QX disease (*Marteilia sydneyi*) of the Sydney rock oyster (*Saccostrea commercialis*) on the central coast of NSW.

FRDC Project No. 94/156

Research organisation: The University of Queensland

Principal investigator: Dr R.D. Adlard*

Department of Parasitology

The University of Queensland

Brisbane, Qld 4072

***Current address**: Queensland Museum

PO Box 3300

South Brisbane, Qld 4101

Tel: (07) 3840 7723, fax: (07) 3846 1918

Email: R.Adlard@mailbox.uq.edu.au

FISHERIES RESEARCH & DEVELOPMENT CORPORATION

Report prepared by R.D. Adlard

(ii) Summary

The distribution of QX disease (causitive agent *Marteilia sydneyi*) is limited currently on the central coast of New South Wales to the Georges River estuary alone. In 1996, oysters became infected with the parasite between 30 January and 19 February, oysters brought into risk areas after that period did not become infected with the disease. Management to reduce the impact of the disease must include provisions for stock to be removed from areas of highest QX disease risk for that period.

Oyster leases in upper estuarine sites are most at risk from infection with an average of more than 90% of stock in these leases affected by QX disease. More than 50% of oysters infected with QX disease in February 1995 had died by September 1995. The condition of remaining live oysters was extremely poor, with little or no chance of regaining marketable condition before the following year's recurrence of QX infection.

(iii) Background to the research project

The paramyxean parasite *Marteilia sydneyi*, aetiological agent of QX disease, is undoubtedly the most pathogenic parasite of commercial rock oysters in culture on the east coast of Australia. The disease has been responsible for significant mortality of oysters in culture for many years, and has been responsible for losses of more than 90% of stock on some leases (Nell & Smith, 1988). To avoid the impact of the disease, leases in endemic localities are left empty of oysters between January and March, during the period of highest risk of infection.

Prior to June 1994, the distribution of QX disease was limited to the estuaries of southern Queensland (north to the Great Sandy Strait 25°30'S) and northern New South Wales (south to the Macleay River 31°S). In 1994, while examining oyster samples collected from the Georges River (34°S) in connection with a separate project (FRDC 93/153 Lester), *Marteilia sydneyi* was found to be present in the hepatopancreas of oysters from upriver leases within the estuary. Diagnosis was confirmed by the comparison of ultrastructural elements with that of the original description of *M. sydneyi* by Perkins & Wolf (1976). An immediate survey of cultured stock and of naturally caught stock was undertaken to determine the distribution of the disease within the Georges River. A trend became apparent that upriver leases showed a higher prevalence of the disease than downriver leases (Adlard & Ernst, 1995), but correlations were obscured because farming practices included movement of stock between leases within the estuary.

Marteilia sydneyi is categorised as a List B pathogen (a pathogen of socio-economic importance) by the Fish Diseases Commission of the Office Internationale des Epizooties (OIE), and regulations require that the relevant authority be notified as soon as its presence has been detected from a previously disease free area. NSW Fisheries were informed of the diagnosis and acted under their legislation to close the Georges River for export of live oysters for relaying live elsewhere.

Even though QX disease has been a problem in northern NSW and southern Queensland oyster culture for many years, there is little robust data available on the dynamics of the disease during an outbreak. This is due to both a lack of knowledge

of the life cycle of the disease (apart from the stages that occur in the oyster host) and the fragmented geographic and temporal distribution of outbreaks and of oyster culture in this region. Furthermore, there is no data on the dynamics of a disease outbreak from an estuary that was regarded previously as QX-free. Certain characteristics of the Georges River also provided the potential to optimise data collection on the disease, this detailed information would then complement studies on the epidemiology of the disease (see FRDC final report 93/153 Lester). Those characteristics are: the Georges River has been intensively farmed for oysters for decades and oyster culture is widespread; oyster culture occurs both in estuarine conditions (upriver high siltation areas) and in more marine conditions (downriver sandy areas); and the infrastructural support for such a project was already in place (oyster industry members, NSW Fisheries officers).

(iv) Need

The outbreak of QX disease in the Georges River was 400Km south of its previously known range and raised concerns in the oyster industry that outbreaks may occur in other estuaries. At that time (1994) the geographic extent of the disease was largely unknown on the central coast of NSW because microscopic examination of oysters for the presence of *M. sydneyi* had not been not undertaken routinely. There remained a possibility that the disease was present in other estuaries at a prevalence that had not resulted in significant mortalities and consequently the presence of the disease may have gone undetected. This led to concern by Industry and Management that the factors that had predisposed the Georges River estuary to an outbreak of QX disease may also be in place in other estuaries that produce a significant commercial crop of oysters. Thus, there was an immediate need to assess whether the disease was indeed present in other (previously QX free) estuaries on the central coast. Furthermore, it was unknown whether the disease would reoccur in the Georges River in the following year, and if it did, precisely what impact it would have on oyster cultivation.

After discussion with industry members and fisheries management it became apparent that there was a urgent need to determine the geographic distribution of QX disease on the central coast of NSW and to collect detailed information on the development of the epizootic in oysters in the Georges River.

This project was funded initially for 12 months (October 1994 to October 1995) during which time its stated objectives were met. In October 1995, new objectives deriving from the results of the initial project were identified, and, at the request of Industry, an extension of funds was applied for and granted for the period (January 1996 to June1996).

(v) Objectives of the research project

1. To establish the geographic range of the QX organism (*Marteilia sydneyi*) on the central coast of NSW.
2. To establish the period of risk from initial infection with QX disease in the Georges River.

3. To determine whether this period is different in different parts of the Georges River.
4. To determine whether young oysters imported for growout from other rivers are already infected with QX disease.

The milestones specified were:

June 1995 Three estuaries in central NSW being monitored for QX disease. Management of the Georges reviewed with fisheries management.

Nov 1995 Geographic range of the QX organism on the central NSW coast determined. Management recommendations to Industry and Fisheries Management made.

Dec 1995 Monthly sampling from 3 central coast estuaries continuing - assessment of impact on Georges River made.

June 1996 Details on QX prevalence and mortality recorded for 2 episodes of infection in the Georges River.

June 1996 Duration of initial infection with QX determined for the Georges River, management plans reviewed.

(vi) Methods

1994/1995 sampling:

In October 1994, a system of monthly regular sampling was started in the Georges River (5 sites, Figure 1), Hawkesbury River (4 sites, Table 1) and Port Stephens (3 sites, Table 1) estuaries. Local oyster stock (approximately 2 years old) to be used as samples was sourced from each estuary to avoid the risk of transmitting disease between estuaries. Oysters (n=30) from this stock were placed in plastic mesh bags (600mm x 250mm, 12mm mesh size), bags were identified with tags and 12 bags placed at each site in each estuary (total number of sites = 12, total number of oysters = 4,320, number of months sampled = 12; October 1994 to September 1995).

One sample bag was collected from each site each month and processed in our laboratory at the University of Queensland. Oysters were measured, number of dead oysters recorded and live oysters dissected. The condition factor of each oyster was scored on a scale of 1 to 5 (1 = thin, watery with little or no gonad development, 5 = full gonad development, good condition) and hepatopancreas colour (indicative of the presence of QX disease) scored on a scale of 1 to 3 (1 = pale/cream, 3 = dark brown, healthy). Tissue imprints of the hepatopancreas of each oyster were made on glass microscope slides. Imprints were stained with Hemacolor (Merck), which had been shown previously to differentially stain not only sporonts of *Marteilia sydneyi*, but also early developing stages of the organism. Imprints were microscopically examined (magnification x400) for the presence/absence of *M. sydneyi.* The intensity of infection and stage of development were recorded for oysters infected with *M. sydneyi*.

In other estuaries, samples from stock that showed either abnormal mortalities or areas that were considered high-risk (as identified by NSW Fisheries officers, coordinated by Laurie Derwent, Oyster Manager NSW Fisheries, Pyrmont, Sydney) were also investigated for the presence of QX disease (Kalang/Bellinger River,

Clarence River, Sandon River, Wooli River, Wallis Lake; see Table 2 for details). Oysters from these areas were collected by fisheries officers and processed as described above.

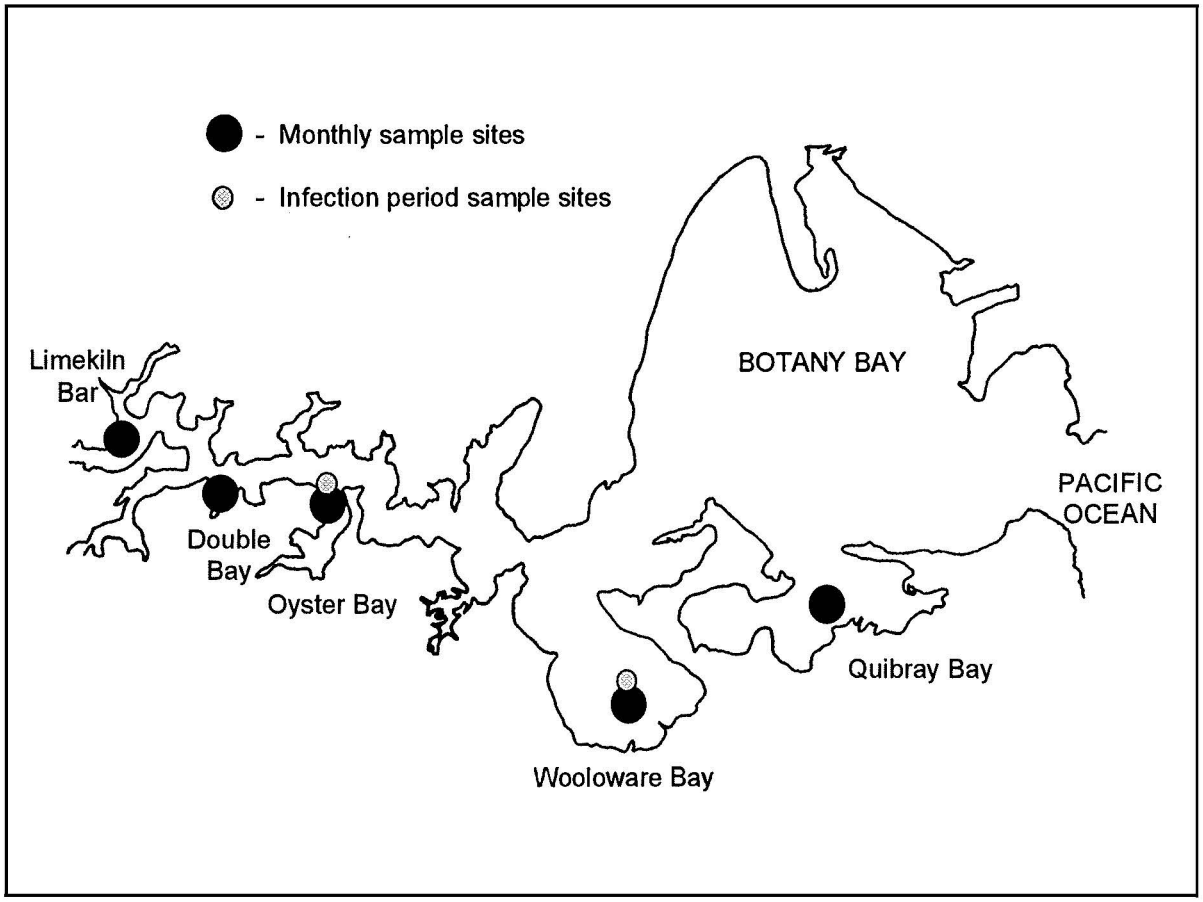

Figure 1: Georges River sites sampled monthly for QX disease in oysters, and sites sampled to determine the duration of initial infection of oysters by *Marteilia sydneyi*..

1996 sampling:

The severe impact of QX disease on oyster farming in the Georges River in 1995 (see results section for details) galvanised concern in the oyster industry. Two main outcomes from further studies in 1996 were required: a continued monthly sampling from the sites in the Georges River, Hawkesbury River and Port Stephens estuaries as well as samples from other areas thought to be at risk; and a definition of the period of risk from initial infection with *M. sydneyi* in the Georges River.

Local oysters were again sourced from each of the 3 estuaries (Georges River, Hawkesbury River, Port Stephens) and placed in bags at the same sites as described above in December 1995. Bags were collected monthly, oysters processed and examined for *M. sydneyi* as described above (total number of sites = 12, total number of oysters = 2,160, number of months sampled = 6; January to May 1996, July 1996). The final sample in this series (June 1995) was delayed by 1 month before collection

to increase our ability to assess the mortality due to QX disease in 1996. The sample from Double Bay to be collected in July, 1995 had been removed or lost.

To determine the timing and duration of initial infection of oysters by *M. sydneyi* in the Georges River, sample oysters were sourced from Port Stephens. Oysters were tested and found negative for QX disease. Oysters (n=50) were placed in plastic mesh bags (n=16), bags were tagged and kept on a lease in Port Stephens. A single bag was transferred to each of 2 sites in the Georges River (Woolooware Bay, Oyster Bay) on 22 January 1996 and remained at these sites for 6 weeks before being collected and the oysters examined for developing stages of *M. sydneyi*. Subsequent bags were transferred singly from Port Stephens to these 2 sites in the Georges River every 2 weeks, the last bags were transferred to the Georges River on 29 April 1996 and final collection made on 10 June 1996. Thus, each sample bag in the infection study was on site in the Georges River for a period of 6 weeks and overlapped the next bag by 4 weeks and the previous bag by 4 weeks. This method then enables the infection period to be calculated to within a 2 week period (see Figure 5 for details).

(vii) Detailed results

1994/1995

A second epizootic of QX disease occurred in the Georges River in 1995. It was first diagnosed in March, in 3 oysters collected from Double Bay in a sample of 29 live oysters (of 30 oysters placed at the site in October 1994). Early, developing stages of *M. sydneyi* (primary and secondary cells but no sporonts) were present in all 3 oysters. The time of initial infection of these oysters was estimated from the date of the last negative sample from Double Bay and the date that the positive sample was removed from the water. Thus, the period of initial infection was between 6 February 1995 and 6 March 1995.

Samples collected from the Georges River in April 1995, showed 4 of the 5 sites positive for QX disease, with the prevalence of QX disease in oysters on upper estuary leases (Limekiln Bar, Double Bay, Oyster Bay sites) reaching an average of 90.1%. At the downstream mid-estuary site, QX prevalence was significantly lower at 3.4% (Woolooware Bay site). Oysters sampled from the site closest to the mouth of the estuary (Quibray Bay) showed no indication of infection. Figure 2 shows the prevalence of QX disease from all sites over the whole period sampled.

The prevalence of QX disease in the upper estuary sites of Limekiln Bar, Double Bay, and Oyster Bay was remarkably similar (in June 1995 QX prevalence 87.5%, 91.3%, 94.1% , respectively), and indicative of a homogeneous distribution of the parasite (and by inference a homogeneous distribution of stages infective to the oyster) in this area. Prevalence from these 3 sites averaged between 90.1% in April 1995 and 46.1% in September 1995. The apparent reduction of QX prevalence by September (Figure 2) was due to the death of infected oysters, rather the loss of the infection from the oyster.

In the mid estuary site (Woolooware Bay) prevalence of QX disease peaked at 20% in the sample collected in August 1994, but no QX disease was evident in the sample taken one month later, even though this sample had been placed on site at the

same time. The results indicate that the distribution of QX disease at Woolooware Bay is more patchy than that in the upper estuary leases. The different distributions of this disease in different areas may be directly proportional to the density of infective stages that reach the oyster samples, and this in turn may be correlated with the presence/abundance of potential intermediate hosts that inhabit specific sediment types (for details see final report FRDC93/153 Lester).

Oyster samples examined from the site near the mouth of the estuary (Quibray Bay) showed no evidence of QX disease for the whole period of this study.

Oyster mortality in the Georges River in 1994/1995 (Figure 3) can be divided into three components. First, a 'background' component responsible for oyster deaths between November 1994 and May 1995 at all 5 sites (then masked by disease induced mortality). This component produced an average of 5% mortality of oysters with undetermined cause (the most likely possibities include: predation, bacterial invasion, and physical damage from cultivation techniques). Secondly, mortality induced by QX disease, which became a significant component of total mortality in the upper estuary sites in June 1995 (see Figure 3). Average mortality at these sites totalled 28.9% in June and escalated to an average mortality of 53.3% in September. Since the initial infection of these oysters occurred in February/March, it appears that as the disease interrupts digestion of nutrients the energy reserves of infected oysters become depleted, and they lose condition over a period of months then die. The condition of surviving oysters in the sample collected from upper estuary sites in September was an average of 2.2 (on a scale of 1 to 5, i.e. thin, with little gonad development and unmarketable). Thirdly, there is a component of mortality due to a second protistan parasite, *Mikrocytos roughleyi*, the causitive organism of 'winter mortality' of oysters. The distribution of this disease in the Georges River estuary is opposite to that of QX disease, with sites closer to the estuary mouth (Quibray Bay, Woolooware Bay) more susceptible than those in the upper estuary. The presence of this organism in oysters at those sites then explains the increasing oyster mortality between July and September (peak mortality in Woolooware Bay samples of 73.3% and in Quibray Bay samples of 50.0%) even though QX disease had a maximum prevalence of only 20% at one site and was not found at the other.

The results of monthly sampling from sites in the Hawkesbury River and Port Stephens estuaries are given in Table 1. QX disease was not found in any samples from any of the sites sampled in these estuaries. The levels of oyster mortality were recorded for these estuaries and are compared with oyster mortality from the Georges River (Figure 4).

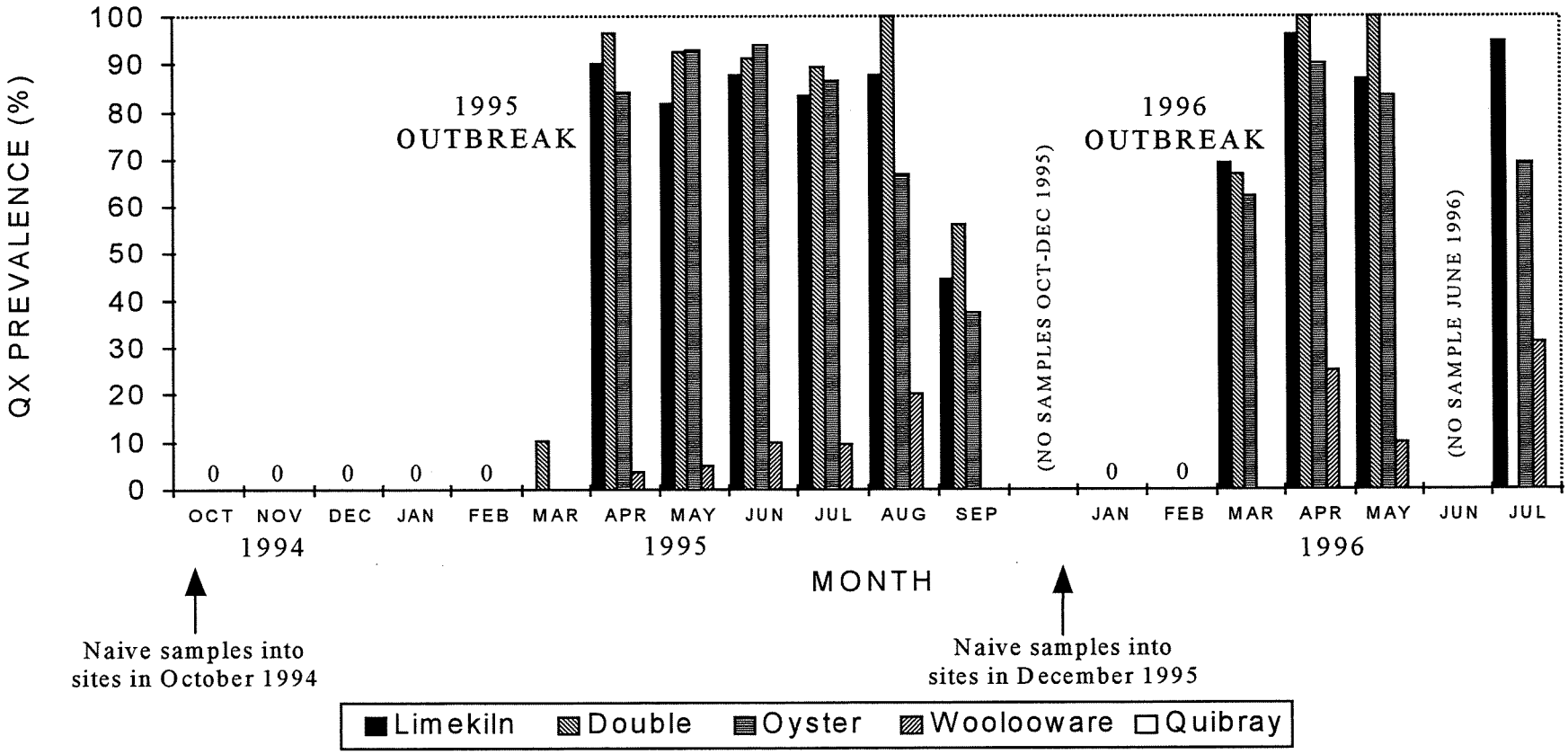

Figure 2: QX prevalence (%) from cultured oyster samples collected at 5 sites in the Georges River, Sydney October 1994 to July 1996. Note that Quibray Bay remained uninfected, and that no sample was recovered from Double Bay for July, 1996 (n=30 oysters per site per month).

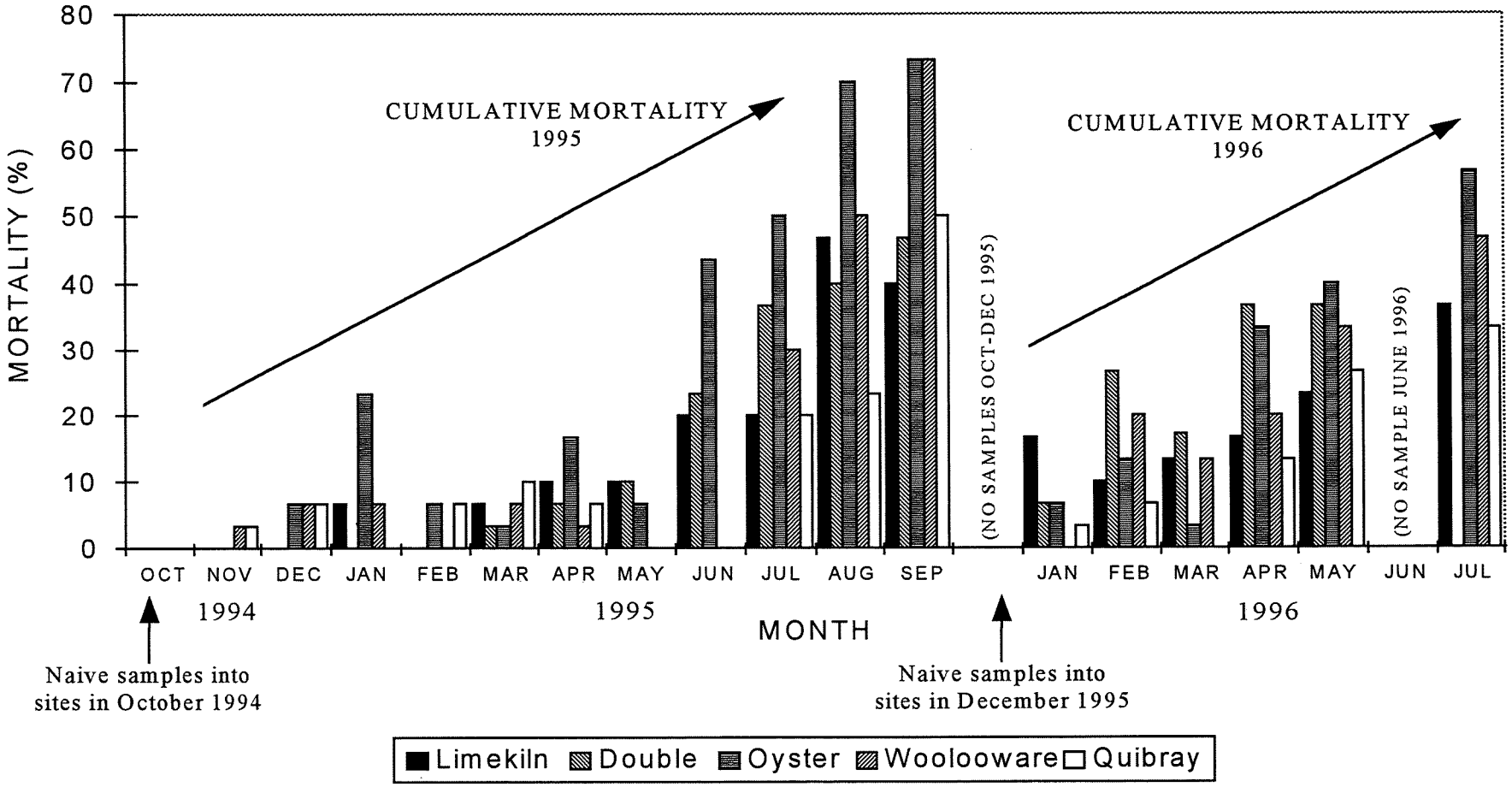

Figure 3: Cumulative mortality of cultured oysters collected from 5 sites within the Georges River, Sydney October 1994 to July 1996. Note that at sites closer to the mouth of the river (Oyster Bay, Quibray Bay, Woolooware Bay), 'winter mortality' contributes to oyster death (n=30 oysters per site per month).

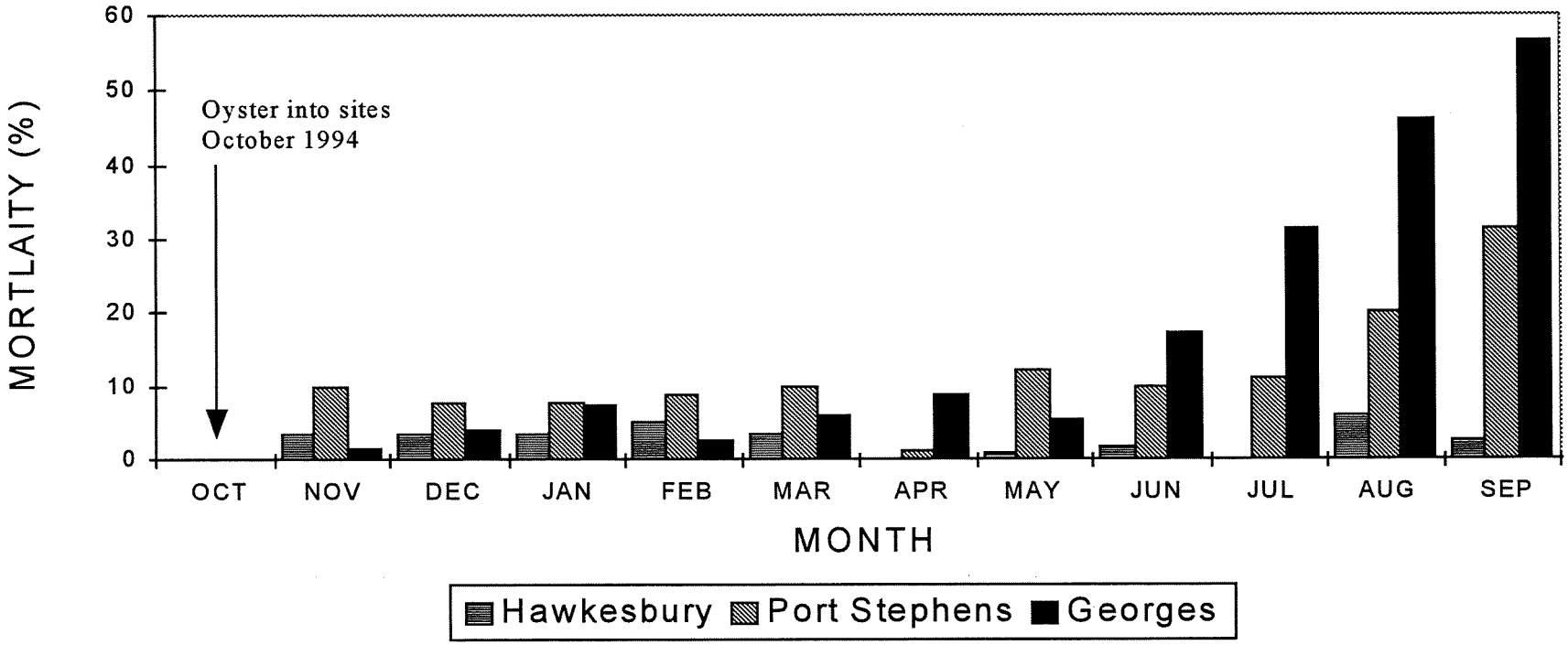

Figure 4: Cumulative mortality of cultured oysters in 3 estuaries on the central NSW coast. Increased mortality in the Georges River (June - September 1995) is due largely to outbreaks of QX disease. Data are derived from average mortality per month from 5 sites in the Georges River, 4 sites in the Hawkesbury River and 3 sites in Port Stephens estuary. (n=30 oysters per site per month).

Hawkesbury River samples:

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Mullet Creek	30	28	29	28	29	30	30	29	30	30	27	30
Cogra Bay	30	30	29	30	29	30	30	30	28	30	29	30
Snake Island	30	29	29	25	24	30	30	30	30	30	30	28
Marra Marra Ck	30	29	29	29	28	28	30	30	30	30	27	-

Port Stephens estuary samples:

	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
Corrie Island	30	29	29	30	27	27	30	24	30	24	25	25
Swan Bay	30	26	27	28	27	28	26	30	27	30	24	25
Tilligerry Creek	30	26	27	25	28	26	30	25	26	26	23	8

Table1: Results of oyster sampling of 30 oysters per month at 4 sites in the Hawkesbury River and 3 sites in the Port Stephens estuary during 1994/1995. Numbers given are surviving oysters in each sample. Note that QX disease did not occur in any of these oysters sampled.

Mortality in oysters in the Georges River induced by QX disease is responsible for much of the difference in mortality between this estuary and the 2 QX-free estuaries in which regular sampling was undertaken. Oyster mortality in the Hawkesbury River is remarkably low with an average 2.5% deaths (n=120) in oysters from 4 sites collected in September 1995 (after being on site since October 1994). In Port Stephens, oyster mortality was significantly higher at an average of 31.3% deaths (n=90) in oysters from 3 sites collected in September 1995 (after being on site since October 1994). This average increase at Port Stephens in that month, is due largely to high mortality in one of the 3 samples, in which 73.3% (n=30) of oysters died. Mortality at both of the other 2 sites in Port Stephens was 16.7% thus implicating a site specific mortality event in the sample with high mortality. The cause of mortality was undetermined, but there was no indication of the presence of other pathogens (e.g. *Mikrocytos roughleyi*) and no indication of physical damage to the oysters (e.g. from predators). Nevertheless, during the sampling period the average oyster mortality at Port Stephens was higher than that in the Hawkesbury River, and occurred largely during winter.

1996

A third epizootic of QX disease occurred in the Georges River in 1996. *M. sydneyi* was diagnosed in samples collected on March 3 from the upper estuary leases of Limekiln Bar (69.2% prevalence), Double Bay (66.7% prevalence) and Oyster Bay (62.1% prevalence). The timing of initial infection of oysters was determined from results of the infection 'window' experiment detailed below, but the previous month's

regular sample collected from these 3 sites on 30 January 1996 was negative for the organism, and shows that initial infection with QX disease occurred during that 4.5 week period.

The distribution of QX disease in the Georges River in 1996 was similar to the disribution in 1995 (Figure 2). Upper estuary sites showed the highest average prevalence of 95.3% in April, prior to an apparent reduction in prevalence due to infected oyster mortality. *M. sydneyi* was diagnosed at lower prevalences from the mid-estuary site at Woolooware Bay in April (25%), in May (10%), and in July (31.3%). This variability in prevalence may again indicate a patchy distribution of infective stages of the QX organism during the initial infection of oyster samples. Quibray Bay near the mouth of estuary was again free from QX disease in all samples.

The results of the experiment to determine the timing and duration of initial infection with *M. sydneyi* (i.e. 'risk period' or 'infection window') are given in Figure 5. Detailed sampling of cultured and naturally caught stock was undertaken at 5 sites in the Georges River on 30 January 1996. No developing stages of QX disease were found in any of the oysters sampled (n=150 cultured stock, n=150 naturally caught stock).

Early developmental stages of *M. sydneyi* were first diagnosed from oyster samples that had been brought into Woolooware Bay (1 of 45 oysters positive, 2.2%) and into Oyster Bay (18 of 44 oysters positive, 40.9%) from Port Stephens on 22 January 1996, and had remained on site until 4 March 1996 (six week period). No positive diagnoses were made for any subsequent samples from Woolooware Bay. Developmental stages of *M. sydneyi* were also diagnosed from the second sample (33 of 49 positive, 67.3%) transferred to Oyster Bay from Port Stephens on 5 February 1996 and removed from the water on 18 March 1996 (6 week period). No further positive diagnoses were made for any subsequent samples from Oyster Bay. By reference to the dates that subsequent negative samples were introduced into both sites and by reference to the negative samples collected on 30 January 1996, the period of risk from infection with QX disease can be identified as occurring between 30 January 1996 and 19 February 1996.

Summary of results on period of risk of initial infection with QX disease:

- from 1995 regular sampling - starts between 6 February 1995 and 6 March 1995 but no data on end of period of risk from these samples.
- from 1996 regular sampling - starts between 30 January 1996 and 3 March 1996 but no data on end of period of risk from these samples.
- from 1996 infection window sampling - starts between 30 January 1996 and ends by 19 February 1996.

It is clear from these results that QX infection of oysters occurs as a pulse of limited duration in the Georges River. This in turn infers that the infective stage *of M. sydneyi* is shortlived. Infections at the upper estuary site (Oyster Bay) occurred at the same time as infections in the mid-estuary site (Woolooware Bay), while the apparent difference in duration of the infection period may reflect the difference in prevalence

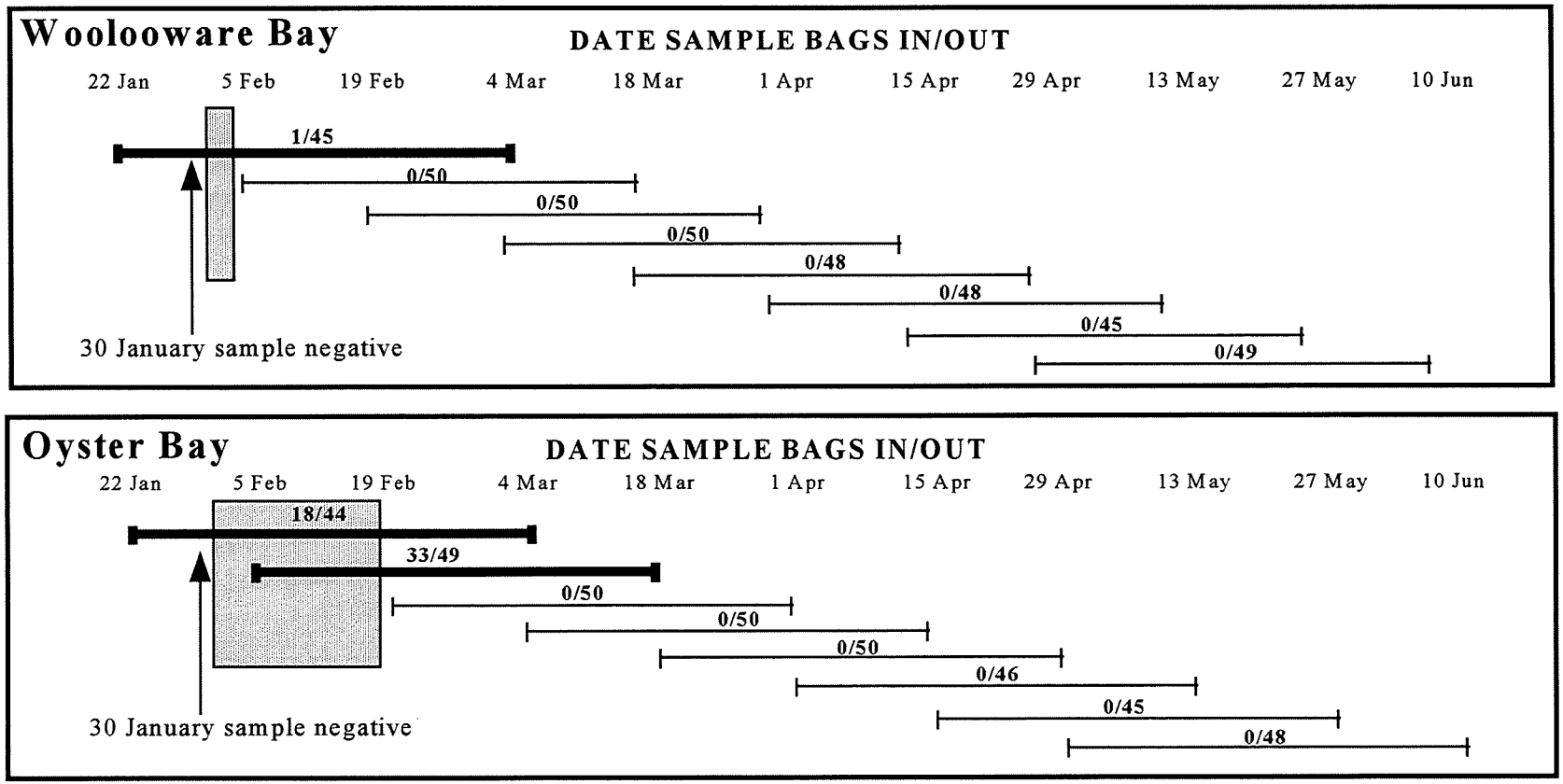

Figure 5: Period of risk of infection with QX disease from 8 overlapping samples of oysters at 2 sites in the Georges River during 1996. Note that local oysters from both sites were sampled on 30 January 1996 and found to be negative. Bold lines indicate samples of naive oysters (brought in from Port Stephens estuary) in which developing stages of the parasite were found.

at these sites and the statistical limitations on the detection of the parasite from populations that harbour a low prevalence of the disease.

The periods of initial QX infection in 1995 and 1996 in the Georges River are remarkably similar and correlate with periods of infection from southern Queensland (Wesche, 1995).

Oyster sampling from other estuaries.

Samples from other estuaries were identified by NSW Fisheries staff by reports of sick and/or dying oysters, and were examined for the presence of *M. sydneyi*.

ESTUARY	DATE	NUMBER EXAMINED	NUMBER WITH QX DISEASE	COMMENTS & ORIGIN
Kalang River	31/3/95	30	0	R. King, single seed
Wallis Lake	22/5/95	14	0	T. Dent, tray stock
Wooli River	26/5/95	29	0	Lease 71.245
Wooli River	26/5/95	30	0	Lease 87.45
Wooli River	19/5/95	30	0	Lease 73.47
Sandon River	19/5/95	16	0	Lease 58.271
Sandon River	24/5/95	30	0	Lease 71.136
Sandon River	19/5/95	20	0	Lease 72.188
Clarence River	19/5/95	10	2	Lease 64.208
Clarence River	23/5/95	22	5	Lease 76.106
Kalang/Bellingen River	9/6/95	30	0	natural caught
Kalang/Bellingen River	9/6/95	30	0	tray cultured
Kalang/Bellingen River	9/6/95	30	0	natural caught

Table 2: Oyster stock examined for the presence of *M. sydneyi* from estuaries other than those from which regular samples were collected.

QX disease was diagnosed only from oysters collected in the Clarence River, an estuary within the northern and previously known region of QX endemicity.

Publications and extension of information from this project.

ADLARD, R.D. & ERNST, I. 1995. Extended range of the oyster pathogen *Marteilia sydneyi*. *Bulletin of the European Association of Fish Pathologists* **15**:119-121.

ADLARD, R.D. in preparation. Dynamics of *Marteilia sydneyi* outbreaks in commercial rock oysters, *Saccostrea commercialis*, in the Georges River, Sydney. Target Journal: *Journal of Eucaryotic Microbiology*.

ADLARD, R.D. & HUDSON, D.A. 1995. An epizootic of QX disease (*Marteilia sydneyi*: Protozoa, Paramyxea) in oysters from the Georges River, Sydney. *Proceedings of the Australian and New Zealand Societies for Parasitology Conference*, Adelaide, September 1995 (Abstract).

Adlard, R.D. May 16, 1995: Presented research results and participated in a workshop on research, management and industry objectives of the NSW oyster industry -

Fisheries Research Institute, Cronulla, Sydney (invited by Laurie Lardner - Acting Chair, Oyster Research Advisory Committee).
Adlard, R.D. 1994 QX disease. *Oyster News* - NSW OFA publication. Vol 4(7) November 1994.
Adlard, R.D. 1995 QX in the Georges River. *Oyster News* - NSW OFA publication. Vol 5(3) June 1995.
Adlard, R.D. 1995 QX update. *Aquaculture Newsletter* - NSW Fisheries publication. Vol 2(1) August 1995.
Adlard, R.D. 1995 QX update. *Aquaculture Newsletter* - NSW Fisheries publication. Vol 2(2) December 1995.
Adlard, R.D. 1996 QX update. *Oyster News* - NSW OFA publication. Vol 6(2) April 1996.

Plus personal visits by Dr Adlard to oyster farmers and NSW Fisheries personnel from Port Stephens to Georges River. Total number of contacts between October 1994 and June 1996 was 61, progress on the project and strategies to reduce the impact of the disease were discussed.

(viii) Benefits

This project has provided detailed information on outbreaks of QX disease. The likelihood of infection of cultivated oysters in different areas within the Georges River has been quantified. Those areas most likely to show a severe impact from QX disease have been characterised. This information has been extended to Industry and Management both verbally and in industry publications.

Results were relayed immediately to NSW Fisheries management, with the direct outcome that bans on the export of live oysters from Georges River for relaying live elsewhere were maintained. This reduced the potential for disease transmission to other estuaries via translocated oyster stock, and was of direct benefit to the long term viability of oyster industry.

The risk period of infection with QX disease was communicated to industry members in the Georges River who avoided either buying young stock and placing it on leases in high risk areas during that period or avoided moving stock from other leases in the Georges River to upper estuary leases during the risk period. This will provide a management tool for oyster cultivation in upper estuary leases in future years, and, in the event of an outbreak of QX disease in other estuaries, provides clear information on the dynamics of the disease.

It is difficult to estimate the impact of this project in monetary terms. Maintaining the ban on live exports of oysters from the Georges River and reducing the risk of disease spread between estuaries is a significant saving to the industry. An estimated 50% of the cultivation area in the Georges River was affected with QX disease, with an average of 50% to 90% of that stock either killed or unmarketable. If these figures are extrapolated to a industry worth approximately $35 million/year, then control of the spread of the disease could potentially save the industry between $8.75 million and $15.75 million/year.

(ix) Intellectual property

No intellectual property, apart from authority of scientific publications, is identified from this project.

(x) Further development

Members of the oyster industry and fisheries management now have a framework, on the dynamics of QX disease outbreaks, on which to base management decisions. During the project a need for site specific diagnostics was identified, from industry members who either required 'disease-free' certification of their stock or certification of stock they were about to purchase for growout. In areas of QX endemicity industry members voiced a need for ongoing studies to determine the period of risk of infection in their estuaries.

Both of these identified needs are site specific and inappropriate for funding from external sources. It is suggested that if required, these services be funded by industry members either individually or through estuary cooperatives or funding sought from appropriate local authorities.

(xi) Staff

Full time.
October 1994 - September 1995. D.A. Hudson, fulltime research assistant.
January 1996 - June 1996. S.C. Wesche, fulltime research assistant.
Casual. Between October 1994 and June 1996
T.C. Jones, casual research assistant - various dates.
I. Ernst, casual research assistant - various dates.
S.B. Pyecroft, casual research assistant - various dates.

(xii) Final cost

A full accounting of the costs of the project will be made available by the University of Queensland Research Services Section, who are responsible for research fund disbursement within the University.

(xiii) Distribution

Copies of this report were distributed directly to the following beneficiaries, relevant libraries and relevant authorities:

NSW Oyster Farmers Association
Queensland Oyster Growers Association
National Fishing Industry Council
Nat. Fishing Industry Training Council
CSIRO Division of Fisheries
Qld Department of Primary Industry

Fisheries Research Institute, NSW Fish.
University of Queensland Library
University of New South Wales Library
University of Tasmania Library
Curtin University of Technology

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