments such as that of the Clarence and Hunter have

[14] It has been recently suggested that *Bonamia* and winter mortality are related diseases.

lower runoff per unit catchment area than smaller, neighbouring catchments due to the variability of rainfall over large areas. The general risks for oyster growing due to runoff generation are therefore greater for smaller northern catchments than for catchments below the Hunter.

The annual catchment average runoff coefficient (ratio annual runoff per unit catchment area to mean annual precipitation) for NSW Catchments is shown in Fig 1. The average coefficient of approximately 29% for NSW coastal catchments is much more than the mean annual runoff coefficient for Australia as a whole of only about 8% (Smith, 1998). The catchment average runoff coefficients in Fig. 1 indicate where landuse changes may have, potentially, most impact. Smaller catchments such as the Brunswick, Bellinger, Bega, Hastings and Tweed have relatively high runoff coefficients and we expect that landuse changes in those catchments will have proportionally more impact on estuarine water quality and ecology than in streams with lower runoff coefficients. Urbanisation can have major impacts on runoff coefficients. In some parts of urban catchments runoff coefficients, can be as high as 0.95. If these areas are close to oyster growing areas then their impacts can be immediate.

Mean annual figures of runoff, however, only indicate the overall probability of excess water and threats to mean production. It is individual events that determine impacts on oyster health. As a consequence of their high rainfall variability, Australia and South Africa share the highest variability of annual streamflow (McMahon *et al.*, 1992). extreme rainfall events, as well as length of dry season, critically determine exports of water and pollutants into coastal streams. Fig. 2 shows an analysis of 2 year-averaged extreme wet and dry periods on the Macleay River droughts over the last 120 years. Simple rainfall ranking of accumulated rainfall periods provides an excellent method of examining the risk of extreme events (White *et al.*, 1999a).

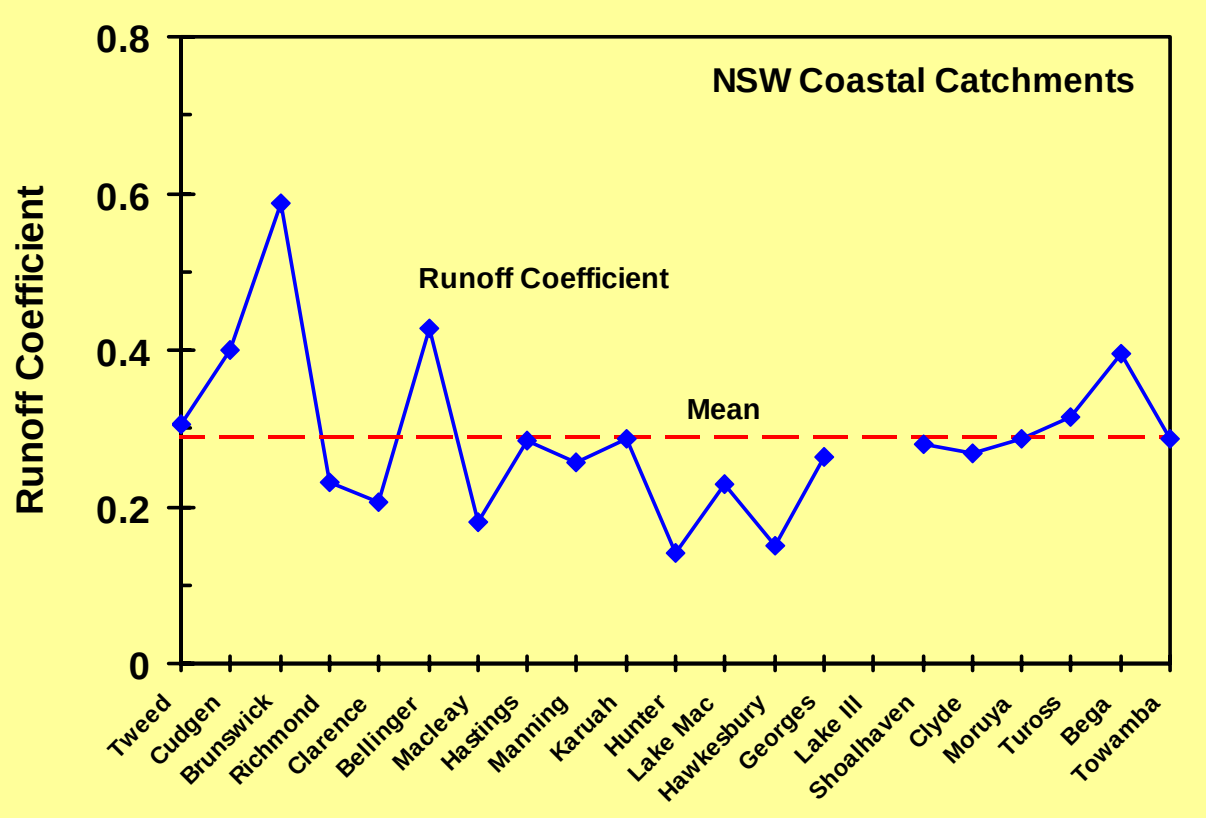

Figure 1. Runoff coefficients for NSW coastal catchments.

Extreme rainfall events in Fig. 2 are defined as events which fall below 10% (10% lowest rainfalls) or lie above 90% (the highest 10% of rainfall) for a period. Such analyses can clearly identify the risk to growers of prolonged wet or dry periods in an estuary. The overall correlation of these extremes with the Southern Oscillation Index (SOI) in coastal NSW is poor, and the SOI cannot be used as a predictor of oyster production. Fig. 2 shows an extended dry period from 1900 to 1923 and an extended wet period from 1950 to 1967. The extreme variability of rainfall in coastal NSW is evident.

The predicted impact of Climate Change on flooding and streamflow in coastal floodplains is widely and hotly debated. In Australia, these predictions are starting to converge, with quite different impacts expected across the country. Sea levels are now predicted to rise by about 0.25 m in the next 50 years and in the east, the climate may be drier but with more intense rains. The implications for coastal floodplains, ecosystems and their management and oyster production remain to be elucidated but increased coastal flooding would appear to be a major issue (Smith, 1998) and has implications for the production of healthy oysters.

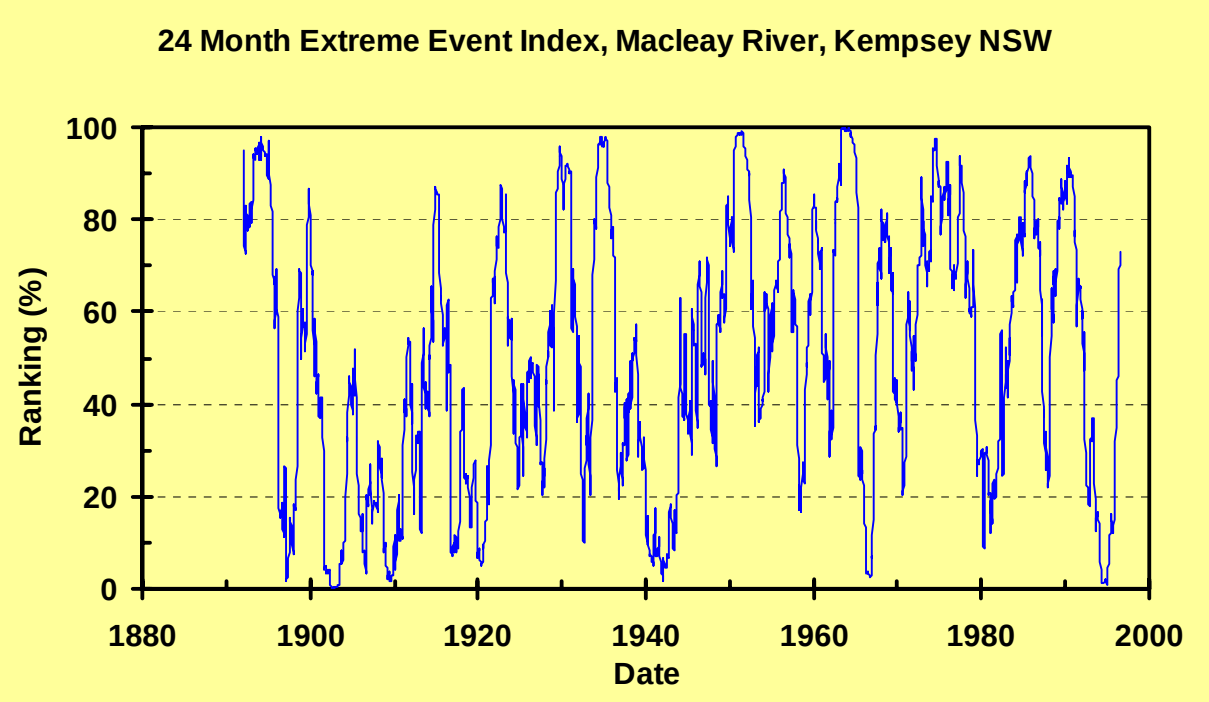

Figure 2. Analysis of extreme rainfall and drought events in the Macleay River Catchment.

While excess freshwater in floods creates less than optimal conditions for oyster growth, the demands for fresh water upstream of estuaries also presents a threat by increasing the salinity of estuaries above optimal conditions (Healthy Rivers Commission, 1999a; 1999b; 1999c; 2000a). Water extractions have been a particular problem in the Hawkesbury River (Healthy Rivers Commission, 1999a). The issue of balancing upstream demands for freshwater against the provision of adequate environmental flows for estuarine ecosystems is complex (Healthy Rivers Commission, 2000a). Most diversions and extractions have decreased the frequency of low to medium flows. The maintenance of these flows is essential for oyster production. Proposed flow objectives for NSW Rivers recognise the importance of maintaining these flow regimes in a close to natural state (EPA, 1997). As part of the Water Reforms in NSW, Catchment Management Boards and Water Management Committees are currently examining the setting of flow objectives in coastal rivers.

3.4 Geomorphic Setting

Before European settlement, coastal floods resulted in many natural backswamp areas remaining inundated for sometimes half the year. The government-encouraged development of coastal floodplains for agriculture resulted in the major re-engineering of backswamps and coastal streams through flood mitigation and drainage works. Crops, generally, require floodwaters to be removed within five days so that drained floodplains have quite different hydrological characteristics to natural floodplains.

3.41 Floodplains

Floodplain re-engineering has occurred at two scales. Flood mitigation works have been carried out at the floodplain scale and have been designed to divert upland flows rapidly through the floodplain. Critical factors here are the ratio of the floodplain area to the upland area, distribution of rainfall and runoff across the catchment, and the volume of storage in the floodplain. Coastal catchments with smaller floodplain to upland ratios require higher drainage densities to cope with upland flows. Fig. 3 shows these ratios for New South Wales. The geomorphic difference in the ratio of floodplain to catchment area between northern and southern NSW is apparent. Rivers such as the Clarence, Hunter, Hawkesbury and Manning have substantial upstream areas that contribute both water and exported materials to the lower floodplains and estuaries.

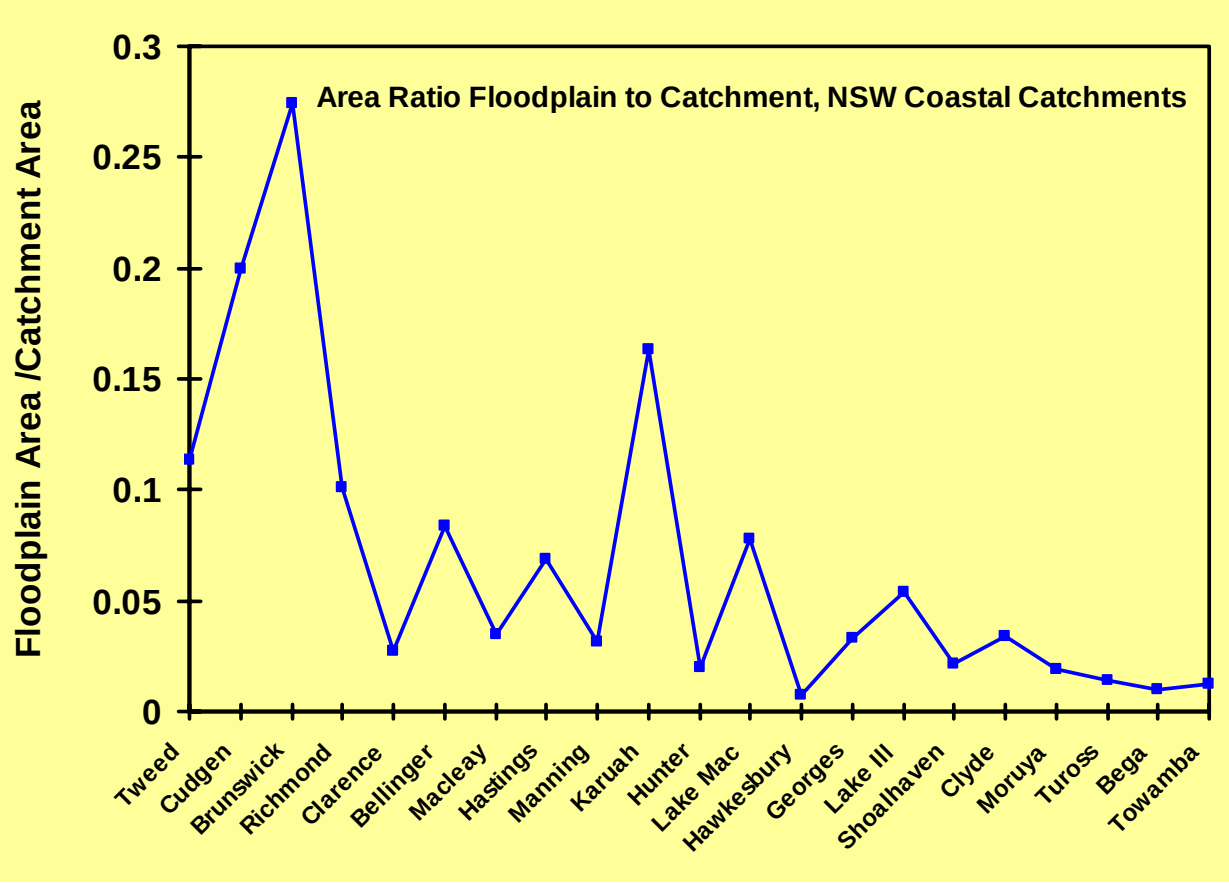

Figure 3. Ratio of floodplain area to total catchment area for NSW coastal catchments.

Previous flood mitigation works and indeed most estuarine engineering works have overlooked the ecological consequences of drainage, installation of floodgates and levee construction. In NSW, the focus of engineering works has broadening with State Government projects such as DLWC's "Returning the Tide". At the more local scale, coastal floodplains in New South Wales have been drained by smaller, drainage union drains. Drainage unions, were set up under the Drainage Act of 1903 to empower local groups of farmers to drain floodplains cooperatively.

Coastal floodplains are especially sensitive to landuse change. They generally have higher runoff coefficients, have shallower watertables and the residence time for dissolved and suspended materials there is usually very short, of the order of days to weeks. The catchments in Fig. 3 with large relative areas are those of the Tweed, Cudgen, Brunswick, Bellingen, Hastings, Karuah, Lake Macquarie and Lake Illawarra. Floodplain developments in these catchments, particularly those that involve broad scale drainage of sewerage effluent disposal, can be expected to have significant down-stream ecological impacts.

The Gosford City Council has sponsored research by the University of Newcastle to investigate the effect of catchment disturbance on the quality and quantity of seston in estuaries and the implications for feeding growth and survival of Sydney rock oysters. Preliminary results in Lake Macquarie and Brisbane Waters show that quality and quantity of seston, unsurprisingly, are affected by catchment disturbance. Quantity of total particulate matter in disturbed catchments tended to increase while its food quality decreased during rainfall.

3.42 Acid Sulfate Soils

Associated with the low-lying floodplains are natural deposits of iron sulfide-containing soils and sediments, the so-called acid sulfate soils. In Australia, recognition of their importance has lagged behind the rest of the world. The first Australian maps, showing their widespread distribution, were only published in 1995 (Naylor *et al.*, 1995) together with guidelines for their management and use (Blunden and Naylor, 1995). Acid sulfate soil maps in NSW are risk maps showing the probability of occurrence of acid sulfate soils. The highest risk category is where the iron sulfide layer is within 0.5 m of the soil surface (Naylor *at al.*, 1995). Fig. 4 shows the areas of high-risk acid sulfate soils in coastal NSW.

Acid sulfate soil risk maps have recently been incorporated into Local Environment Plan (LEP) maps. The intention is that all coastal councils will develop LEPs for acid sulfate soils in their region so that works on mapped areas likely to cause discharge of acid will require a development approval (DA). In northern NSW, sugarcane growers have won exemption from the DA process for normal farm operations by developing and adopting a Cane Industry Code of Best Practice with clearly identified performance indicators against which they can be audited. Failure to abide by the code could result in a grower's cane being refused by the mill.

The area of acid sulfate soils in Fig.4 is much larger in the northern part of NSW than in the south, again reflecting the change in river morphology between coastal embayments in the north and flooded river valleys in the south. The largest concentration of high-risk soils occurs on the Clarence River. Research on the Tweed (Wilson *et al.*, 1999) and Richmond Rivers (Sammut *et al.*, 1996) has found acid production rates of order 0.1 to 0.5 tonnes sulfuric acid/ hectare/ year together with similar amounts of dissolved iron and aluminium. Some coastal floodplains are capable of discharging 1,000 tonnes of sulfuric acid and 500 tonnes of dissolved monomeric aluminium following a single storm event. Once oxidised, floodplains can continue to discharge acid water for centuries (White *et al.*, 1997). Tidal floodgates on drainage channels

promote the formation of acid reservoirs that chronically leak acidic waters into the downstream environment for months (Sammut *et al.*, 1996).

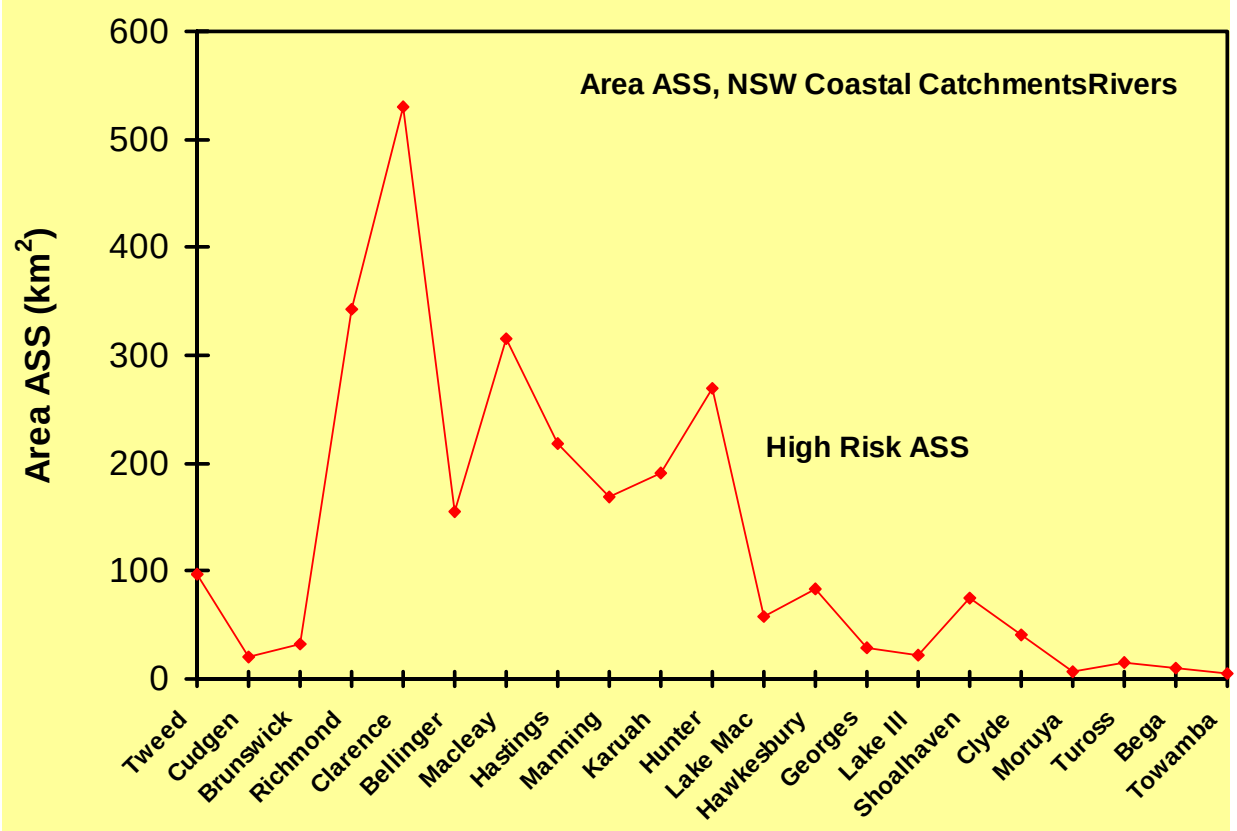

Fig. 4. Areas of high-risk acid sulfate soils in NSW coastal catchments.

Oyster embryos are dramatically effected by acid sulfate soil drainage (Wilson and Hyne, 1997). Oyster growing areas that have been directly impacted by acid discharges from acid sulfate lowlands include the Richmond, Macleay, Hastings, and the Manning. Concerns have been expressed also by growers in the Tweed and Shoalhaven.

3.43 The Role of ASSMAC

Because of conflicts between fishers and farmers, the NSW Minister for Agriculture and Fisheries established the Acid Sulfate Soils Management Advisory Committee (ASSMAC) in 1994 to provide government with advice on the management of acid sulfate soils. Because acid sulfate soils cut across the jurisdiction of many government departments, ASSMAC has attempted to supply a whole of government approach to the problem. Over the last few years membership of ASSMAC has been expanded to include industries using or impacted by acid sulfate soils, including the oyster industry.

ASSMAC has provided information, a discussion forum, training, guidelines and maps on acid sulfate soils. ASSMAC has used an approach based on awareness, education, research, and legislation (as a last resort). Until recently, however, this effort was under-resourced. In 1997 the NSW Government set up the ASSPRO funding program, with $ 2.1 M over 3 years, to provide resources for education and training, research and remediation projects. This funding has been renewed and in 2001 the NSW Government has provided $3.5 M to address 7 acid sulfate soil “hot spots”.

Despite this progress, ASSMAC has been criticised by landholders, fishers and aquaculturists as being too bureaucratic, too timid, too slow to act and ineffective. The impatience of sectors that are being adversely by acid runoff is understandable. However, the task being undertaken by ASSMAC is complex. In the 7 years ASSMAC has been established, an array of information materials have been produced and projects have been completed. ASSMAC's tasks are politically, economically and institutionally complex, reflecting the complexity of natural resource management in general, acid sulfate soils in particular, institutional arrangements and conflicting stakeholder demands. ASSMAC's output has been quickly transferred to industries and other states. Indeed, the NSW Cane Industry has developed a code of best practice for acid sulfate soils, the first industry in the world to do so. This code of practice forms part of the Self-Regulation of the industry under the Tweed LEP. The National Working Party on Acid Sulfate Soils produced the National Strategy for the Management of Acid Sulfate Soils that has been endorsed by all governments largely as a result of initiation from ASSMAC.

ASSMAC has encouraged the adoption by coastal councils of Local Environment Plans, LEPs, specifically for acid sulfate soils. Hastings Shire Council was the first to approve such a strategy followed by Tweed Shire Council. Compliance with these LEPs is a significant issue. Overarching regulation, such as a State Environment Protection Plan, SEPP, has been deferred by ASSMAC in favour of LEPs. The involvement of landholders in addressing acid sulfate soil problems is fundamental to treating acid discharges. SEPPs are mistrusted by landholders and consequently are seen by governments as almost an instrument of last resort. LEPs have to be approved by the Department of Urban Affairs and Planning and this process imposes uniformity of local government-developed LEPs. If local governments fail to develop LEPs, ASSMAC could review the need for a SEPP.

Successful prosecution under the Clean Waters Act of any recent, deliberate discharge of acidity from acid sulfate soil areas through drainage would send a strong signal to the community. The NSW EPA has settled the first successful case on discharge from drains in acid sulfate soils. Previously, the EPA had regarded acid discharge from drains in acid sulfate soil areas as diffuse, rather than point discharge and therefore outside the ambit of the Clean Waters Act.

Prosecution is seen as a last resort. Tweed Shire Council, in northern NSW, has led the way in facilitating cooperative approaches to estuarine management. It brought together landholder, fisher, aquaculture and other representatives to agree on common goals and has provided them with expert advice. As a result, canefarmers have been using their own resources in attempts to improve water quality by re-engineering the floodplain using laser levelling to remove low spots which pond water and improve surface shedding of water. In this technique, fewer drains are needed resulting in lower acid discharges. This has resulted in a win-win situation as cane production has been improved by 10 to 30%. In addition, farmers are applying lime to further decrease acid production and have also opened floodgates in order to increase fish passage and tidal neutralisation of acid water. This cooperative model involving consensus between landholders, fishers and aquaculturalists, with the facilitation of local and state governments, funding from state and federal resources and collaboration with researchers may be appropriate model for the management of all our estuaries.

At the Commonwealth level, Environment Australia (Commonwealth Government) has established the Coastal Acid Sulfate Soils Program (CASSP) and has funded pilot projects to demonstrate remediation techniques throughout Queensland, South Australia and NSW. Harries (1997) has estimated that the cost of remediating already acidified mine dumps in Australia

could be as high as $ 110,000/ ha. If this applies to already acidified coastal floodplains, then the cost of remediation could be hundreds of millions. Economically, there are no quick fixes for already acidified floodplains. In China, rice paddies still produce acid outflows from acid sulfate soils at least two hundred years after they were first developed (White *et al.*, 1999b).

3.44 Structure of Estuaries and Tidal Exchange

Geomorphic and geologic factors control the size, tidal exchange, flushing, and trapping abilities of estuaries in eastern Australia (Roy, 1984). The conditions for optimal oyster growth require adequate tidal exchange to provide food supplies remove wastes and dilute any potential pollutants. Tidal exchange is a complex interaction of the general structure of the estuary, the conditions at the mouth of the estuary and the shape of local waterways. Modelling tidal exchange is a site-specific, costly and time-consuming exercise. Oyster farmers have integrated their experiences to identify productive sites.

Roy (1984; 1994) and Roy and Boyd (1996) classified the estuary types in eastern Australia as:

1. Bays-(ocean embayments such as Botany Bay)
2. Tide-dominated estuaries (drowned river valleys such as the Hawkesbury River)
3. Wave-dominated estuaries (barrier estuaries such as Lake Macquarie; barrier lagoons such as the Broadwater; interbarrier estuaries such as Port Stephens)
4. Intermittent estuaries (saline coastal lagoons such as Smiths Lake; small coastal creeks such as Harboard Lagoon)
5. Fresh water bodies (brackish barrier lakes such as Myall Lakes; backswamps such as Everlasting Swamp on the Clarence River)

It is important to recognise that the coastal waterbodies of NSW are part of an evolutionary sequence. The now productive floodplains of the Tweed River were once part of a shallow barrier lake. Oysters are grown in the first 4 types of estuaries in NSW. The Draft Natural Waters Based Sustainable Aquaculture Strategy (NSW DUAP and NSW Fisheries, 2001) has examined the tidal conditions necessary for aquaculture site selection. While it recommends local studies be conducted on tidal exchange and circulation, it suggests that sites should be chosen where the tidal amplitude is greater than 300 mm and where the tidal flushing time is less than 15 days. On this basis, intermittent estuaries, where the mouth is frequently blocked for prolonged periods would not appear to be preferred sites for aquaculture.

Lakes with poor drainage can periodically experience prolonged periods of low tides often caused by ocean currents and wind direction. Where oysters are grown on sticks in racks, oysters can be exposed to the atmosphere and extreme temperatures for long times, leading to oyster deaths. In 1968/69, such conditions continued for 3 weeks in Wallis Lake leading to severe losses.

3.45 Bottom Sediments

The type and distribution of bottom sediments in estuaries depends on the interaction of freshwater fluvial transported sediments and marine transported materials. Sediments play a key role in determining the quality of water in estuaries, particularly coastal lakes and represent a massive storage. The interaction between bottom sediments and oyster health and between oyster farming and bottom sediments is largely unknown in NSW. As a result of filter feeding, oysters produce faeces and pseudofaeces that are ejected by the oysters. These fall to the sediments beneath growing areas. The impact of the cultivation of oysters on the quality of sediments, and the feedback of this quality on oyster growth and health is yet to be explored in NSW.

It has been speculated that part of the change in disease incidence in moving upstream may be due to the variation in particle size of bottom sediments from clean quartz sands to organic rich muds. Fine bottom sediments are capable of storing large amounts of nutrients and other pollutants that may be released under certain dissolved oxygen and temperature regimes. These sediments play an important role in the denitrification of shallow coastal water bodies and in the hysteretic properties of estuarine water bodies. Adverse changes may not readily or easily be reversed (Harris, 1999).

3.5 Water Pollution

The filter feeding of oysters leads to the bioaccumulation of dissolved or finely suspended heavy metals, microalgae biotoxins, bacteria, and viruses.

3.51 Heavy Metals

The marine waters of Australia's eastern coast have exceptional low background concentrations of heavy metals (G. Batley, pers. com., February, 2001). Accumulated heavy metals in seafood have, in general decreased in Australia due to the reduction in point industrial discharges (State of the Environment Australia, 1996). One of the principle concerns of growers was tributyl tin, (TBT) used as an antifouling paint on boats. TBT was found to effect the growth of oysters. In 1988, the use of TBT on non-aluminium boats less than 25 m was discontinued. Before 1988, levels of TBT in waters close to marinas and dockyards were up to 50 times higher than the guideline. Levels have now dropped below the guideline in places such as the Georges River (Batley, 1995).

Acid drainage from acid sulfate soils can contain dissolved heavy metals, leached from minerals in the soil. Currently there is no evidence of bioaccumulation of heavy metals in oysters grown in waters subject to acid outflows.

3.52 Biotoxins

Microalgae such as dinoflagellates and diatoms, major food sources for oysters, under certain conditions produce biotoxins that are accumulated in the oyster. Biotoxins such as Paralytic Shellfish Poisoning are of particularly concern. To date there is no record on any biotoxin poisoning through eating oysters in NSW.

Algal blooms of dinoflagellates, the red tides, are a particular risk. Although nutrients are linked to these algal blooms, the exact processes involved have yet to be discovered. It has been suggested that dissolved iron plays a role in initiating massive blooms of *Lyngbya majuscula* in Moreton Bay (T.D. Waite, pers. com., May, 2001). Drainage from acid sulfate soils is a major source of dissolved iron in estuaries.

Testing for biotoxins is currently not routinely undertaken in NSW estuaries subject to algal blooms. The proposition that the oyster industry should fund such testing of public waterways, under the NSW Shellfish Quality Assurance program, is unfair (Rodgers, 2001).

3.53 Organic Contaminants

There have been no reports of problems with the contamination of oysters in NSW from herbicides, pesticides or organic contaminants.

3.54 Sewerage

The principal concern in the contamination of oysters comes from the ingestion by oysters of sewerage effluent and the retention of bacteria and viruses. Extensive testing of both waters and oyster flesh for *E. Coli*, an indicator of faecal contamination, is routinely carried by oyster growers, as part of the NSW Shellfish Quality Assurance Program. This program has recently been thoroughly reviewed (Rodgers, 2001). In addition to this routine testing, preliminary sanitary surveys of growing areas have been undertaken by growers to determine the risks of contamination. It seems remarkable it has been expected that growers should undertake such surveys. Rodgers (2001) emphasises where the responsibility lies by placing a quote from the 1925 Conference of the US Surgeon General:

> *" The beds on which shellfish are grown must be determined, inspected, and controlled by some official, State agency…"*

The Draft NSW Natural Waters Based Sustainable Aquaculture Strategy (NSW DUAP and NSW Fisheries, 2001) proposes that environmental factors must be considered in site selection and the granting of aquaculture leases. A funding proposal is currently before the NSW Cabinet for resources to undertake thorough sanitary surveys of all oyster-producing areas.

Mandatory depuration[15] of oysters was introduced into NSW in 1983 following the Georges River incident, as a method of removing potential faecal contamination, irrespective of the quality of waters in which oysters are grown[16]. Most growers see depuration as a costly process that degrades the quality of their product. Oysters are essentially unfed during recycled depuration and the risk of spawning during the process, and attendant loss of condition is greatly increased. Depuration is currently being studied in an ORAC-initiated FRDC-funded project.

Rodgers (2001) has suggested that it is extremely important that growing areas in NSW be classified, in line with practice in the US and the rest of Australia. Those schemes rank areas as:

- approved – product can be sold directly for human consumption;
- conditionally approved – harvesting is allowed when conditions return to the approved level or oysters may be relayed or depurated;
- restricted – oysters must be depurated;
- conditionally restricted – meets restricted conditions but must be closed wen conditions are exceeded; and
- prohibited – site is contaminated and sale of shellfish from these areas is prohibited.

Classification of growing areas is embodied in the Draft NSW Natural Waters Based Sustainable Aquaculture Strategy (NSW DUAP and NSW Fisheries, 2001).

One criticism levelled at the current shellfish and water testing undertaken by the Shellfish Quality Assurance Program is that *E. Coli* may not be a good indicator of the persistence of pathogenic organisms, such as viruses in oysters. Viruses and other small pathogens appear to take longer to clear from oysters than the mandatory 36-hour depuration period[17]. A problem

[15] Depuration involves placing oysters in tanks of circulated, sterilised, estuarine water for 36 hours and allowing the natural pumping mechanism of feeding oysters to remove any contamination.

[16] Mandatory depuration only applies in NSW. Oysters imported into NSW from Tasmania, South Australia and New Zealand have not in general been depurated.

[17] The physiologically optimum conditions for depuration have not been determined. Throughflow systems, in which natural but UV-treated seston is continually supplied, would appear to enhance clearance rates by supplying oysters with food.

here, which was exposed during the Sydney Water Crisis (McClellan, 1998), is that current testing procedures may not differentiated between virulent and non-virulent forms of pathogens. Pathogen analysis and the use of phages as viral indicators is an on-going area of research, not just in environmental water quality but in standards for drinking water. The introduction of a classification scheme for growing areas, based on sanitary surveys, water and oyster meat quality, and environmental conditions, would remove at least part of the problem.

3.55 Self-Pollution

There is the potential for self-pollution of oysters due to farming practices. Two potential sources of self-pollution are possible. The first is from faeces and pseudo faeces ejected by the oysters themselves. The build up of waste products under leases and their impact on growth rates and health of oysters has not be been studied in NSW. It would appear to pose minimal threats in locations with adequate tidal exchange and where carrying capacity has not been exceeded. The draft Aquaculture Industry Development Plan proposes to set estimated sustainable yields for estuaries, based on historic data, to ensure that carrying capacity is not exceeded.

The second potential threat of self-pollution comes from the materials on which oysters are grown. Stick and tray culture and other activities require the use of wood. In order to protect wood from marine borers and other pests, growers have traditionally used tar coatings. More recently, Arsenic-Copper-Chromium impregnated timbers have been used. While there is no evidence that growing oysters have been contaminated due to the use of treated timbers, the industry has voluntarily agreed to a four-year phase-out of tar and treated timber. Work has commenced to assess suitable, alternate materials and practices. Safe, anti-fouling coatings produced by ORAC initiated research at the University of NSW appears to offer promise.

3.6 Industry Concerns about Environmental Threats

Industry concerns about environmental threats differ along the NSW Coast. It is therefore difficult to get a consensus of the priorities. A recent strategic planning session to develop a 5-year strategic plan for research and development for the NSW oyster industry (ORAC, 2001) provides some measure of the industry concerns. This plan is focussed around five programs: ecological sustainability; diseases, pollution and pests; quality assurance; hatchery and farm technology; and industry economics and marketing. The first three are most directly relevant to this work. Strategies were developed within this framework and were ranked by members of the industry. The relevant highest priorities are summarised below under these programs.

Ecological Sustainability

1. To identify areas within estuaries where oyster production is affected by acid releases from acid sulfates soils.
2. To identify estuaries or areas within estuaries where oyster production is affected by water quality (nutrients, chemicals, sediments etc).
3. To understand the relationship between the occurrence of QX disease and the environmental health of an estuary.
4. To develop the capacity to model “optimal” stocking densities within an estuary.

Diseases, Pollution and Pests

1. To obtain a better understanding of QX disease.
2. To obtain a better understanding of winter mortality .
3. To develop monitoring and management tools to better manage QX disease.

4. To develop QX and winter mortality-resistant oysters.

Quality Assurance
1. To develop a unified, whole of government waterway classification model with clearly defined assessment criteria.
2. To develop simple testing procedures for the presence of marine biotoxins.

Notwithstanding the fact that human population pressures are probably the greatest threat to oyster production, a strategy to investigate the potential that increasing population pressures may cause an accumulation of viruses or bacteria that are harmful to humans within oysters and/or the environment was ranged low priority.

3.7 Institutional Issues

Many disparate organisations, state, local government and community, are partially responsible for the management of and health of estuaries and the oysters produced in them. These include (Healthy Rivers Commission, 2000a):
- NSW Fisheries
- NSW Safe Food Production[18]
- Department of Land and Water Conservation (DLWC)
- Environmental Protection Agency
- National Parks and Wildlife Service
- Department of Urban Affairs and Planning
- Local Governments
- Catchment Management Boards
- Water Management Committees
- Coast Watch
- NSW Coastal Council

In its examination of the management of selected coastal rivers, the Healthy Rivers Commission (1999 a; 1999b; 1999c; 1ph999e; 2000a) has concluded that there is no single authority with sole responsibility for the health of the river systems. Because many agencies are responsible, ultimately no one is. The Commission has identified conflicting objectives amongst those agencies currently managing rivers and estuaries.

One solution canvassed was the appointment of a River Manager with sole responsibility for the health of the river. Victoria, with a similar but broader aim, established Catchment Management Authorities (CMA) with considerable responsibilities, power and resources. The recent change in government in Victoria, however, removed from CMAs their ability to rate properties. In response to the 1998 Sydney water "crisis"[19], and following the Healthy Rivers Commission model, the Sydney Catchment Authority was established to oversee the quality of water from Sydney's catchments (McLellan, 1998). Despite the logic behind the River Manager and CMAs, both solutions appear generally unacceptable in NSW, since they introduce, essentially, an additional level of government and one with questionable accountability to the broader community. The recently appointed Catchment Management Boards in NSW have been given the urgent task of prioritising and preparing targets for the management of NSW rivers. These

[18] The NSW Shellfish Quality Assurance Program is run under NSW Safe Food Production
[19] High levels of apparently non-virulent *Cryptosporidium* and *Giardia* were detected in Sydney's drinking water supplies in 1998 leading to a recommendation to boil all drinking waters.

have are still evolving and it is too early to predict what influence they will have on the health of coastal catchments[20].

There are a plethora of extant laws applicable to the protection of coastal estuaries in NSW. The more important of these are the Rivers and Foreshores Hydraulic improvement Act of 1948, the Fisheries Act of 1994, the Clean Waters Act, the Local Government Act, the Native Vegetation Act and the Protection of the Environment Act. There are several specific, State Environment Protection Plans, such as SEPP 14 Wetlands, SEPP 16 and SEPP 46, the Clearing of Native Vegetation. SEPPs are almost universally disliked by broadacre landowners and farmers, since they deprive them of total freedom of decision-making over landuse on their properties. Because of this, ASSMAC has been loath to recommend an acid sulfate soil SEPP. The general perception amongst fishers and oyster farmers is that there is reluctance on the part of government agencies to use existing legislation to protect estuaries. In addition, in some areas, local government is considered by in-stream industries as a key contributor to estuarine degradation. In other areas, such as the Tweed, the Hastings and more recently the Shoalhaven local governments have played a vital and constructive role in seeking solutions.

Rapid and profound changes and are occurring in the way the Australian environment is managed. Some are the result of the national thrust for Ecologically Sustainable Development, some result from National Competition Policy and the COAG 1995 reform process. These changes include (Dovers and Guillett, 1999):

- a move away from regulation towards self-regulation, codes of practice and agreements;
- 'marketisation' of government authorities and the reduction of government involvement through outsourcing, corporatisation and the application of market-based policy instruments;
- a large shift to community participation and involvement in environmental management and monitoring;
- increasing use of risk assessment and management approaches and policy and decision making in the face of uncertainty; and
- a strong regional focus in planning, policy implementation and program delivery.

The 'marketisation' of government authorities has considerable implications for the management of estuarine environments. It has led to the downsizing of management and regulation departments with associated loss of corporate memory and a reliance on consultancies whose products are of variable quality. Monitoring, an expensive process, is often an early casualty, and there is a danger that the considerable store of data will either be more difficult to access or will be lost. Downsizing also means that the supply of advice to local government and community groups involved in environmental management inevitably decreases. Indeed, the very necessary supply of back-up advice and information to such community groups has not been adequately resourced in the transfer of responsibilities to these groups for coastal management (Healthy Rivers Commission, 2000a, b).

Partly as a consequence of marketisation, government authorities have been swept by waves of natural resource priorities: water reforms; natural vegetation; biodiversity; salinity; acidification; etc. Most of these involve the employment of short-term appointees. This is little chance in this process to develop long term strategies on any one facet of natural resource management before the next priority breaks. There is no opportunity to develop a corporate culture and knowledge or to review outcomes.

[20] Oyster farmers on the Boards are optimistic about the potential outcomes.

Regionalisation has the advantage of transferring assessment and decision-making back to the affected area. This ought to move these responsibilities back to the community. Since regional bodies in NSW are appointed by state government and not accountable directly to the community, this possibility is weakened. Regionalisation also tends to duplicate functions and tends to diminish or even abandon activities where the centralisation of knowledge and skills is appropriate. The effect of all these changes on the management of estuaries remains to be fully documented, but is not expected to be positive.

Dovers (2001) has examined the characteristics of institutions that are necessary for sustainable natural resource management. He concludes that we cannot progress sustainable management without institutional change. The sorts of institutional characteristics necessary for sustainable are those best met by adaptive management[21] institutions with the following characteristics (Dovers and Mobbs, 1997):

- Persistent - maintenance of efforts over time in order to learn and adapt;
- Purposeful - guided by widely supported principles and clearly stated goals;
- Information rich - strong research base and ethos, integration across disciplines, multiple sources of information, commitment to monitoring, communication;
- Independent – a degree of independence from short term political pressures and temporary mandates;
- Participatory – genuine involvement in policy and management of concerned communities;
- Flexibility -preparedness to learn and evolve;
- Adequately resourced-financial, human and information; and
- Legal basis – a clear basis in statute law.

These characteristics provide a useful measure for examining existing and planned institutional arrangements for managing estuaries.

The Provincial Resource Policy, May 1993, of the Ministry of Agriculture, Fisheries and Food of British Columbia[22] provides an excellent policy model for managing the environment in and surrounding estuaries. It is based on the recognition that land and water suitable for agriculture and aquaculture are scare and valuable resources in British Columbia (*as in NSW*) and should be protected.

The Policy provides a coherent set of policies for protecting and enhancing the health of the environment, and ensuring the conservation of natural resources and protecting the ecological processes that sustain them. It provides that planning must actively consider the existing and future needs of agriculture (including aquaculture), fisheries and food sectors at the local, subregional and Provincial land and watershed scale. It also specifies that Provincial economic and social programs to foster the development of agriculture (including aquaculture), fisheries and food sectors should complement, and be in compliance with, efforts to protect important agricultural aquatic. A detailed examination of this approach and its outcomes would be valuable for NSW.

[21] A note of caution needs to be introduced in terms of adaptive management of coastal estuaries. Harris (2001) believes that estuaries may 'flip-over' from one state to another and the process may be hysteretic so that adverse changes may not readily be reversed. This is due, in part, to the massive storage capacity of estuarine sediments.

[22] I am grateful to J. Long of the Healthy Rivers Commission of NSW for providing me with a copy of this policy.

3.8 Availability of Finance

Oyster farming involves the growing of a product with a 2 to 4 year time-to-harvest. While forestry involves a crop with a much longer maturation time, the length of oyster maturation time and oyster diseases and pollution risks, together with incidents of contaminated product, engender a perception that oyster growing may be a risky business (ACIL, 1997). Additionally, a perception in the finance industry of a weak commitment by governments to sustain the oyster industry means that it is difficult to raise capital to invest in the industry. Additionally, some processors of oysters are extremely slow to pay producers for their product[23], and cash flow can therefore be a significant problem. Current prices for oysters[24] indicate that the product is undervalued. In order to provide cash returns, growers sell oysters at an earlier and smaller stage of development. Recent data shows that the proportion of lower grade oysters sold is increasing.

The Shellfish Quality Assurance Program was introduced to reduce the risk of product contamination. It requires significant financial and human resources from the industry to operate. Although in its early stages, its establishment and industry support provides evidence to financial institutions that the industry is determined to decrease risks. ORAC's strategic plan (ORAC, 2001) also provides a signal that the industry has examined actual and potential impediments to production and is setting out in a systematic way to overcome those impediments. Additionally, the *Draft Natural Waters Based Sustainable Aquaculture Strategy* (NSW DUAP and NSW Fisheries, 2001) and the thrust of Health Rivers Commission reports and recommendations (Healthy Rivers Commission, 2000a, b) shows that the NSW Government has appreciated its responsibilities for providing a secure future for aquaculture in NSW. All these should increase confidence in the long-term economic future of the NSW oyster industry.

3.9 Industry Associations

There are two professional associations that represent oyster growers in NSW, the Oyster Farmers Association, and NSW Farmers Association (Oyster Section). Because of historical differences, it has been difficult for these associations to reach agreement on key issues. Essentially, the position of the industry is weakened because it does not speak with a single voice. This presents particular problems to governments and their agencies when they are exposed to conflicting opinions.

Marketing and promotion provides an example of conflict in the industry. NSW Oysters compete in the marketplace with oysters from Tasmania, South Australia and New Zealand and with other seafood products. Tasmania and South Australia have a well-coordinated marketing and promotion plan. In NSW there is no such promotion of the product because of the lack of consensus on its value. Instead, individual estuaries such as the Clyde have attempted to market their oysters as a product.

3.10 Age Structure of the Industry

Like many rural industries, the average age of oyster farmers is increasing. Oyster farming

[23] It is reported that some processors take 6 to 9 months to pay growers.
[24] Estimated to approximately $4.00/dozen at the farm gate (NSW DUAP and NSW Fisheries, 2001). In Bergen, Norway recently, mediocre quality Pacific oysters were selling for the equivalent of $4.00 **each**.

traditionally in NSW has been a family business with sometimes up to five generations following in oyster production. In recent times, it has been increasingly difficult to attract younger farmers into the industry. This is partly due to the expanding educational and career opportunities available to younger generations and partly due to the perceived risks of oyster farming, the lack of sources of finance for entry into the industry and the perceived lack of commitment of government to the industry. Attracting younger farmers into the industry is a significant challenge and will depend on a decrease in the real and perceived threats to the industry.

3.11 Advice and Recommendations

Identify the types of actions that would be necessary within estuaries and their catchments to rehabilitate and/or maintain areas for oyster cultivation.

There are increasing threats to growing healthy oysters in NSW from the continued growth in coastal populations, especially in the northern part of the state. The abstraction of freshwater upstream during low flow periods constitutes a threat to growing healthy oysters. Pollution of estuaries from point discharges is of principal concern including broken, leaking or overflowing sewer mains, sceptic tank discharges, industrial and agricultural chemical discharges, urban stormwater outlets, agricultural drains in acid sulfate soils. Diffuse sources of excess nutrients and pollutants, such as agricultural runoff. Land reclamation, engineering works, over-fishing, boating, waste disposal sites, weed infestation and the clearance of catchments, particularly riparian zones all represent major threats to the health of estuaries and oyster production. Urban and agricultural developments in coastal catchments have dramatically altered the character and quality of storm runoff and its subsequent impact on estuarine ecosystems.

The Healthy Rivers Commission has identified most of these issues in the types of broad management strategies it has proposed as part of the *Coastal Lakes Assessment and Management Strategy*. Some of the other strategies proposed under the lake categories that permit commercial oyster production address specific threats to oyster production. These include:

Significant protection

- Limit development of new dwellings to within the boundaries of existing villages and rural residential areas;
- Mitigate (or remove) existing sewerage discharges, overflows and septics (no new discharges);
- Encourage use of best farming and forestry practices;
- Exclude new intensive agricultural or aquaculture development;
- Stringently manage recreational and commercial uses.

Secure healthy, modified conditions

- Enforce stringent controls on new urban, rural residential and intensive agricultural developments (provided these are demonstrated to be sustainable);
- Locate no new assets (such as sewerage, roads, and dwellings in areas subject to flooding/ water logging under natural entrance conditions; and
- Exclude new sewerage discharge or overflows, stringent management of septics.

Given the sensitive of oysters to acid runoff from acid sulfate soils, and the concerns of the industry a specific strategy dealing with the avoidance of their disturbance in areas neighbouring coastal lakes, or, where acid is already discharging, the complete treatment of

runoff is important. As well, an overall strategy for those lakes in which oysters are grown, in which any new development proposals should specifically address the increased risks posed by the development on oyster health and growth. A potential amendment to SEPP62 “Sustainable Aquaculture Strategy” is currently being examined which would require consideration of the impacts of all sewerage, stormwater and acid sulfate soil developments.

- It is recommended that the Healthy Rivers Commission liaise with ASSMAC and DUAP over the inclusion of strategies specific to the disturbance/drainage/treatment and rehabilitation of acid sulfate soils in the proposed Coastal Lakes Strategy.
- It is recommended that in oyster producing lakes a strategy be included that specifically requires all new developments (private and public) within the lake catchment identify the risk they pose to oyster production.

The lease area taken up by oyster growers is an important industry sustainability indicator and the yield trends provide valuable information on the efficiency of production in estuaries.

- It is recommended that lease area taken up by growers and yield of oyster be used as indicators of the success of the Strategy in oyster producing lakes.

Institutional arrangements will play an important role in the success of the Strategy. For oyster growers, a “one-stop-shop” would remove many of the institutional impediments to maintaining healthy estuaries. While the Strategy provides a unifying framework, institutional barriers will still persist. It appears inevitable that at least three departments, NSW EPA, NSW Fisheries and NSW Safefood Production will be involved in matters relating to oyster-producing estuaries.

- It is recommended that mechanisms for establishing a “one-stop-shop” for managing estuaries or the simplification of procedures be further explored.

4 TRENDS IN OYSTER PRODUCTION IN NSW

Examination of the trends in oyster production in NSW provides valuable information on the economic and ecological sustainability of estuaries. It also helps identify priority issues and locations where remedial action is necessary.

4.1 Major Production Estuaries

The top 14 estuaries for oyster production in NSW over the period 1937 to 1995, together with their percentage contributions are ranked in Table 1. These top 15 estuaries contribute over 93% of the state's production. Also shown in Table 1 is the ranking for the period 1995-2000.

Table 1. Ranking of estuaries by percent contribution to NSW's oyster production for the periods 1937 to 1995 and 1995 to 2000.

1937-1995		1995-2000	
Estuary	%	Estuary	%
Port Stephens	25.0	Wallis Lake	30.3
Georges R.	21.9	Hawkesbury R.	12.7
Wallis Lake	13.9	Brisbane Waters	11.1
Hawkesbury R.	9.4	Port Stephens	8.5
Clyde R.	4.1	Clyde R.	7.7
Manning R.	4.0	Wagonga R.	3.5
Brisbane Waters	3.0	Hastings R.	3.3
Hastings R.	2.9	Manning R.	3.2
Wagonga R.	1.8	Merimbula Lake	2.8
Merimbula Lake	1.6	Crookhaven R.	2.4
Crookhaven R.	1.4	Nambucca R.	2.1
Macleay R.	1.4	Camden Haven	1.9
Camden Haven	1.1	Tuross Lake	1.7
Tweed R.	1.1	Pambula R.	1.3
Clarence R.	0.9	Wonboyn/Nul'ca R.	1.2
Total	93.4		93.8

Several key issues emerge from a comparison of the rankings for the two periods in Table 1. The first is the dominance of the top 3 estuaries. In both lists the top 3 contribute over 50% of production. The second, and most disturbing, is the disappearance of the once second-ranked Georges River from the entire top 15 producers in 1995-2000. The third is the three-fold reduction in percentage production from Port Stephens and its change in ranking from first to fourth. The fourth is the removal from the top fifteen of the northern rivers, the Macleay, Tweed and Clarence.

On a more positive note, the relative contributions to the state's total production has more than doubled in Wallis Lake, Brisbane Waters, Nambucca River, Tuross Lake, Pambula River and Womboyn Lake and the Clyde, Wagonga, Merimbula, Crookhaven and Camden Haven estuaries show well over a 50% increase in relative contribution. These relative increases do not necessarily mean an increase in absolute production since absolute production has fallen as will be discussed in the next section.

4.2 Historic Trend in Production

The historic trend in total, plate-and bottle-grade oyster production over nearly 70 years is shown in Fig. 5. The increase in production due to relaying of oysters is evident, as is the continuing decline in oyster production since the maximum in 1978. The total sustainable yield for NSW is estimated to be around 109,000 bags (NSW DUAP and NSW Fisheries, 2001).

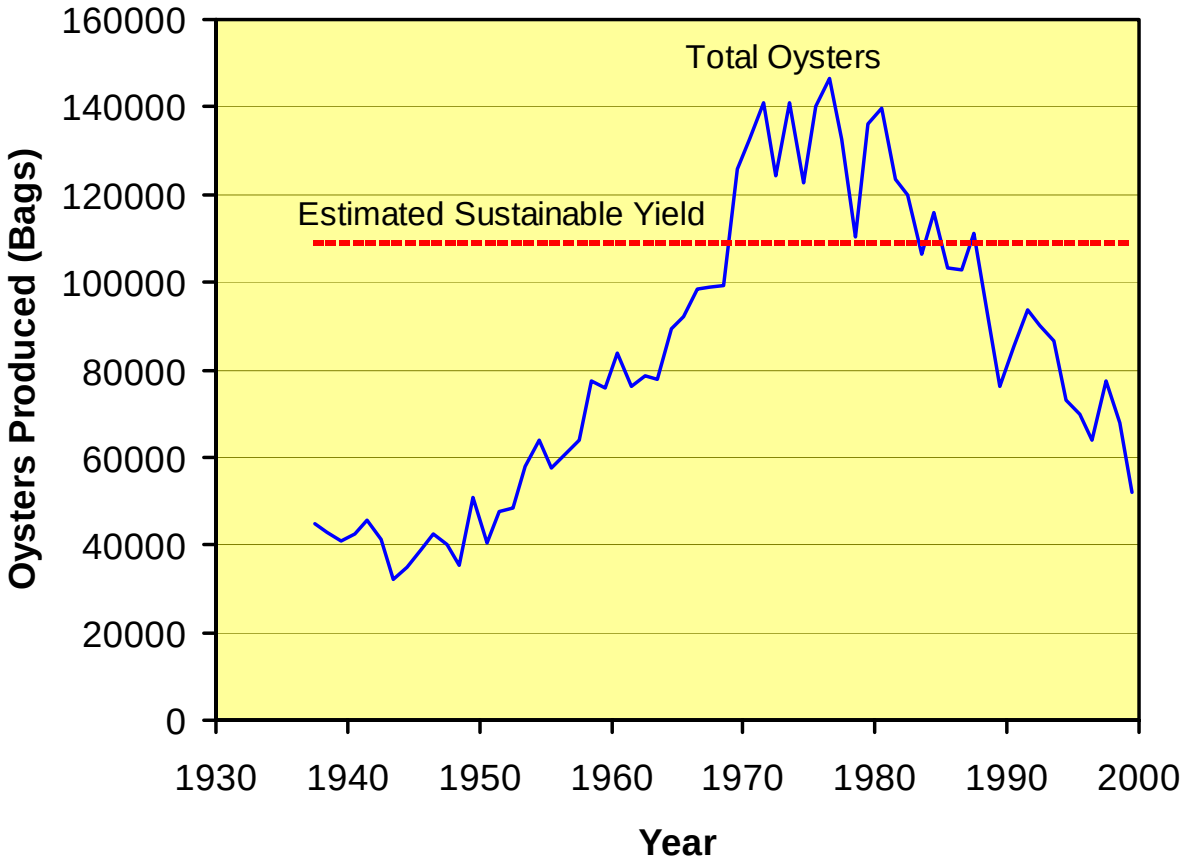

Figure 5. Historic, plate- and bottle grade oyster production in NSW (Source NSW Fisheries).

Fluctuations around the two major trends are evident in Fig. 5. Some of the major fluctuations appear to be due climatic factors. The increases in production in 1980/81 and the early 1990's appear due to major droughts in southeastern Australia. The decreasing trend in production is examined in Fig. 6. The mean trend can be fitted simply to:

$$\text{Oyster Production (Bags)} = 6.04\text{x}10^{6} - 2990\text{x}\text{Year} \qquad r^2 = 0.87 \qquad (3)$$

This strong linear decreasing trend with time shows that there has been an average yearly decline of nearly 3,000 bags (3.6 million oysters) since the early 1970s. If this linear trend is extrapolated, it predicts production of oysters in NSW will cease in 2020. Since a major decline in oyster production in that period has been in the once-major oyster nursery, Port Stephens, due to the introduction of Pacific Oysters, there is no reason to suspect that the trend will continue at that rate.

Fig. 7 shows the trend in oyster production since 1944 for the 5 potentially largest oyster-producing estuaries in NSW. Potentially, these could produce 58% of NSW production.

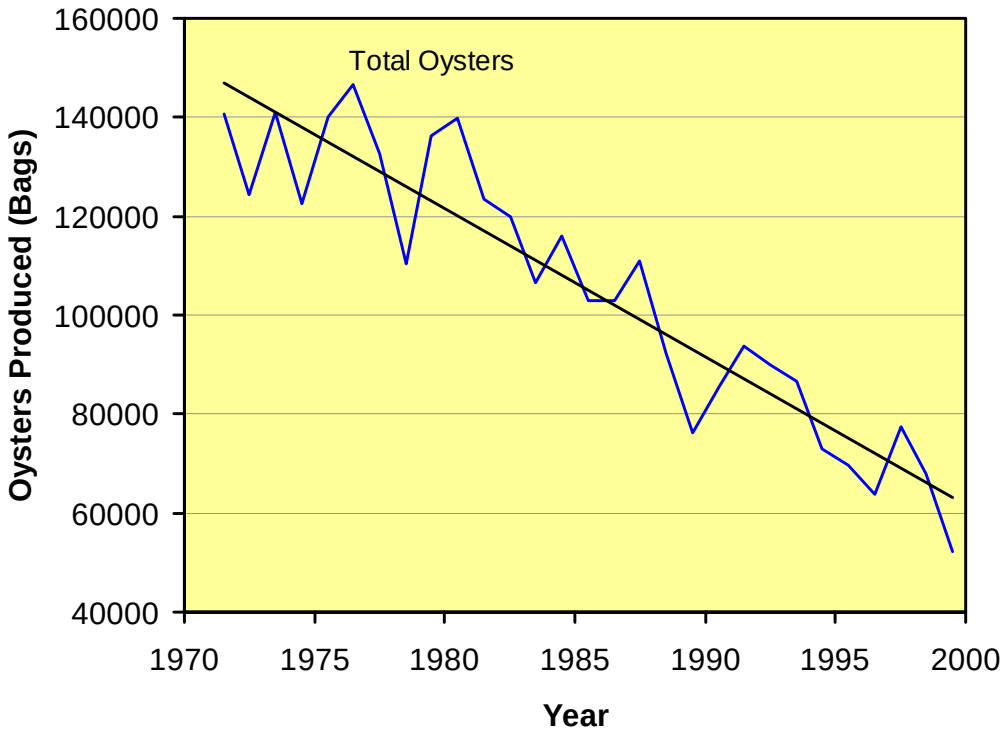

Figure 6. The strong, decreasing trend in oyster production in NSW since the early 1970's.

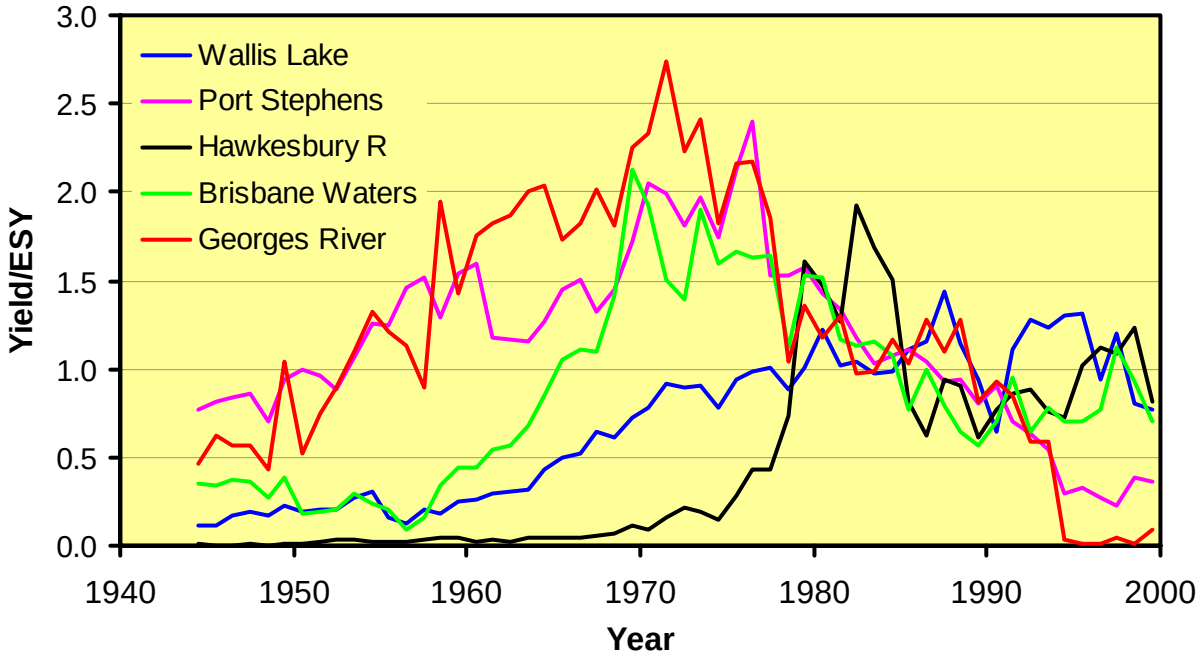

Figure 7. Trends in oyster production (expressed as a ratio of the actual yield to the estimated sustainable yield, ESY) of the 5 main oyster-producing estuaries in NSW.

Production in Fig. 7 has been expressed as the ratio of the actual production (Yield) to the estimated sustainable yield (ESY). All except Wallis Lake show an increase to a peak production in the period 1970 to 1984, well above the estimated sustainable yield, followed by a decline to a value that fluctuates around the ESY. Wallis Lake shows an approximately monotonic increase to the estimated sustainable yield. Two of the estuaries in Fig. 7 show a collapse in oyster production. One, Port Stephens, was due to the introduction of Pacific Oysters. The other, George's River is due to QX disease. It is clear that a major proportion of the decline in oyster production in NSW in Figs 5 and 6 is due to the decline in oyster production in these two estuaries.

4.3 Impact of the Collapse of Two Major Estuaries

Fig. 8 shows the comparison between the total production in NSW and that for all estuaries less the two estuaries, Port Stephens and Georges River, whose production has dramatically decreased. In order to compare results, the data is expressed as the ratio of yield to ESY for both cases. It is clear that, until 1978, these two estuaries made a major contribution to yield. After this time, however, the other estuaries behaved in a similar fashion. More disturbingly, the continued decrease in production is evident in the other estuaries.

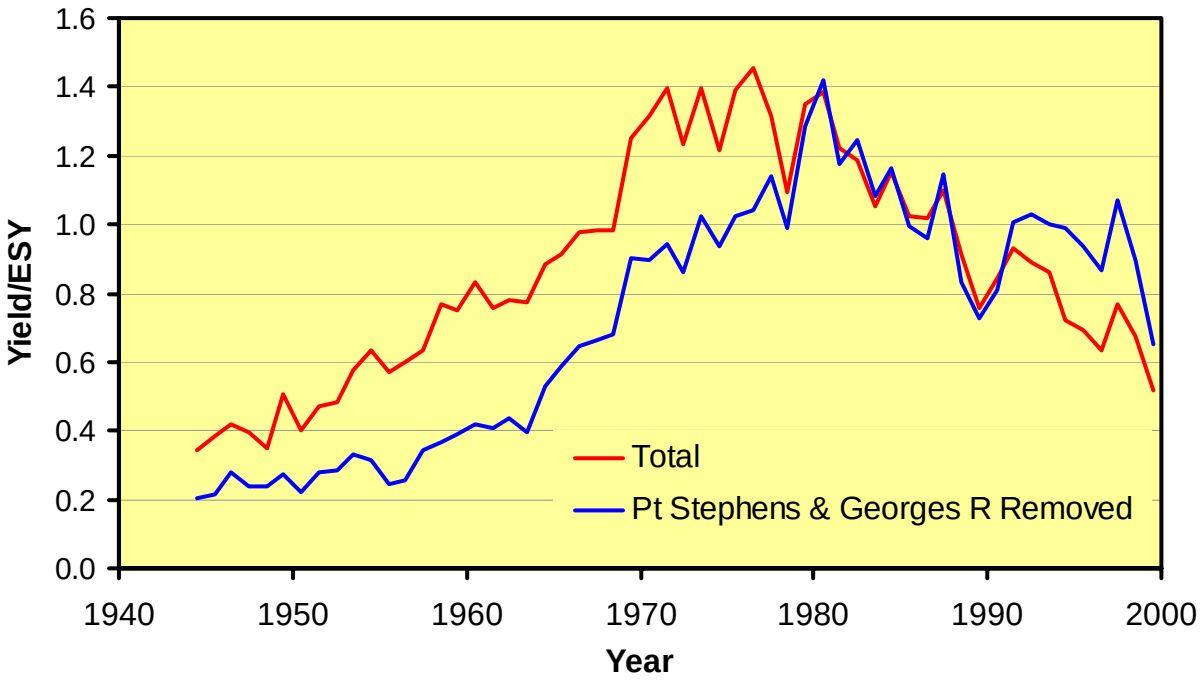

Figure 8. Total normalised, post-war production of oysters in NSW compared with total production of all estuaries without Port Stephens and Georges River.

The similarity in behaviour in the post-1977 yield trends can be seen it Fig. 9, which amplifies the period since 1975. Figure 9 includes an additional comparison with production from all other estuaries excluding Port Stephens, Georges River and Wallis Lake in addition. These three estuaries contribute over half the state's current production. From 1977 to 1987, all other estuaries show an identical, decreasing trend to that including Wallis Lake, Port Stephens and Georges River. After 1987, the impact of the collapse of the two estuaries is notable. Following 1987, production in other estuaries still declines, but at a lower rate. The total production for all estuaries decreased by an average of 3.3% per year over the period 1987-2000. That of the other estuaries, excluding Georges River, Port Stephens and Wallis Lake decreased by 2.5% per year

while that excluding Georges River and Port Stephens, decreased on average by 1.7% over the period. While the decrease in oyster production in NSW is partly due to the collapse of the Port Stephens and Georges River fisheries, there are other factors contributing to the decline. This overall decreasing trend in other estuaries is a major concern.

Port Stephens was a major source of spat for other growing areas in NSW. Part of the declining trend in other estuaries may be attributable to the loss of that source, however shortage of spat does not appear to be a problem. Additionally, the introduction of Pacific oysters and the outbreak of QX disease has meant that relaying of oysters is restricted, so that growers have more limited opportunities to maximise production. It is noticeable in Figs 8 and 9 that the significant fluctuations in oyster production are very well correlated and are not attributable to fluctuations in the three former major growing estuaries. These fluctuations appear to be attributable to climate fluctuations.

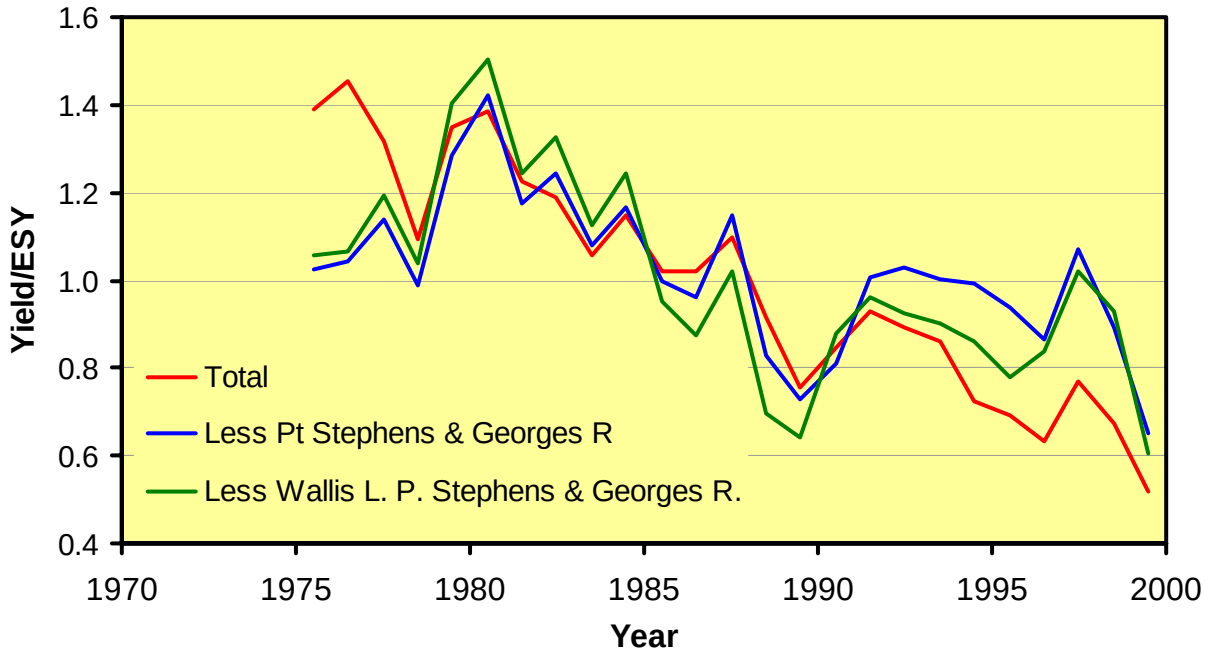

Figure 9. Comparison of trends in normalised oyster production since 1975 with and without the major producing estuaries.

4.4 Recent Trends in and Stability of Oyster Production

The most recent trends in oyster production are of particular interest because of the major changes that have occurred over the last 10 years. Fig. 10 shows the production of plate and bottle oysters for all estuaries in NSW over the period 1995 to 2000. The continued dominance of the Wallis Lake fishery followed by those of the Hawkesbury, Brisbane Waters, Port Stephens and the Clyde is apparent. In general, the overall decline in oyster production can be seen to be widespread, although there are some notable exceptions on the south coast.

The coefficient of variation, CV (here expressed as a percentage) is a simple measure of the stability of production in an estuary and is defined as:

$$CV = 100\frac{\sigma_X}{\bar{Y}_X} \qquad (4)$$

where $\overline{Y}_X$ is the mean production for that estuary over the last X years and σ_X is the standard deviation over the same period. Values of the CV higher than 30% show production areas that are subject to large swings in production. Values below 30% show relatively stable areas. Fig. 11 shows the coefficient of variation of production over the last 10 years (1989/90 to 199/2000) in NSW estuaries.

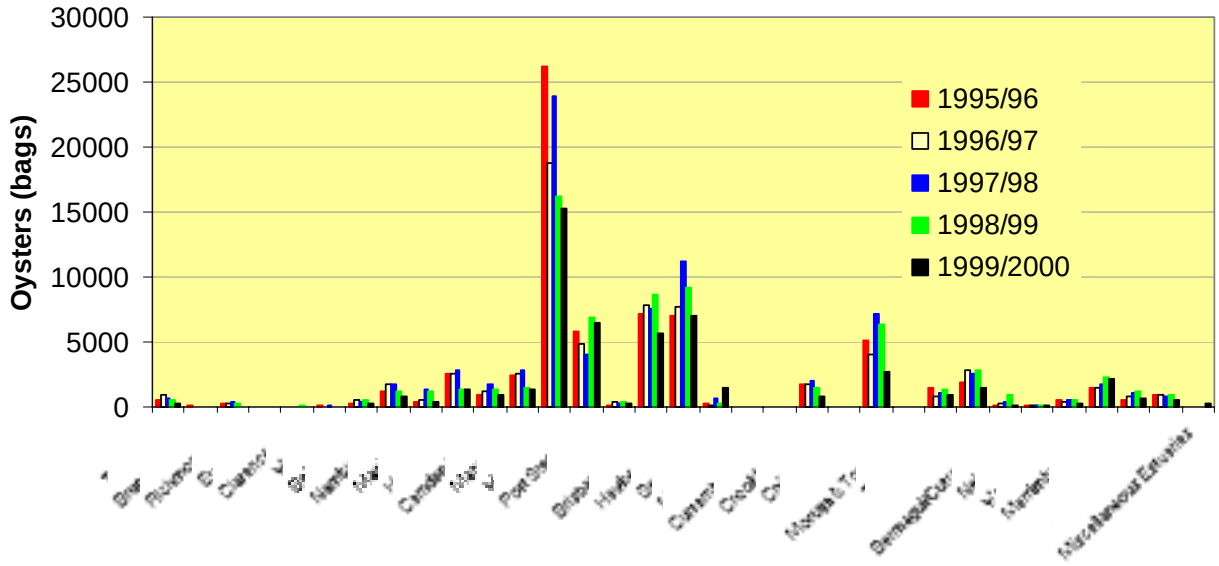

Figure 10. Plate and bottled oyster production in NSW estuaries, 1995-2000 (NSW Fisheries).

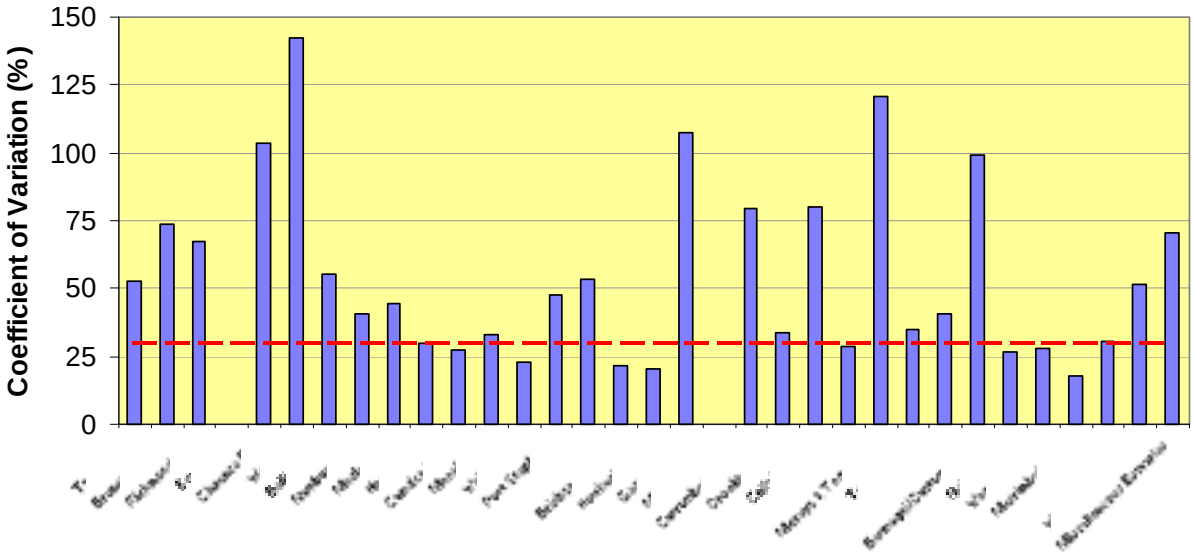

Figure 11. Coefficient of variation of oyster production in NSW estuaries over the past 10 years (1989/90 to 1999/2000).

In general, the larger oyster-producing estuaries have lower CV's than smaller estuaries, as expected. The major producers, Wallis Lake, Hawkesbury River and Brisbane Waters, have CVs in low 20% range compared with the CV for the total state production of 16.4%. The

notable exceptions to this general rule are: Port Stephens and the Georges River, that have higher CVs than expected, and the Hastings, Clyde and Pambula Rivers, Camden Haven and Nelson, Wapengo and Merimbula Lakes, that have low CVs relative to their size. The latter show relatively stable production over the past 10 years.

4.5 Production and Trend Indices

In order to examine the recent trends in oyster production we introduce an index called here the oyster production index, OPI. The OPI is defined in a similar way to the Southern Oscillation Index:

$$OPI = \frac{Y_{Year} - \overline{Y}_X}{\sigma_X} \tag{5}$$

where Y_{year} is the oyster production in any estuary for a particular year[25]. The OPI measures the number of standard deviations a year's production is away from the mean. Positive values of the OPI correspond to higher than average production while negative values indicate lower than average production. Values of the OPI equal to or greater than + 2 and values equal to or less than –2 indicate exceptionally high or low production years[26].

Fig. 12 shows the OPI for the 5 main oyster-producing estuaries in NSW over the past 10 years. Three classes of behaviour are evident. The first is estuaries which start the 10 year period with OPI positive and end with it negative (Port Stephens and Georges River), thus showing a decreasing trend. The second is estuaries that start with OPI negative and end with it generally positive (Hawkesbury River and Brisbane Waters), displaying an increasing trend. The third shows fluctuations about the mean (Wallis Lake).

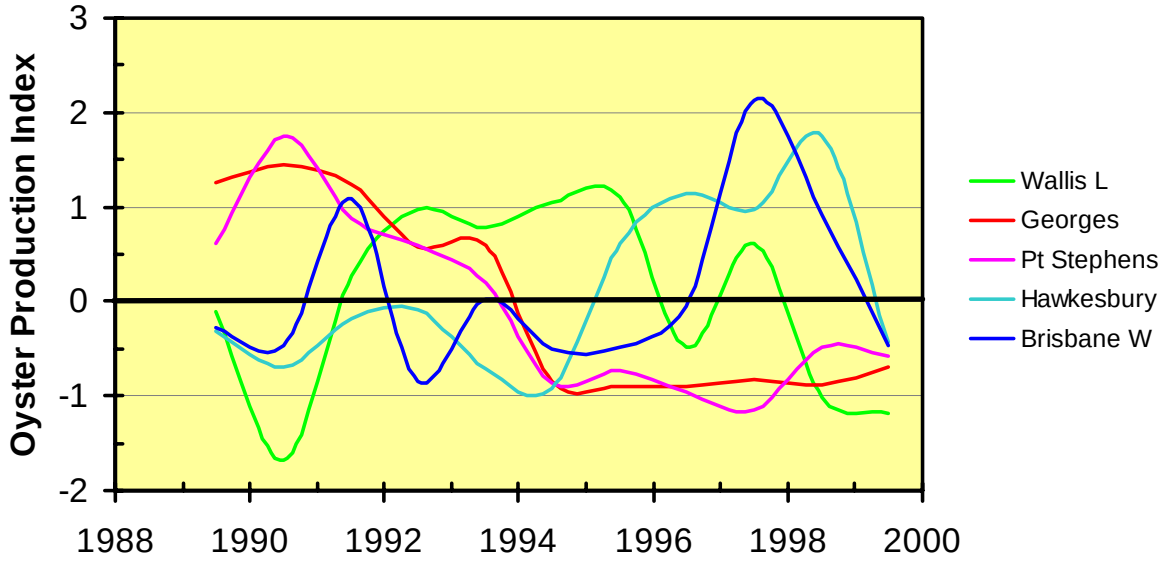

Figure 12. The oyster production index for NSW's main oyster producing estuaries over the past 10 years.

[25] This treatment assumes that oyster production is normally distributed over the period of *X* years. Nonparametric methods are available for handling non-normally distributed data.

[26] The OPI can be applied to the whole state's production, a particular estuary, a location within an estuary, an individual farmer's production or a single leases production.

The trend in oyster production, TOP can be defined as the sum of the OPI for each year in an estuary over the last half of the period of interest (here over the last 5 years of 10 year period),

$$TOP = \sum_{i=X/2}^{X} OPI_i = \sum_{i=X/2}^{X} \frac{\left(Y_i - \overline{Y}_X\right)}{\sigma_X} \qquad (6)$$

Values of TOP between –1 to +1 indicate estuaries with no significant trend in oyster production. Those with values between + 1 to +3 and –1 to –3 show increases and decreases, respectively. Estuaries with TOP values greater than +3 or less than –3 show areas where production has significantly increased or decreased significantly, respectively, over the past last half of the decade. Fig. 13 shows values of TOP for NSW estuaries over the past 5 years. Table 2 lists the various estuaries in those categories.

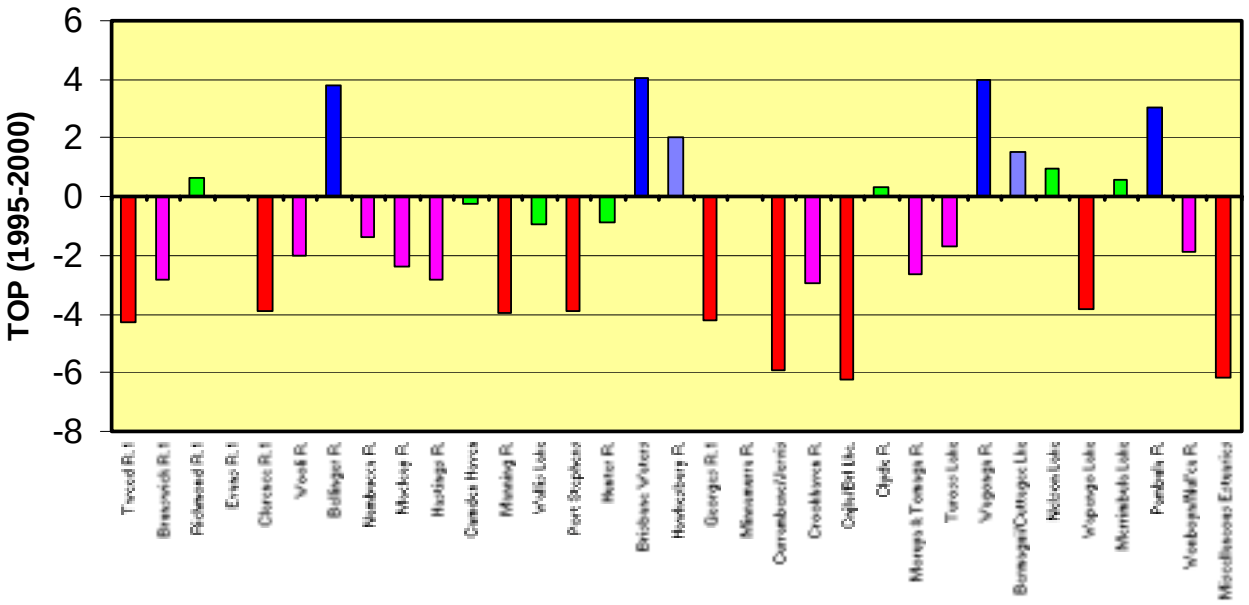

Figure 13. Values of the trend in oyster production over the last five years of the decade 1989/90 to 1999/2000.

In essence, the TOP values in Fig. 13 and Table 2 are measure of a sustainablity index for oyster production in estuaries in NSW and constitute a "league table" on industry and estuary management. It is clear that the number of estuaries where production has decreased greatly outweighs those where production is stable or increasing. The industry's major producing areas with two exceptions, Port Stephens and Georges River, fortunately lie in the stable to increasing categories at present.

The loss of the Georges River and the decline of the Port Stephens' fisheries, once major producers, must be considered as a failure of commitment to sustainable production. Some of the significant declines in production in Fig. 13 and Table 1 in small production areas appear due to structural adjustments in the industry, as small or part-time producers are no longer able to produce economically. There are a significant number of estuaries with major deposits of acid sulfate soils that are in the decreasing to significantly decreasing categories.

Table 2. Trends in oyster production in NSW estuaries over the last 5 years of the decade 1989/90 to 1999/2000.

Trend in Production	TOP Value Range	Estuaries
Significant Increase	>+3	Bellinger Brisbane Waters Wagonga Pambula
Increase	+1 to +3	Hawkesbury Bermagui & Cuttagee Lake
Stable	-1 to +1	Camden Haven Wallis Lake Hunter Clyde Nelson Lake Merimbula Lake
Decrease	-3 to -1	Brunswick Wooli Nambucca Macleay Hastings Crookhaven Moruya & Tomago Tuross Lake Wonboyn
Significant Decrease	<-3	Tweed Manning Port Stephens Georges Currambene/Jervis Bay Conjola & Burrill Lakes Wapengo Lake Miscellaneous

4.6 Trends in Leases and Lease Areas

In order to determine if the decreasing trend in production is due to a decreased effort, it is necessary to examine the trend in the area of estuaries under production. Unfortunately, this is not as easy as may seem at first glance. There are two reasons for this. The first is that leases and lease areas that are not in production are not identified. Some farmers take up neighbouring leases and deliberately keep them idle sometimes to control carrying capacity in the neighbourhood of productive leases. The second is that data base is incomplete. During the critical period 1981 to 1993, NSW Fisheries was part of NSW Agriculture and data in suitable

form does not appear available. Fig. 14 shows the trends in the number of leases issued and the estimated total area of oyster leases in NSW from 1968/69 to 2000/01[27].

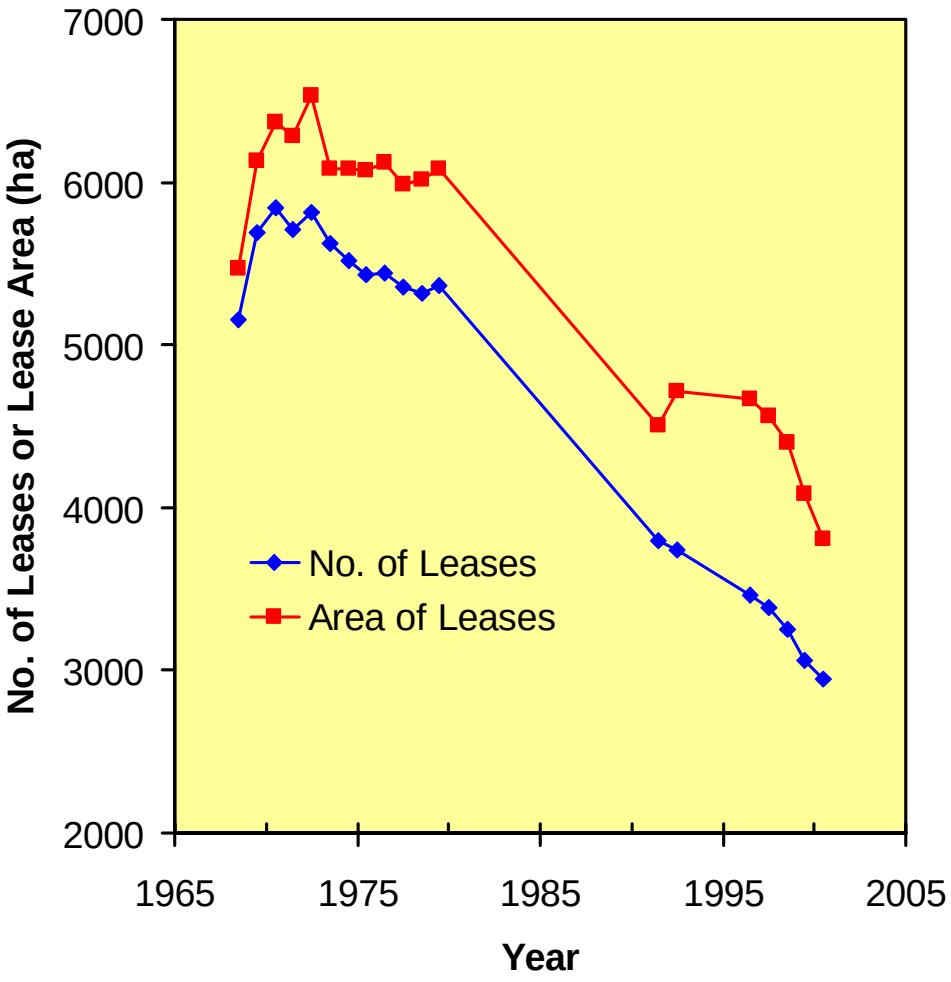

Figure 14. Trend in number of oyster leases in NSW and their estimated total area for the period 1968/69 to 2000/01

It can be seen in Fig. 14[28] that there was over a 42% decrease in the number of leases issued and a 30% decrease in the area of leases over the period[29], in other words a decrease in effort. The trend mirrors the production trend in Fig. 5. In any other area of primary production, a 30% loss in cultivation area, basically habitat loss over 20 years, for whatever reason, would raise an outcry.

Fig. 15 shows the trend in lease area since 1996/97. It can be seen that there is a strong linear decline in lease area. This decline fits:

[27] In the period 1968/69 to 1992/93 leases were separated into Foreshore and Offshore leases. While the area of Offshore leases is given, only the length of foreshore frontage is available for this period. In order to calculate the area of foreshore leases it has been assumed here that the average width of foreshore leases is 30m (F. Dorman, NSW Fisheries, pers. com., July, 2001). Under the 1994 Fisheries Act the areas of all leases are reported.

[28] There are two gaps in the data in Fig 14, from 1980 to 1991 and 1993 to 1997 due to administrative and data base changes.

[29] Currently leases surrendered to NSW Fisheries are, after a period, returned to DLWC, the resource owner. These lease areas are effectively lost to the industry.

$$Lease\ Area. = 421226 - 208.6 \times Year \qquad r^2 = 0.988 \qquad (7)$$

If extrapolated, this trend line predicts that the oyster lease area in NSW will be zero in 2019. The extrapolated trend line for oyster production in eqn(3) suggested that oyster production would cease in 2020. This suggests a close coupling between oyster production and lease area. Again, the linear decrease in production area of nearly 209 ha per year in the state's most valuable aquaculture industry should be a cause of major concern.

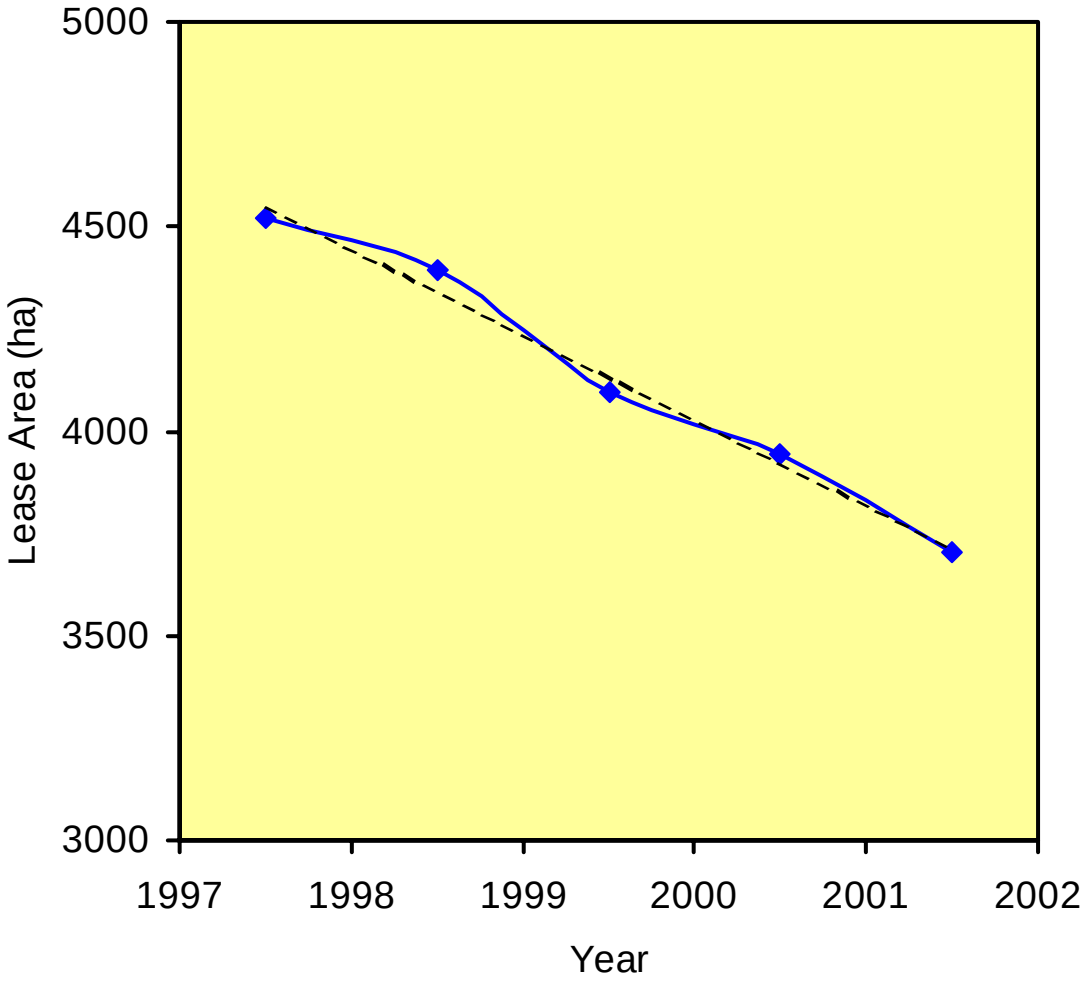

Figure 15. Recent trend in total oyster lease area in NSW since 1996/97. The dashed line is the linear trend line

Figure 16 shows the relation between annual production of oysters for NSW and annual lease area[30]. A simple linear trend (r^2 = 0.75, leaving 25% of the variance unexplained) shows that, on average over the period 1968/69 to 2000/01, the annual yield for the state is 20.5 bags/ha.

[30] This data is incomplete. Data is not available for the period prior to 1969 or for the period 1980/81 to 1990/91.

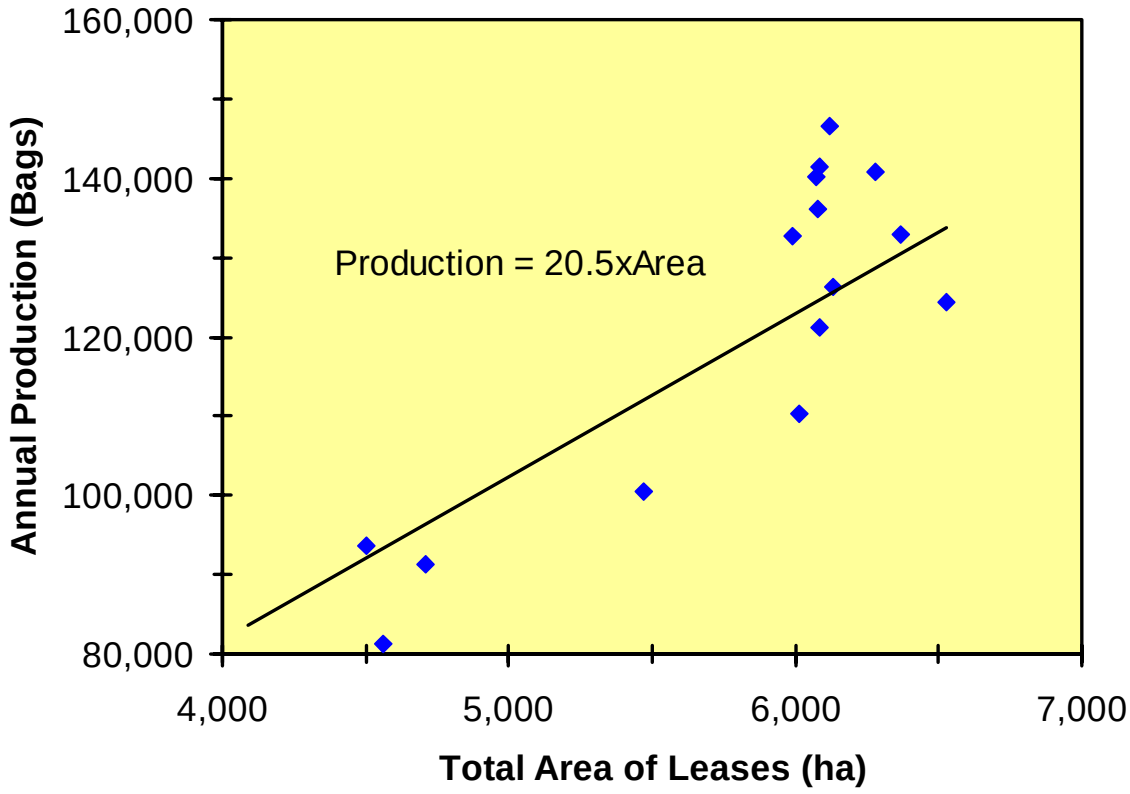

Figure 16. The relationship between annual production of oysters in NSW and the annual total area of leases in the state.

4.7 Trend in Permit Holders

Another measure of effort in the oyster industry is the number of oyster permit holders. Some care is required here since, in the past, not all permit holders produced oysters. Mandatory costs, age and other factors are bringing about major structural changes in the oyster industry. The trend in number of permit holders since 1996/97 is shown in Fig. 17.

Fig. 17 shows almost a perfect linear decrease in time of oyster permits. The trend line (dashed line) fits:

$$Permit\ Holders = 121555 - 60.5 \times Year \qquad r^2 = 0.998 \qquad (8)$$

If extrapolated, eqn (8) predicts that, at the current rate, there will be no permit holders in NSW by 2009, an even faster fall off that predicted by oyster production or lease area.

Fig. 18 shows the relationship between total lease area and permit holders. The trend line fits:

$$Lease\ Area(ha) = 2129 + 3.41 \times Permit\ Hoders \qquad r^2 = 0.976 \qquad (9)$$

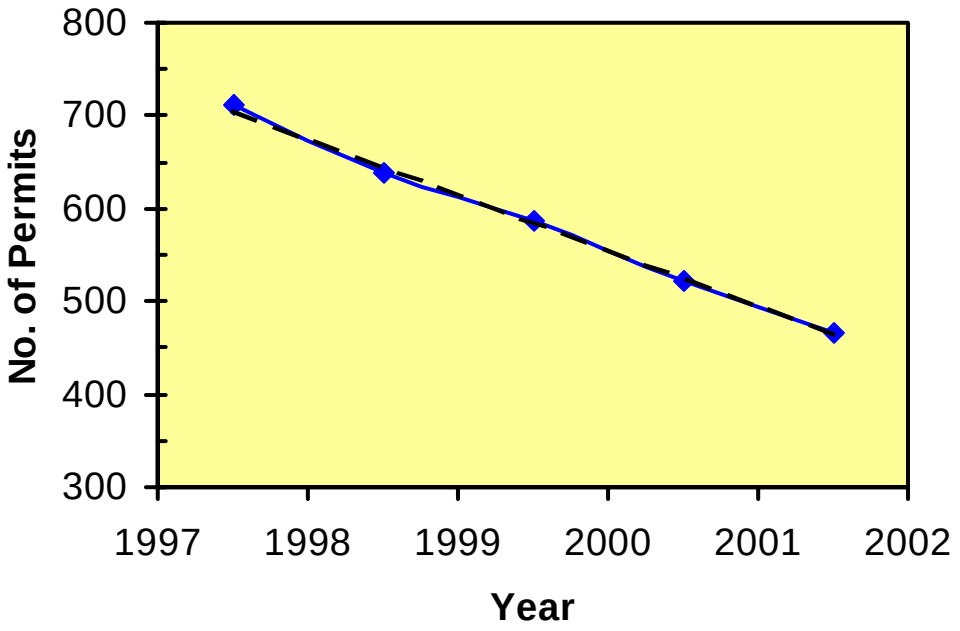

Figure 17. The trend in the number of oyster permit holders in NSW since 1996/97. Dashed line is the linear trend line.

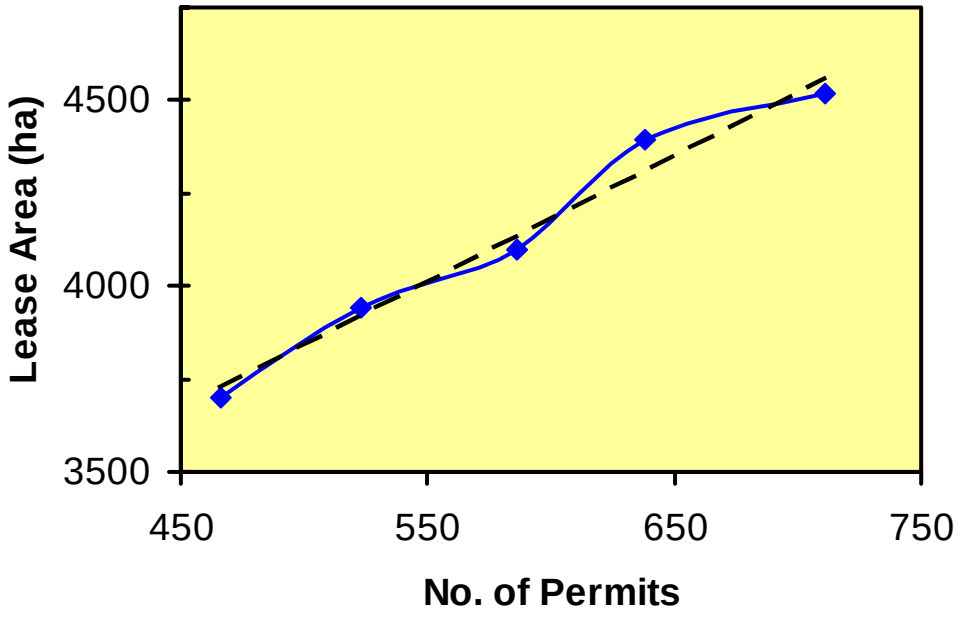

Figure 18. The relationship between lease area and the number of permits since 1996/97. The dashed line is the linear trend line.

Eqn (9) suggests that each permit holder exiting the industry farmed on average about 3.4 ha of oyster leases. While surrendered leases may be purchased by other growers, this strong linear trend would suggest that the smaller producers are leaving the industry. The large positive intercept also shows that there are a small number of very large producers still in the industry.

4.8 Yield at the State Level

Because of declining lease areas and permit holders, total oyster production does not provide a good indication of the industry's productivity. A better measure is yield expressed as oysters produced per unit area farmed. Unfortunately data on the actual area farmed is unavailable. Instead, only data on the total area leased is available. If we assume that the proportion of "sleeper" leases (leases kept out of production) or of uncultivated lease area[31] has remained unchanged state-wide over this period, then the trend in the yield of oysters can be estimated from the total annual production per total annual lease area. Fig 19 shows the annual yield of oysters[32] over the period 1968/69 to 2000/01 in NSW. In the period 1968/69 to 1992/93 the yield was relatively stable and fluctuated about a mean of 21.1 bags/ha with a standard deviation of only 1.87 bags/ha (coefficient of variation, CV, of less than 9%). Since 1992/93 the average annual yield has dropped, reducing the long-term average state yield 20.0 bags/ha with a standard deviation of 2.58 bags/ha (CV, of almost 13%).

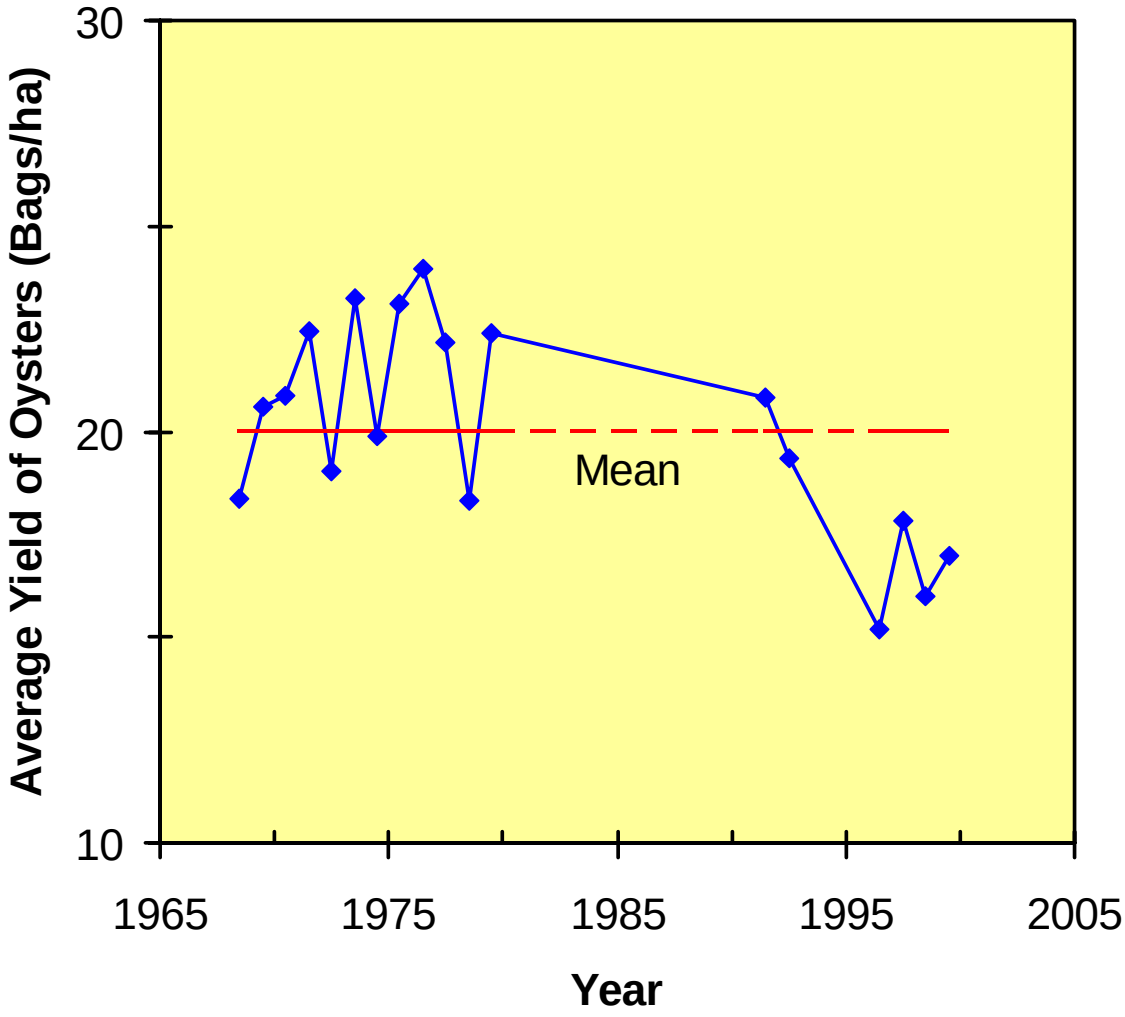

Figure 19. Annual average state yield of oysters in NSW for the period 968/69 to 1999/2000.

[31] Not all lease area is cultivated. Under modern cultivation techniques, as little as 10% of lease area may be used.
[32] Here yield is expressed in number of oysters/ha. A better measure would be weight of oysters/ha.

If the assumption of the constant proportion of unused leases over the period is valid, then Fig. 19 shows that the yield of oysters, despite fluctuations, remained virtually unchanged over this period 1968/69 to 1992/93. Since then, average yield appears to have declined in a period that has seen the introduction of new technology, such as the growth of single oysters in trays and tumblers[33]. The decline in total oyster production in Fig.5 may have two components. From 1978 to 1993, the production of oysters decreased as lease area decreased. Since then both lease area and average yields per area have declined. With the present data, it is not possible to say if the loss in production area and yield are directly due to disease, environmental degradation or to other factors such as socio-economic factors, particularly over the last 5 years. Identification of the reasons for surrender of lease area would provide valuable information for assessing environmental impacts on oyster production.

4.9 Comparison of Yields between Estuaries

Properly based yield data (production per unit area) can be used to compare the relative efficiency of production in terms of oysters produced per unit lease area for different estuaries along the state's coast[34]. Fig. 20 shows this comparison for 1992/93 and 1999/2000.

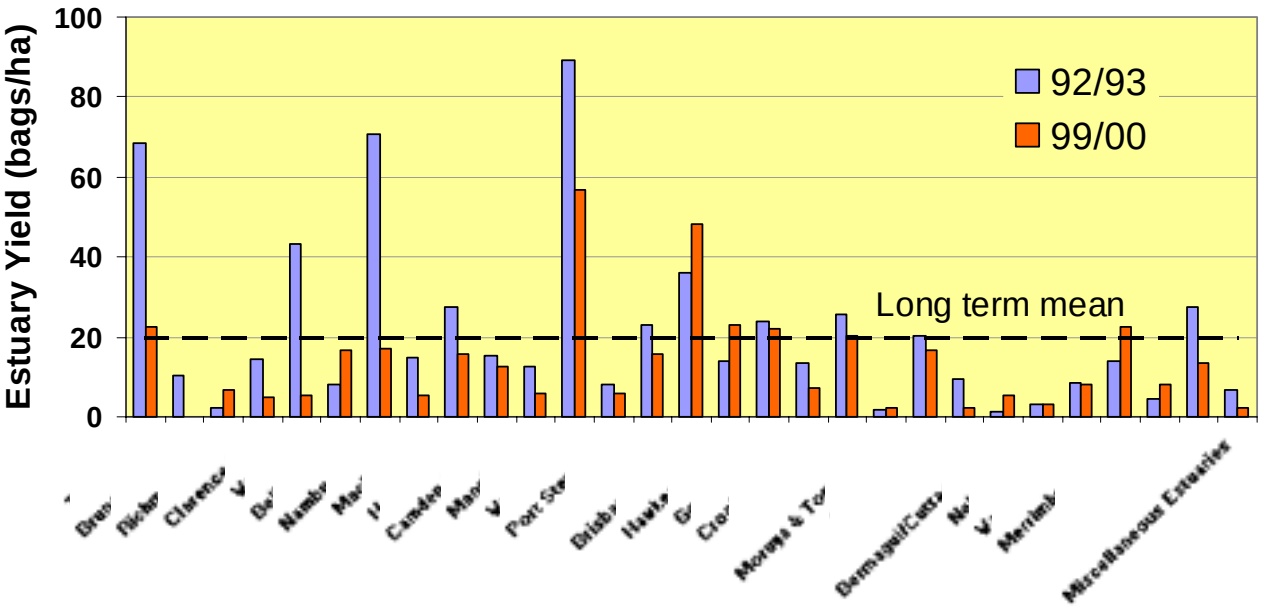

Figure 20. Yield of oysters for NSW estuaries for the years 1992/93 and 1999/2000.

The generally lower yields in the southern part of the state below Brisbane Waters are noticeable in Fig. 20. This could be due to larger proportion of unused sleeper leases in the south, to the impact of winter mortality disease or to the impact of the generally lower temperatures in the southern part of the state on oyster growth rates. The yield data in Fig. 20 are not normally distributed. The distribution of yields is better represented by a log normal

[33] It is noted that NSW Fisheries revamped production return data in 1995-96. The quality of data post 1995 is considered to be more reliable than pre-1995 data.

[34] Caution should be used here, since production techniques differ in different estuaries. Parts of some estuaries, such as Wallis Lake and Brisbane Waters, are used to "finish-off" oysters prior to sale. So that oysters finally sold from a particular location may not have spent their life there.

distribution. The log mean yield of all estuaries in Fig. 20 for 1992/93 was 13.3 bags/ha. The log mean of estuaries from Brisbane Waters north in this period was 19.8 bags/ha, approximately double that of the estuaries south of Brisbane Waters, 8.7 bags/ha. In 1999/2000 the state log mean was 10.0 bags/ha and that north of Brisbane Waters was 12.3 bags/ha, 50% more than that south, 8.1 bags/ha. This 50% is close to 35% increase in growth rates expected from the temperature differences from north to south (see Section 2.1).

Fig. 20 shows that a few estuaries in NSW have yields well above the state long term average. The yield of oysters in Wallis Lake for 1992/93 was nearly 90 bags/ha. Fig. 21 shows the trend in yield for Wallis Lake. For the period 1968/69 to1979/80 production averaged about 44 bags/ha. A significant peak is apparent in the period 1991/93, followed by a decrease. The peak may be due to a shift to selling younger, lower-value oysters. Over the period 1968 to 2000 the average yield for Wallis Lake is 50.3 bags/ha (stand deviation, 14, CV 28%), 250% above the state average. Brisbane waters, Tweed and Nambucca Rivers also appear highly productive. Wallis Lake and Brisbane Waters are used to "finish-off" oyster prior to sale. Given the productivity and importance to NSW oyster production of Wallis Lake, its protection should be paramount[35].

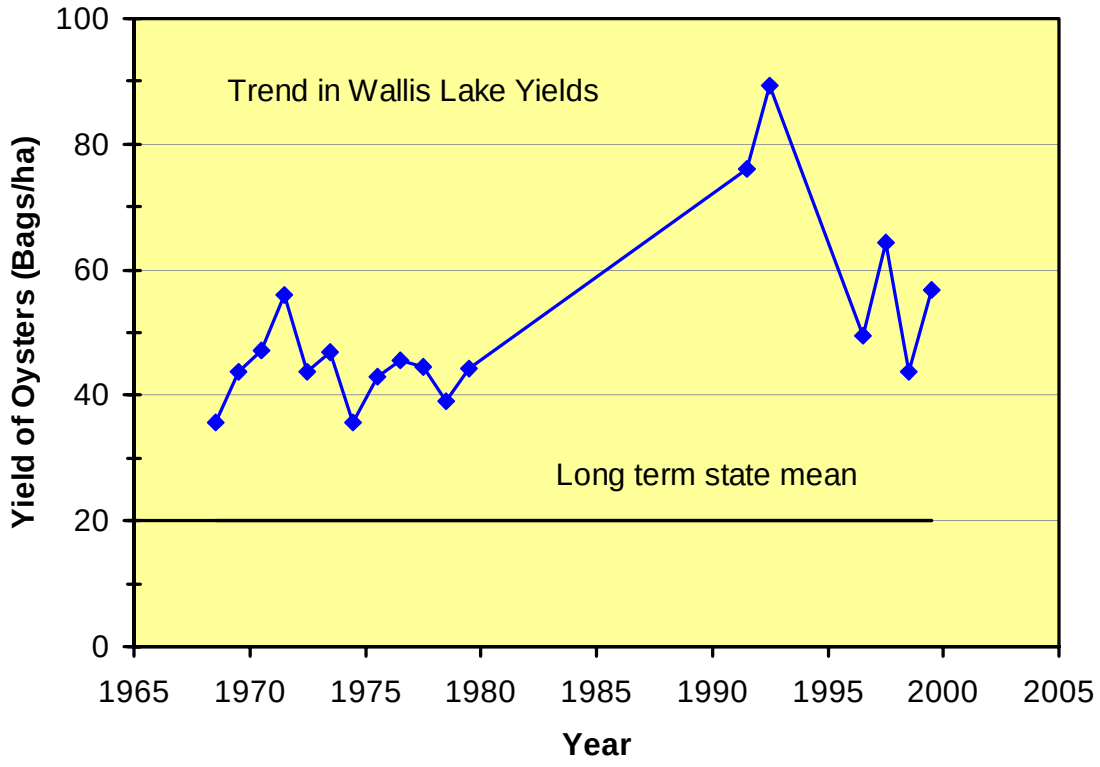

Figure 21. The trend in yield of oysters in Wallis Lake for the period 1968/69 to 1999/2000.

To contrast yields along the coast, Fig. 22 shows the trend in oyster yield in the south coast Wapengo Lake. Again the unused lease area and the reason for the rapid increase in yield between 1972/73 and 1973/74 and the decrease in 1995 to 98 are not known. The mean yield over the period for Wapengo Lake (6.4 Bags/ha) is nearly 8 times smaller than the mean yield of Wallis Lake (49.3 Bags/ha) over the same period. Winter mortality is a problem in southern

[35] Wallis Lake is unusual in that uncertain numbers of oysters are relayed there from the Manning, Hawkesbury and Brisbane Waters for finishing and are reported as a product of Wallis Lake.

estuaries below Port Stephens. It is important that the reasons behind the extreme variability in yield across NSW estuaries be clearly identified.

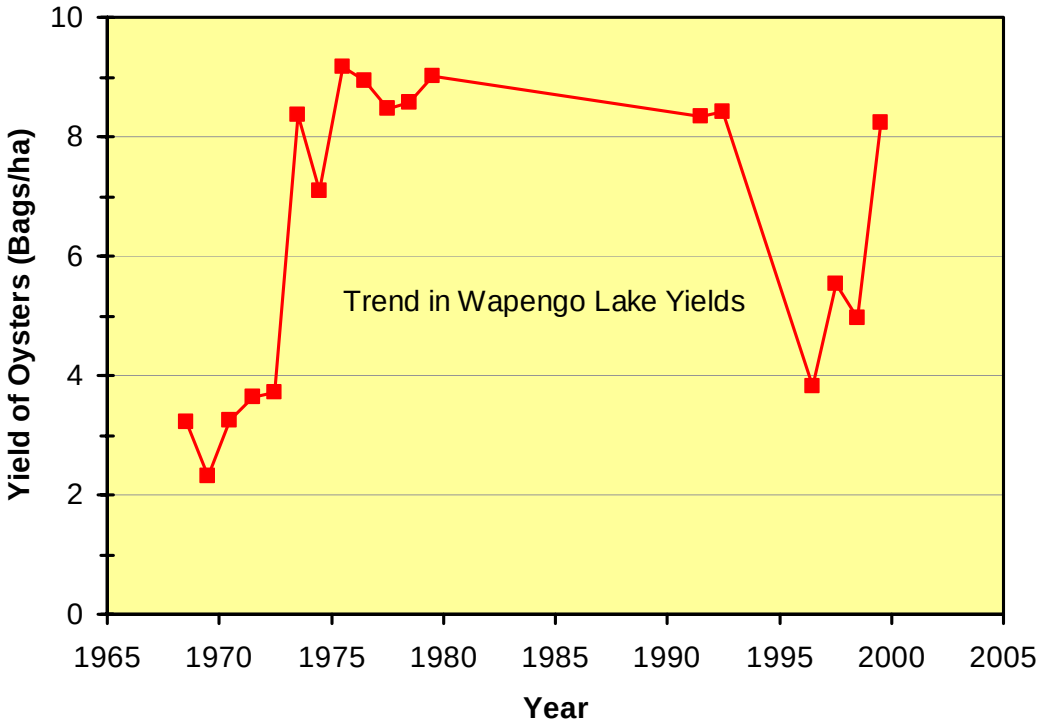

Figure 22. The trend in yield of oysters in Wapengo Lake for the period 1968/69 to 1999/2000.

The results in this section indicate that sustainable annual yields of over double the state average are possible in some locations. This would suggest that an increase in production is possible in NSW, provided the present area suitable for cultivation is maintained. Two key indicators of oyster production have been discussed here. The first is the total lease area available for production. The decline in oyster production in NSW over the last 25 years mirrors the decline in lease area, but with a recent drop in mean yield over the last 7 years. Available lease area is a socio-economic and environmental indicator of sustainability of the industry. Any management prescriptions for restoring coastal lakes must aim at maintaining or recovering lost production areas and exploring planning controls and management techniques for optimising the use of the suitable, available areas.

The second is the annual yield, which appears to have remained essentially static over the period 1968 to 1993 and may have declined since then. In calculating this yield, it has been assumed that the proportion of lease area that is producing oysters has remained unchanged over the state. This may not be so. As well, oysters produced from an estuary may not have spent their lives there because of relaying. This makes the comparison between estuaries problematic.

Unfortunately, the available lease area data is incomplete over periods of critical importance. If yield data based on harvest from actual farmed areas could be collected then farmers, management agencies and governments would have a key indicator of the health of estuaries, a comparator between estuaries and information on primary productivity. The collection of

information on why lease areas are surrendered would provide direct information on the costs of factors such as disease and environmental degradation on production.

4.10 Value of Oyster Yield and Cost of Foregone Production

An approximate measure of the gross returns on oyster leases hectare can be estimated from the mean state production per lease area (20.0 bags/ha) in Fig. 19. If we assume a gross 2001 value of $4.00/dozen oysters, then the gross return is $8000/ha of lease area. This far exceeds gross returns/ha for almost all agricultural crops[36]. For Wallis Lake in 1991 to 1993 present day gross return corresponded to an amazing $35,700/ha[37].

If we assume that the trend in lease area lost is linear in the period of missing data between 1979 and 1991, and 1993 to 1996, then we can estimate the cumulative present-day value of lost production due to the decrease in lease area, since the 1970's. The estimate is shown in Fig. 23 and is based on the assumption that the value of lost are is $8,000/ha. The results in Fig 23, show that the estimated gross, present-day value of the cumulative loss in lease area up to 1999/2000 was around $314 million. If we assume that 1/5 of the lease area lost over the last twenty years is due to water quality problems then we find that the cost of lost production due to environmental factors could be as high as $60M (to 1992/3).

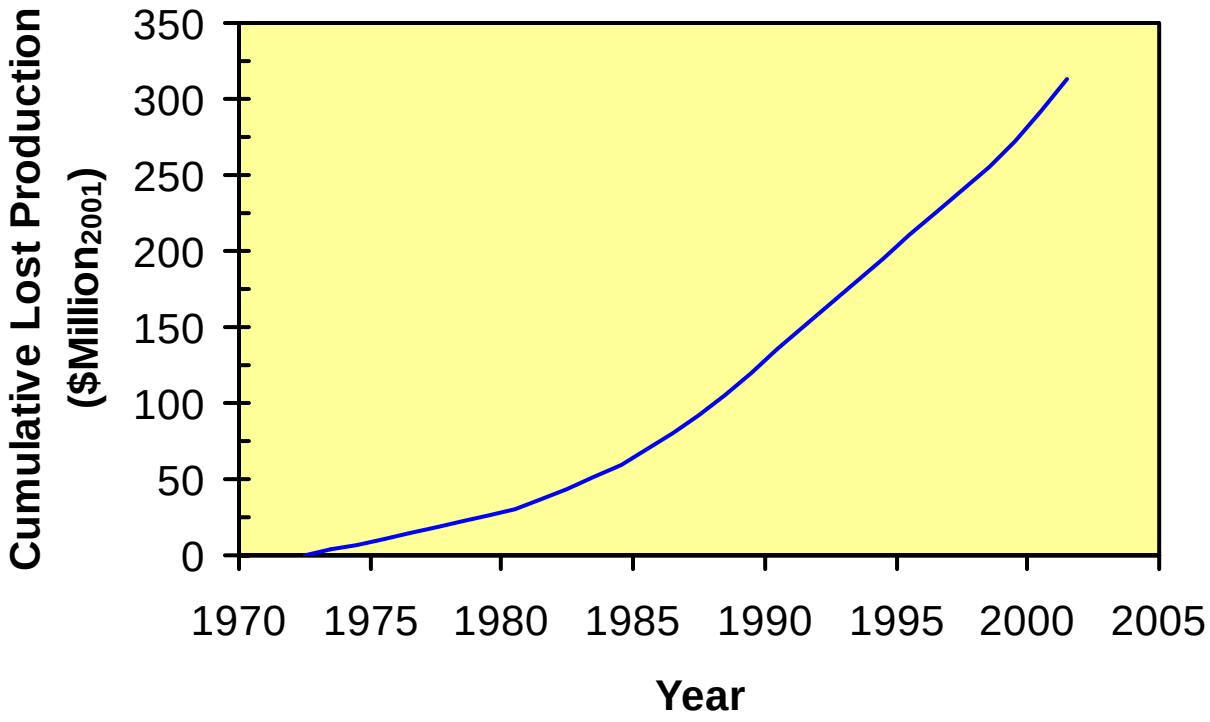

Figure 23. Estimated cumulative value of lost production of lease area for oyster growing.

[36] Recent estimates in Queensland put the value of sugarcane production at $2,000/ha. When converted to shrimp aquaculture that rose to $70,000/ha (R.Tynan pers. com., August 2001).
[37] Assuming a average price of $4.00/dozen. Wallis Lake may produce more smaller oysters than the state average.

4.11 Prognosis Based on Current Trends

There is an increased demand world wide for quality seafood, which is mirrored in Australia. That demand is predicted to continue. The oysters produced within NSW are a unique product. The long "shelf-life" and distinctive flavour make them an ideal product for export, particularly to Southeast Asia. Faced with these, there is cause for considerable optimism for the NSW oyster industry. The above analysis suggests that yield values of close to $35,000/ha are possible, at least in some ares in NSW. This optimism must however be tempered with reality. The trends discussed above are all negative, loss in total production, loss in cultivation area, exhibiting of permit holders and the recent decline in state average yields. If the linear decreasing trend since the late 1970's in Fig. 6 is extrapolated (which it ought not to be) it predicts oyster production in NSW will cease in 2020. Lease area extrapolation suggests that production will cease in 2019, while the number of permits being surrendered suggests that there will be no permit holders by 2009.

The trend in oyster production, TOP, values in Fig.13 and Table 2, show that only 4 estuaries in the state have shown a significant increase in production over the last 5 years. A further two have increased while 7 have remained stable. The rest have declined with nine areas showing significant decreases over the last 5 years. Of those two were once major contributors to the state's production. Even taking these two out, Figs 8 and 9 show a continuing decline in production. This decline appears attributable to a decrease in leased area for production and a recent decrease in average state yields.

The continued high population growth rates in coastal areas, particularly northern NSW, and the development of coastal catchments are the greatest threat to growing healthy oysters. As long as decisions are based on short-term, returns that threat will remain. The foregone production of the oyster industry, currently grossing on average around $8,000/ha, is not taken into account, nor is the long-term sustainability of the estuarine ecosystem. Additionally, the institutional issues of the best way to manage estuaries remain to be addressed. To the industry, governments and their multitude of agencies at all levels have been unable and, in part, unwilling to reverse the decline in oyster production in the state's oldest and most valuable aquaculture industry, despite a raft of legislation and tools[38]. To governments, the industry appears as a disunited, cottage industry, unable to reach consensus on critical issues. Both perceptions are changing.

The introduction of the NSW SQAP and the industries active involvement in monitoring of estuaries signals the industry's commitment to quality product. Rapid structural changes are occurring within the industry. Rodgers (2001) clearly identified the responsibility of governments for maintaining healthy, viable and productive estuaries. The Healthy Rivers Commission (2000b) Independent Inquiry into Coastal Lakes, the draft NSW Natural Waters Based Sustainable Aquaculture Strategy (DUAP & NSW Fisheries, 2001), the acceptance of the Rodgers Report and NSW Government coastal policy provide evidence that this responsibility has been accepted. Together, these suggest a commitment to a viable and healthy oyster industry in NSW.

[38] Growers, in particular, have singled out the Conservation branch of NSW Fisheries for an apparent lack of success in protecting the oyster industry.

5 PROPOSED MANAGEMENT FRAMEWORK FOR COASTAL LAKES

The Independent Inquiry into Coastal Lakes (NSW Healthy Rivers Commission, 2000b) seeks to find ways to improve the health of NSW's coastal lakes. The Commission's concept of a healthy lake includes environmental, social and economic characteristics that define the lake's ecological condition and its ability to support commercial activities and social amenity. The Inquiry will include an assessment of strategies required to secure the health of coastal lakes in which commercial oyster farming is practiced. This is because of the degree of concern over oyster production, issues of public health and the NSW's government's request for strategic advice. The proposed Coastal Lakes Assessment and Management Strategy represents a unique opportunity to protect the quality of estuarine waters in coastal lakes for oyster production. It would be extremely valuable if the Healthy Rivers Commission could discuss the Strategy with the Oyster Management Advisory Committee.

The Inquiry covers 90 lakes spread over the entire coast. It is a salutary lesson that only one of these lakes remains in a truly pristine condition. Of the 90 coastal lakes, fifteen support oyster cultivation and data is available on ten of these lakes. These lakes produce about 37% of the state's total production and include Wallis Lake, which alone produced over 30% of the state's oysters in the past 5 years (see Table 1).

5.1 The Coastal Lakes Assessment and Management Strategy

The Commission has identified that a more effective approach to the management of coastal lakes is urgently required. There are similarities between the 1998 Sydney water crisis (McCellan, 1998) and the contamination of oysters at Wallis Lake, namely the inadequate overall direction in catchment management and the *ad hoc* management activities by agencies, councils and other bodies[39]. The Commission emphasises that improved planning and management of coastal lakes is an imperative and has formulated a draft Coastal Lakes Assessment and Management Strategy as a response to the complex challenges of managing coastal lakes. The draft strategy is based on the Commission's previous Inquiries (summarised in Healthy Rivers Commission, 2000a) and rests on the principles of whole system management, clear accountabilities, more direct management plans, internalisation of the costs of development, and adaptive management[40].

The Commission has concluded that it is essential that a new, stronger, overall framework be introduced to determine the orientation of management decisions and the type of strategies for coastal lakes. It is intended that this framework must provide a platform against which the actions of agencies, councils, developers, industries and interest groups can be tested and due diligence determined.

The recommended strategy for coastal lakes includes:

- adoption of a management framework for major classes of coastal lakes, with flexibility to address the needs of specific coastal lakes;
- preparation of Sustainability Assessments to determine the capabilities and limitations of each coastal lake to sustain human activities, and so provide better information for the preparation of directive plans for existing and new activities and to guide the expenditure of public funds;

[39] *Ad hocery* and policy amnesia are common characteristics of natural resource management in Australia (Dovers, 2001).

[40] Again a note of caution needs to be raised on adaptive management of coastal estuaries. Harris (1999) believes that estuaries may be hysteretic so that adverse changes may not readily be reversed.

- arrangements to implement key elements of the strategy, including assignment of implementation responsibilities, processes to involve councils, agencies and citizens and resolve disputes, monitoring and review, and dedication of resources; and
- a range of supporting initiatives.

The strategy is essentially a practical approach to a complex problem. It appears to be based on the unwritten assumption that all understand and recognise the value of well-managed estuaries. The strategy would be strengthened by included as a first step a formal process of identifying, and clearly stating the basic ethical principles underpinning the sustainable management of estuaries and promoting their common acceptance. The current state of NSW estuaries is largely due to our failure to acknowledge and act on these principles. These principles include equity, environmental justice, sustainability (rates of regeneration and assimilative capacity), and the protection of livelihoods. Fundamentally, the almost cultural notion that estuaries are the "end of the waste pipe" must be changed[41].

5.2 The Management Framework

The management framework is the central plank of the Coastal Lakes Assessment and Management Strategy. It introduces a more defined framework for managing each of the Commission's four major categories of coastal lake and is intended as a guide for critical management decisions. Lakes are categorised according to the underlying intention (or orientation) of management decisions. The framework provides guidance for each category as to:

- the underlying intention of management decisions;
- the intended outcomes of decisions against which success can be monitored;
- the types of broad management strategies appropriate for the lake category; and
- a range of management mechanisms or "tools" to implement the strategies.

The framework is designed to be sufficiently flexible to encompass the unique features of specific lakes and includes mechanisms to monitor the effectiveness of strategies and provide feedback for adaptive management. The framework is essentially a practical, transparent approach to the preservation and restoration of the health of coastal lakes. It identifies key issues and provides clear guidelines for governments, agencies, industries, community groups and the public.

The four categories that highlight the intent of management decisions are:

- comprehensive protection;
- significant protection;
- secure healthy, modified conditions; and
- targeted repairs.

5.3 Sustainabilty Assessments

Sustainabilty Assessments are a key processes in the Management Strategy. The Commission that the capabilities and limitations of coastal lakes to support human activities should be made at three levels: state; lake specific; and site specific.

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[41] The Provincial Resource Policy, May 1993, of the Ministry of Agriculture, Fisheries and Food of British Columbia[41] provides an excellent model for the explicit recognition of the key ethical principles for managing the environment in and surrounding estuaries.

5.31 State Wide Assessment

The Commission's Inquiry is essentially the state wide assessment and the Commission has made a preliminary classification of coastal lakes in NSW according to its four categories. The Commission intends that Sustainability Assessments would become the basis for explicit and rigorous local environment plans (LEPs) supported by development control plans for all coastal lakes.

5.32 Lake Specific Assessments

The Commission proposes that relatively brief and straightforward Lake Specific Assessments, mostly based on existing information, should be conducted by local council(s) in conjunction with state agencies and would consider the opportunities and constraints for existing and future human activities. There is, of course, a resource implication here. The Commission has already noted that the devolution of responsibilities by state governments to local governments has occurred without the corresponding provision of resources. State agencies are also heavily committed in their work plans. In addition, coastal councils vary widely in their capability. It would seem that in order to carry out Lake Specific Assessments, specific allocation of resources to the task is required.

The illustrative example given by the Commission envisages a Lake being zoned into various categories. In the example, these categories include:

- extreme risk-no development/ no boat discharge;
- high risk-no septic. Sewer overflows;
- moderate risk-stringent controls on on-site systems; and
- low risk-standard controls.

In commercial oyster producing lakes, it would seem that there is considerable overlap with Lake Specific Assessments and the shoreline sanitation surveys of the NSW SQAP. It would be efficient to include the work of local SQAP committees in Lake Specific Assessments of these lakes. In addition, the Draft Aquaculture Industry Development Plan, AIDP proposes the zoning of aquaculture areas. While the Strategy has a much broader thrust than the development of aquaculture, it is fundamentally important that these complementary approaches be mutually consistent and be carried out cooperatively. In particular aquaculture maps produced under the AIDP will indicate generally where water quality is good. These will provide useful information for lake-specific assessments.

5.33 Site Specific Assessments

The Commission proposes that site specific assessments should be undertaken by the proponents of development proposals and would represent the fine-tuning of lake-specific assessments. Site specific assessments would form the basis for decisions on a proposal's design details. Such assessments would determine the actions necessary for a specific development to comply with the findings of a lake specific assessment and resultant planning requirements. In commercial oyster producing lakes any site specific assessments should include a specific assessment of the impact of development on the production of healthy oysters.

5.4 Mechanisms for Implementing the Strategy

Implementation of the Strategy is fundamentally important. In previous reports (summarised in Healthy Rivers Commission, 2000a), it has been shown that the plethora of governments, agencies, and organisation with responsibility for the health of estuarine waters, but often conflicting objectives, is a major impediment to their management (see Section 3.7). The notion

of a single authority responsible for the health of a river system is very attractive (Sturgess, 1998). Indeed the NSW Government has adopted that model for Sydney's water supply catchments with the formation of the Sydney Catchment Authority. Given the general opposition in government to the creation of other levels of organisation, the Commission has not recommended the formation of a Coastal Lakes Authority. Although its suggested use of the Coastal Council of NSW together with the proposed independent Coastal Lakes Expert Group could be considered a *defacto* non-statutory Authority. The Commission initially proposed that the management framework be formalised through a Protection of the Environment Policy[42]. Under this all agencies and councils would be required to consider the management framework and lake classifications in their planning, approval and operational programs. More recently the Commission has advocated the introduction of a State Environment Protection Plan (SEPP).

The Commission proposes that a dispute resolution process should be established in advance to resolve any disputes between citizens, councils and/or agencies. It proposes that the Coastal Council of NSW could mediate in such disputes as an independent, knowledgeable body.

The next stage in implementing the Strategy is the preparation of lake specific Sustainability Assessments. In order that these be creditable and acceptable at all levels, the Commission suggests the formation of an independent Coastal Lakes Expert Group appointed and overseen by the Coastal Council of NSW[43]. Presumably, independent means free from direct government control of the Group's operation.

It is intended that the Group would specify the criteria and methodology for Sustainability Assessments, professionally validate the findings and actions proposed by councils and agencies and provide advice on the content of educational material. It is envisaged that the Group would have expertise in ecological, social, economic and planning issues related to coastal lakes. It is presumed that expertise in geomorphology, hydrology and oyster production is implicit in this list. It is important that the Group has a sufficient life-time to complete its important tasks.

Other steps in the preparation of Sustainability Assessments include:

- Councils and agencies share the lead role in preparing Sustainability Assessments for coastal lakes within their jurisdiction;
- Councils required to develop or review their local environment plans to incorporate the findings of Sustainability Assessment
- Independent, strategic, state-wide reviews of the effectiveness of the Management Framework over the longer term.

Again, the resourcing of the councils' and the agencies planned activities is an issue. The level of advice available to councils and agencies is a critical issue in ensuring the success of the strategy. The Commission suggests that the Coastal Lakes Expert Group will assist councils and agencies with high-level advice. In the past in NSW, such groups have been part-time and almost voluntary organisations. Very little provision is made for state agency employees assigned to such groups where the work is considered an "optional extra". University and other organisation appointees are normally expected to provide their advice free of charge or at

[42] Issued under the Protection of the Environment Operations Act 1997. Alternate mechanisms are a State Regional Environmental Plan or a State Environment Planning Policy under the Environmental Planning and Assessment Act 1979.

[43] In same ways this is similar to the model adopted by NSW Acid Sulfate Soil Management Advisory Committee that set up an ASSMAC Technical Committee to provide technical advice on the management and restoration of acid sulfate soil areas.

notional sitting fees. The Commission also suggests funding support through a range of State agency programs. The possibility of Commonwealth funding from Environment Australia should also be considered. Sustainability Assessments and hence the whole management framework will only be successful if serious attention is paid to the resourcing of the assessment process. The decision by the NSW Government to fund the coastal lakes assessment strategy under its Comprehensive Coastal Assessment is an encouraging step.

There is also a critical issue in terms of the long-term review of the framework that was raised in considering the characteristic of institutions for sustainable management. It is that such institutions must be long-lived and adequately resourced (see Section 3.7). The fundamentally important task of reviewing the effectiveness of the Management Framework requires a long-lived organisation and demands and a commitment longer in term that the term of state governments. It is therefore important that the Strategy be agreed to by all political persuasions and that a commitment be made to the maintenance of such an organisation.

5.5 Coastal Lake Assessment and Management Strategy and Oyster Production

An important facet of the Strategy for oyster production is the Commission's specific proposals that an intended outcome should be to minimise public health and economic risk for oyster growing in Wallis, Wagonga, Tuross, Merimbula, Conjola, Queens/Watson Taylor, Womboyn and Pambula Lakes. Within the four categories of coastal lakes, the Commission has identified the following commercial oyster producing lakes[44] (annual production of oysters in bags for the latest year of production and the percent contribution to the total state production for 1995-2000 are shown in parenthesis where available)[45, 46]:

Comprehensive protection

- Kiah (1 lease, 1.8 ha)

Significant protection

- Conjola [57 bags, 1999/2000]
- Cuttagee [40 bags, 1999/2000, 0.6%]
- Nelson [130 bags, 1999/2000, 0.2%]
- Pambula [920 bags, 1999/2000, 1.3%]
- Wapengo [801 bags, 1999/2000, 0.7%]
- Womboyn [130 bags, 1999/2000, 1.2%]

Secure healthy, modified conditions

- Burrill [29 bags, 1993/94, 0%]
- Cobaki-Terranora (Tweed River) [609 bags, 1999/2000, 0.9%]
- Merimbula [2888 bags, 1999/2000, 2.8%]
- Tuross [1483 bags, 1999/2000, 1.7%]
- Wagonga [2028 bags, 1999/2000, 3.5%]
- Wallaga (2 leases, 1.7 ha)
- Wallaga (Little)
- Wallis [20691 bags, 1999/2000, 30.3%]

Targeted repairs.

Nil

[44] These are lakes for which NSW Fisheries has some current or historic oyster production statistics.
[45] To a first approximation, a bag of oysters is valued at about $400 at the farm gate.
[46] Data from lakes that have only one or two growers is not available due to confidentiality.

Any lake falling under targeted repairs would probably be classed as prohibited under a SQAP classification program.

While not explicitly stated, it would appear from the listed strategies that oyster farming may not be possible in lakes in the *comprehensive protection* category. For lakes under the *significant protection category*, one strategy is to minimise intervention in natural entrance behaviour. Since oysters require adequate tidal exchange, this would appear to limit commercial cultivation to those lakes that are either always open to the sea or mostly open to the sea. Another strategy within this category calls for an exclusion of new, intensive aquaculture development. This would appear to limit any future expansion of oyster production in lakes within this category. It is, noted however, that a listed possible outcome for this category is *minimal risk to existing oyster growing.* Under the *secure healthy modified conditions* category, a proposed strategy is to adjust entrance intervention to protect critical ecological processes such as bird feeding events. Current oyster farming is mostly practiced in lakes with entrances that are normally open. It is envisaged that in most cases this strategy would cause no change. The central point of the proposed lakes' strategy is that actual actions carried out in a specific lake will be resolved by the lake specific Sustainability Assessments.

Setting aside the key strategy of Sustainability Assessment, some of the other strategies proposed under the categories that permit commercial oyster production address specific threats to oyster production. These include:

Significant protection

- Limit development of new dwellings to within the boundaries of existing villages and rural residential areas;
- Mitigate (or remove) existing sewerage discharges, overflows and septics (no new discharges);
- Encourage use of best farming and forestry practices;
- Exclude new intensive agricultural or aquaculture development;
- Stringently manage recreational and commercial uses.

Secure healthy, modified conditions

- Enforce stringent controls on new urban, rural residential and intensive agricultural developments (provided these are demonstrated to be sustainable);
- Locate no new assets (such as sewerage, roads, and dwellings in areas subject to flooding/ water logging under natural entrance conditions; and
- Exclude new sewerage discharge or overflows, stringent management of septics.

These strategies address the principle concerns of oyster growers in terms of human faecal contamination of oysters, increased sedimentation, changes in runoff rates due to catchment development and sources of agricultural nutrients and pollution. Given the sensitive of oysters to acid runoff from acid sulfate soils, a specific strategy dealing with the avoidance of their disturbance in areas neighbouring coastal lakes, or the complete treatment of runoff is important[47]. As well, an overall strategy for those lakes in which oysters are grown, in which any new development proposals must specifically address the increased risks posed by the development on oyster health and growth.

The Strategy represents a very positive step towards providing greater security for investment decisions in the oyster industry. It needs to be seen in the context of other initiatives such as the

[47] This strategy would be linked to the Acid Sulfate LEPs already instituted or being prepared by coastal councils.

response of Safe Food Production NSW to the Rodgers' Report and the Draft Aquaculture Industry Development Plan.

5.6 Conflict Resolution and the Use of Multi Agent Systems

The resolution of disputes over natural resources management depends on the stakeholders' perception of the local constraints and opportunities (Perez et al. 1997). Social rules and economic features often outweigh technical aspects especially in agriculture and fishing (Gintis, 2000). Including these aspects in policy and practices is a significant challenge. Environmental policy implementation is increasingly relying on Decision Support Systems. However social bias may disrupt the rationality of their technical and economic assumptions. Hence, complementary approaches are needed to explore the uncertainty and complexity of the interactions and to resolve disputes (Holling, 1999).

Recent advances in the field of Distributed Artificial Intelligence have permitted the development of a Multi Agent System (MAS) approach, closely related to the problem of complexity (Ferber, 1999). The object-oriented programming allows great flexibility in changing the attributes of the agents and provides an unchallenged replicability of the objects. Therefore, MAS constitute powerful tools for studying interactions between societies and their environment, as Negotiation Support Systems. They have the potential to greatly reduce conflict over natural resource management. Essentially parties in conflict use MAS systems to explore outcomes of decisions together. This exploration allows all parties to develop an appreciation of the requirements of others and of the long-term impacts of decisions on natural resource management.

A case study of the application of MAS to the use and preservation of Coastal Lakes, particularly in terms of the oyster industry would be valuable.

5.7 A Note of Caution on Adaptive Management in Estuaries

Previously in this report, attention has been drawn to a problem in the application of adaptive management to estuaries. Adaptive management is a practical response to the complexities of managing complex situations. Essentially it assumes linear processes where the impacts of erroneous decisions can be readily reversed by altering the decision. It has been emphasised here that estuaries appear to behaviour in a nonlinear, hysteretic manner (Harris, 1999). This means that the impacts of incorrect management decisions may not be easily reversed.

Two cases illustrate the point. The decision to drain backswamp areas in coastal floodplains both for flood mitigation and to improve agricultural productivity has resulted in the acidification of large areas of coastal floodplains in NSW. Acidification changes the soil irreversible and has resulted in the storage of large quantities of acidic products within the soil profile (White *et al.*, 1997). While blocking drains alters the rate of export of acidity, large stores of acid are still remain in the soil to be exported in the recession phase following major flood events. The efforts required to reverse this are orders of magnitude greater than the original effort required to drain floodplains.

The second example is the decision to introduce non-native Pacific oysters into Port Stephens. The robust nature and faster growing rates of the Pacific oyster decimated the Sydney rock oyster fishery within Port Stephens. As a result, Table 1 shows that Port Stephens was the top producer of oysters in NSW, producing 25% of state's oysters in the period 1937-1995 but in

the period 1995-2000 had slipped to the fourth, producing less than 9% of the state's production. This decision has resulted in the loss of livelihood for many growers in the area.

5.8 Advice and Recommendations

Advise on any specific amendments to the Commission's proposed management framework that would make it more effective as a means of assuring safe, commercially viable oyster cultivation in relevant catchments.

The Healthy Rivers Commission Coastal Lake Assessment and Management Strategy represents a major, positive change in the management of estuaries and one that has considerable potential benefits for the oyster industry. Unlike the draft AIDP, it make a specific commitment to ensuring water quality for healthy oyster production. The proposed Strategy represents a unique opportunity to protect the quality of estuarine waters in coastal lakes for oyster production. There would be great benefits to the oyster industry in NSW if the Coastal Lake Assessment and Management Strategy were extended to all commercial oyster-producing estuaries in NSW. The establishment of the coastal lakes strategy will mean that oyster farmers in other coastal estuaries will be disadvantaged relative to their colleagues in coastal lakes.

- It is recommended that the extension of the Coastal Lake Assessment and Management Strategy to all commercial oyster-producing estuaries in NSW be considered.

The Strategy is essentially a practical approach to a complex problem. The strategy would be strengthened by included as a first step a formal process of identifying, and clearly stating the basic ethical principles underpinning the sustainable management of estuaries and promoting their common acceptance. These include equity, environmental justice, sustainability (rates of regeneration and assimilative capacity), and the protection of livelihoods.

While not explicitly stated, it would appear from the listed strategies that oyster farming may not be possible in lakes classified under the *comprehensive protection* category. For lakes under the *significant protection category*, one strategy is to minimise intervention in natural entrance behaviour. Since oysters require adequate tidal exchange, this would appear to limit commercial cultivation to those lakes that are either always open to the sea or mostly open to the sea. Another strategy within this category calls for an exclusion of new, intensive aquaculture development. This would appear to limit any future expansion of oyster production in lakes within this category. It is, noted however, that a listed possible outcome for this category is *minimal risk to existing oyster growing.* Under the *secure healthy modified conditions* category, a proposed strategy is to adjust entrance intervention to protect critical ecological processes such as bird feeding events. Current oyster farming is mostly practiced in lakes with entrances that are normally open. It is envisaged that in most cases this strategy would cause no change. The central point of the proposed lakes' strategy is that actual actions carried out in a specific lake will be resolved by the lake specific Sustainability Assessments. From the oyster industry perspective, any further loss of the suitable area available for leasing for oyster production must be avoided.

- It is recommended that the consequences and options for oyster production be explicitly identified under each lake category.

- It is recommended that the maintenance of all lease areas suitable for healthy oyster production be considered a fundamental objective of the strategy.

Given the priority assigned by the industry to the disturbance of acid sulfate soils the strategy should include particular reference to them.

- It is recommended that the liaison with ASSMAC and DUAP take place over the inclusion of strategies specific to the disturbance/drainage/treatment and rehabilitation of acid sulfate soils in the proposed Coastal Lakes Strategy.

The Strategy suggests the formation of an independent Coastal Lakes Expert Group appointed and overseen by the Coastal Council of NSW. It is intended that the Group would specify the criteria and methodology for Sustainability Assessments, professionally validate the findings and actions proposed by councils and agencies and provide advice on the content of educational material. It is envisaged that the Group would have expertise in ecological, social, economic and planning issues related to coastal lakes. Because of the significant pressures on such experts, careful consideration will need to be given to how this group is supported and resourced.

The provision of incentives and the resourcing of councils' planned activities in Sustainability Assessments are critical issues. The Commission suggests that the Coastal Lakes Expert Group will assist councils with high-level advice. Sustainability Assessments and hence the whole management framework will only be successful if attention is paid to the resourcing of the assessment process including the involvement of the Coastal Lakes Expert Group, councils and the Coastal Council. It is important that a strategic approach to funding by the state be developed. The decision by the NSW government to fund the coastal lake assessment under its Comprehensive Coastal Assessment is a welcomed decision

- It is recommended that a strategy be developed for providing adequate financial resources and incentives over sufficient time for the involvement of councils and the proposed Coastal Lakes Expert Group.

The resolution of disputes over Sustainability Assessments is seen a important and it has been proposed that the Coastal Council could mediate in such disputes as an independent, knowledgeable body. Multi Agent Systems may help in the resolution of disputes.

- It is recommended that the use of Multi Agent Systems in helping resolve disputes be explored.

It has been proposed that the Strategy will employ adaptive management to estuaries. Adaptive management is a practical response to the complexities of managing complex situations. Estuaries appear to behaviour in a hysteretic manner. This means that the impacts of incorrect management decisions may not be easily reversed.

- It is recommended that the risks of using adaptive management in estuaries be explored.

6 THE DRAFT AQUACULTURE INDUSTRY DEVELOPMENT PLAN

The draft Aquaculture Industry Development Plan, AIDP, (DUAP & NSW Fisheries, 2001) has been developed under the Provisions of the Fisheries Management Act 1994. Its purpose is to promote economically and environmentally sustainable natural waters agriculture by providing guidance for responsible aquaculture practices. For the already established oyster industry, the plan comes 100 years late, although its introduction should provide security of tenure for oyster growers. The AIDP is an initiative of NSW DUAP, NSW Fisheries, Department of State and Regional Development, Environment Protection Authority, Department of Land and Water Conservation, national Parks and Wildlife Service, and NSW Agriculture. Although it describes itself as a NSW Government Initiative, at present, it unfortunately does not include the NSW SQAP, or Safe Food Production NSW, a central player in the classification of estuaries.

6.1 Objectives of the AIDP

The specific objectives of the AIDP are to:

1. Provide the basis for attraction of investment and employment in sustainable aquaculture in NSW and the recognition of NSW for its sustainable aquaculture industry.
2. Facilitate sustainable aquaculture in natural waters through:
   a. reinforcing within the aquaculture industry the need for a commitment to environmental sustainable practices and a duty of care for the environment in which the industry is located.
   b. Ensuring environmental factors are considered in site selection for the optimum siting of new aquaculture enterprises;
   c. Ensuring environmental factors are considered in the planning, design and operation of all aquaculture enterprises.
3. To provide the technical basis for the efficient and effective regulation of the industry with up-front certainty to applicants, the community and decision makers as to the appropriate environmental performance of aquaculture.

It is surprising, particularly given objective 1, that there is no up-front commitment here to ensuring the water quality conditions necessary for aquaculture are protected. As Rodgers (2001) pointed out … "*the State needs to provide guaranteed water quality standards consistent with high quality shellfish production*." Such an objective would seem fundamental to the success of attracting investment and sustaining employment in aquaculture.

The AIDI includes detailed guidelines on:

- business planning;
- species selection;
- site selection;
- planning and design;
- operating the farm.

The natural water based AIDP deals predominantly with Crown Lands. Site selection within the plan has a focus on the public values of the lands within or over which aquaculture development takes place. It intends to map the areas that are suitable for aquaculture development, given the statutory requirements of other users (such as navigational channels). These mapped areas are the first level of a site assessment program which consists of a number of "sieves" which provide a mechanism for determining the likely level of environmental risk at

any particular site. While the mechanism is sound for the establishment of new aquaculture sites, it does pose problems for the already established oyster industry with established leases.

The AIDP suggests that overstocking of some estuaries/zones has lead to declines in oyster production. Based on an examination of historic oyster production since the 1930's, the AIDP provides a first-pass, historic-based estimate of the Maximum Sustainable Yields, MSY, of NSW estuaries. These MSY will be used to set input controls on oyster farming including:

- maximum target area for leasing within an estuary;
- maximum target area for leasing within a Zone in an estuary[48];
- permissible types of culture within Zones;
- limits on the area to be cultivated within a lease[49];
- limit on stock within a lease.

Pacific oysters will only be permitted to be grown in Port Stephens and Flat oysters in estuaries where they are indigenous.

The AIDP introduces three aquaculture zones:

- M zones-areas contained within the marine environment;
- E zones-areas contained within the estuarine environment; and
- L zones-areas associated with land-based facilities.

The E-zone, in which only extensive aquaculture will be permitted, is the area of concern of oyster farming and of the Coastal Lakes Management Strategy. Within estuaries, areas will be excluded from aquaculture when they are: within recognised boating or shipping channels; above –.4 m AHD; with a predominant reef or rocky bed; within 100m of any marina, public wharf, public boat ramp or designated mooring area; and that are recognised commercial net hauling grounds.

6.2 Water Quality Requirements

The AIDP acknowledges that access to good quality water is fundamental to the success of all aquaculture. Aquaculture maps produced under the AIDP will indicate generally where water quality is good however site specific tests may be required. The water quality objectives of the AIDP require examination of the waters for species specific water quality information, including:

- appropriate temperature range for the species;
- appropriate salinity, pH and alkalinity;
- freedom from pathogens;
- acceptable levels of suspended particles; and
- acceptable levels of organic, agricultural or industrial pollution.

The AIDP proposes that waters should meet the 1992 ANZECC Water Quality guidelines[50]. The water quality data produced under the NSW SQAP should assist in identifying areas with good quality waters. The AIDP also generally specifies the tidal characteristics required to

[48] Given the extreme variability in yields between estuaries shown in Section 4.7, the use of estuary-wide MSY to inter estuary stocking densities seems problematic.
[49] This could be refined by specifying the maximum stocking density.
[50] Oysters are facultive anaerobes that can survive extended periods of adverse water quality (up to 4 weeks for Sudney rock oysters).

provide adequate exchange and flushing if estuarine waters are to recover rapidly from rain events. The tidal and site characteristics specified are:

- tidal exchange < 15 days;
- tidal amplitude > 300mm;
- access – requiring no deepening or dredging of the estuarine beds;
- not affected by poor water quality or likely to affect others by poor water quality; and
- other water users – no facilities or infrastructure to affect water quality or quantity.

The characteristics identified in the AIDP provide a useful starting point for Lake Specific Sustainability Assessments. Sustainability Assessments in return will also provide a valuable platform for site selection and planning under AIDP since the plan identifies the necessity for early discussions with local council to gauge future strategic land use directions. It notes that sites within "stable" agricultural areas are preferable and that sites in transition from agriculture to rural residential or urban carry long term risks.

A critical issues to oyster farmers is who makes decisions on aquaculture leases. The AIDP identifies the consent authorities as the local council or the Minister for Urban Affairs and Planning, together with NSW Fisheries. The oyster industry would prefer a "one-stop shop."

A draft Port Stephens Region Schedule and associated aquaculture maps have been prepared, as part of the AIDP. These show eight E Zone areas and two M Zones within Port Stephens. Of these, seven E Zones are suitable for conventional oyster cultivation. The eight E Zones cover more than 2,900 ha. This compares with the current lease area for these zones of 561 ha and previous lease areas around 1190 ha. The target lease area in the Schedule for Port Stephens is 750 ha. The Schedule specifies that only 30% of the identified aquaculture area within a zone will be developed (for E Zone oysters 870 ha) and only 1/3 of an oyster lease will be under development at any time.

The AIDP represents a significant and long-overdue improvement for oyster growing in NSW. It complements the Coastal Lake Management Strategy and the Safe Food Production NSW response to the Rodgers' Report. One significant issue will be how the AIDP is applied in transition to the 130 year-old, existing oyster aquaculture industry, rather than to new aquaculture initiatives. Another issue will be the inclusion of all relevant state agencies within the strategy. A "one-stop shop" would be a considerable saving to the oyster industry. Finally, an up-front commitment to ensuring that water quality in estuaries is maintained at a standard required for healthy aquaculture production would seem a necessary object in order to attract investment and sustain employment.

7 CONCLUDING REMARKS

The 130 year-old NSW oyster industry is Australia's oldest, post-European-settlement, aquaculture industry. It is by far most valuable aquaculture industry in NSW, producing 80% of the total value of aquaculture product. The average gross present value of production from oysters across the state is $8,500/ha. Some estuaries have returns as high as $35,000/ha. This makes oyster production the state's most valuable agricultural enterprise per unit area.

An analysis of historic and recent trends in NSW oyster production shows disturbing features. The states' production continues its downward trend from the late 1970's. The Trend in Oyster Production Index, introduced in this report shows only 6 estuaries (4 significantly) increased their production over the last 5 years of the last decade. This is compared with 18 estuaries in which production decreased (9 significantly) while only 7 remained stable. Production in two major oyster-growing estuaries, Port Stephens and Georges River, has almost collapsed due to disease and the introduction of Pacific Oysters. When these estuaries are removed from the state's oyster production, the general, declining trend in oyster production is still apparent.

The available data shows that the decreasing trend in oyster production follows the decrease in area leased up by growers until 1993. After that time both area of leases and annual yields decreased. Many factors contribute to the decline in area leased to growers, some socio-economic, some due to disease, and some environmental. Data is not available to determine the area lost because of environmental degradation. What is surprising is that in the period 1968/69 to 1992/93 the state average state yield of oysters remained remarkable constant at about 21 bags/ha of lease area. Since 1993, average annual state yields have declined despite the introduction of new technologies into the industry[51]. The reasons for this decrease remain to be explained.

Comparison of individual estuary yields (in terms of production per lease area) is more difficult since the assumption of a constant area of unused lease area is problematic between estuaries, particularly between small and large estuaries. In addition, relaying means that not all oysters sold for production from an estuary spent their adult life there. None-the-less, estuary yield trends provide useful information on changes within estuaries and individual yields indicate what is possible. The highest recorded yield in the state was nearly 90 bags/ha at Wallis Lake. Average annual yield at there, 50.3 bags/ha, is 250% above the long-term state yield of 20 bags/ha. Brisbane Waters is also a consistently higher yielding location. Oysters are "finished-off" at both locations. It is suggested that the state's lease area available for oyster production is an important industry sustainability indicator. In addition, that oyster yields are a valuable tool for comparing the efficiency of production between years both at the state level and estuary level.

The decreasing trend in oyster yields and the very large variations between oyster yields in estuaries needs to be explained. Estuary oyster yield data from Wallis Lake and Brisbane Waters suggest that increases in oyster yield, and hence overall production are possible. Wallis Lake, because of its importance to the state's oyster production, and its productivity, deserves special protection.

The maturity and success of the oyster industry in NSW, and the structure of the industry have meant that it has suffered benign neglect from governments. In addition, there has been a

[51] Again it is emphasised that it has been assumed here that the proportion of unused lease area has remained unchanged over he period 1968 to 2000.

general, long-term cultural perception that estuaries are the “end of the waste pipe” so that the fundamental ethical questions about the sharing and use of natural resources in estuaries have not been addressed. The Wallis Lake oyster-born enteric disease outbreak illustrated the problems. The NSW Government has responded to this outbreak and to the more general public concerns about the health of coastal systems. The Healthy Rivers Commission Coastal Lake Assessment and Management Strategy, the acceptance of the Rodgers (2001) Report on NSW Shellfish Quality Assurance Programme, and the Aquaculture Industry Development Plan, together represent a major, positive shift in attitude, and one that is long overdue. All these recommend classification of estuaries and of zones within estuaries as an essential step in their better management and in producing healthy oysters

There are gaps in knowledge about the basic physiology of the Sydney rock oyster. Nevertheless, the general conditions for growing healthy oysters are well known. These are generally, well-oxygenated, clear brackish to saline waters, with pH in the range 6.75 to 8.75, with suitable tidal exchange, adequate phytoplankton food supplies and control of upstream sources of runoff and pollution. The NSW Shellfish Quality Assurance Program was introduced to ensure that harvested shellfish sold for consumption meet specified quality standards in order to reduce the risk to consumers and to protect the industry from a deterioration in both public confidence and growing conditions in estuaries. Rodgers’(2001) clear and rational review of the NSW SQAP provides an opportunity for the industry to attain equivalence with shellfish producers elsewhere in Australia and overseas. This will increase the export opportunities for the industry. More importantly, implementation of the review will result in the classification of growing areas. The classification scheme provides details on the conditions necessary to grow healthy oysters. These classifications should be an important contribution to the Sustainability Assessments which a central plank of the Coastal Lake Strategy.

A great advantage in growing oysters in NSW is the range in growing conditions available along the entire length of the coastline. However there are significant threats to oyster production caused by the range of physical and social environments. The northern area is the region of highest temperatures and greatest oyster growth rates. However, rapid population growth there is a threat to growing healthy oysters. Additionally, the presence of large areas of acid sulfate soils in the region also poses a threat to oyster production. The strategies proposed in the Coastal Lake Management Framework provide clear mechanisms to ensure that any new developments will not increase the threat to oyster production and also provide a means for addressing and correcting existing problems. These strategies address the principle concerns of oyster growers in terms of human faecal contamination of oysters, increased sedimentation, changes in runoff rates due to catchment development and sources of agricultural nutrients and pollution. A strategy relating to the prevention of acidic discharges due to acid sulfate soils should be specifically included.

The institutional miasma surrounding the management of coastal lakes and rivers has been adequately identified by the Healthy Rivers Commission. From the oyster industry perspective, it is costly, inefficient, confusing frustrating, ecologically damaging and a detractor to investment. The development of a “one-stop shop” would be a tremendous advance. The Coastal Lake Management Strategy cannot deliver that, but what it can deliver is a uniform approach so that all agencies, governments and industry are forced to consider the maintenance and improvement in the health of estuaries in any actions.

The Healthy Rivers Commission readily acknowledges that conflict will arise in the process of developing Sustainability Assessments for Coastal Lakes. It proposes that the NSW Coastal Council could mediate in such disputes. It is suggested here that Negotiation Support Systems

based on Multi Agent Systems may be an efficient mechanism for resolving conflicts and should be trialed.

Three things will be needed for the Coastal Lake Management Strategy to be a success. The first is for the NSW government to endorse, and the community to embrace the Strategy. The second is that Lake Sustainability Assessments are adequately resourced. The third is that there is a long-term commitment to the process of reviewing its effectiveness and updating the Strategy. From an oyster industry perspective the Strategy will have been a success if it forces all players in the management of coastal lakes to consider firstly the impacts on the health of oysters and the livelihoods of growers of any actions in, surrounding or connected with coastal lakes.

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