A case study into the development of OHSW processes in the Pinctada maxima Pearling Industry to benchmark world's best industry diving practice.

PEARL PRODUCERS ASSOCIATION

Australian Government

Fisheries Research and Development Corporation

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Authors note

The complete report with all supporting documentation is available on an interactive CD with a Summary Report hyperlinked to the primary History Report through the Year Headings.

By clicking on the year heading readers will be transferred to the same year in the main report which has all of the details for that year with further hyperlinks to the original documentation. This means that one can easily move back and forward from the summary to the main report to the original documents and back again.

The program has been developed such that subsequent years can be included to keep the document live and current.

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OBJECTIVES

1 Write a brief history of the pearling industry focusing on the reasons and 'drivers' for the development of the OH&S processes and programs within the industry.

2 Compile, from all previous reports to FRDC & Fisheries, the Final Research Report on the drift diving profile research and summarise in the review report the results and principles applied to establish their safety. This is the Final Report for FRDC project 94/098 - *'Improved Harvesting Efficiency of Pearl Oysters Through Modification of Dive Profiles'*

3 Document the development process and implementation of the PPA Diving Code of Practice that was developed in conjunction with Fisheries WA and Worksafe WA.

4 Update the PPA drift dive database and draft a statistical report from the dive data base, which will have logged the total man-hours of drift diving over the past 10 years and correlate the reduction in decompression illness (DCI) incidents to the adoption of the research results.

5 Collect and summarise the international presentation papers of pearling industry systems by Dr.R.Wong. Briefly describe the fishing industries worldwide that have adopted the principles that underpin the pearl diving system as conveyed by Dr. Wong at international hyperbaric medical conferences.

6 Document the work done by the PPA in support of hyperbaric medicine including the provision, training and support of the recompression chamber facilities in Broome.

7 In support of the above objectives, to collect all source documents regarding OH&S in the pearl diving industry since the inception of the PPA (1989). (Dive mortalities, Incidents, Coroners reports, Code of Practice development, Recompression Chamber Purchase, International Conference papers etc.)

NON-TECHNICAL SUMMARY

Outcomes achieved:

This Review Report has, in conjunction with the updated systems, protocols and past research reports, provided to the Pearling Industry:

- ∞ Substantiation conclusively of the safety of the pearling industry drift dive profiles and dive management protocols in a single public reference document with capacity for continual updating.

- ∞ Reassurance to Government and other interests that OH&S issues in the pearling industry have been professionally and scientifically tested addressed and that processes are in place for ongoing management and assessment of these issues.

These outcomes have been achieved through the following outputs:

- ∞ A set of Pearl Drift Dive Profiles that all the pearling companies will use for drift diving.

- ∞ A documented history of research, diving systems, dive times, divers, protocols and profiles as a reference for long term health monitoring in the pearling industry.

- ∞ Establishment of an electronic drift dive database and daily fishing logs to all companies so that data can be supplied to the PPA and Department of Fisheries resulting in significant saving in the expense of data entry.

- ∞ A report and documentation that can be used by other diving fisheries as a basis for development of their own dive systems and protocols or adoption and modification of the pearling systems. (eg abalone, beche-de-mer)

At various periods, the lack of detailed information on the development and application of the Western Australian *Pinctada maxima* pearl industry dive protocols has resulted in criticism of the industry's occupation health and safety performance from Coroners, Unions, Government, statutory organisations and other parties.

Due to the fact that the pearl diving protocols differ from the existing accepted diving parameters around the world, it was deemed essential that the pearling industry document the extensive research and processes that has established these protocols as world's best practice.

The documenting of pearling OH&S processes and the drift dive research carried out in support of these processes presents a cogent, supportive history of the pearling industry's safe diving practices. It provides a benchmark document by which further studies and research upon which pearl diver health can be referred and maintained.

The diving systems and protocols developed by the pearling industry are also applicable to similar diving industries who can adopt and develop their own appropriate systems of safe diving.

The report has upgraded the inefficient existing drift dive database tool used for dive data measurement into an electronic one entry, on the vessel system.

This review will act as the benchmark for the current industry accepted protocols and dive

profiles, to which reference will be made for a proposed long term health monitoring of both current and previous pearling industry divers to ensure there are no late onset of diving related health issues.

It covers the years from 1987 through to 2003.

The report is on CD and is interactive with a Summary Report hyperlinked to the primary History Report through the Year Headings. By clicking on the year heading you will be transferred to the same year in the main report which has all of the details for that year with further hyperlinks to the original documentation. This means that you can flick back and forward from the summary to the main report to the original documents and back again.

The program has been developed such that subsequent years can be included to keep the document live and current.

KEYWORDS: **Pearling, dive profiles, Doppler testing, recompression chamber**

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Helen O'Donoghue, Researcher

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Pearl Producers Association members and staff

All pearling divers who participated in the research

BACKGROUND

The first meeting of the Pearl Producers Association (PPA) was held in 1987 to bring the industry together to consider the implications of a number issues requiring industry to present a united front in promoting their interests, including.

- ∞ The suggestion that Government was going to form an *'Underwater Diving Task Force'* to consider the diving safety issues in WA with the pearling industry firmly in their view as a prime consideration. The Underwater Diving Task Force Report recommendations released provided significant implications for the Pearling Industry members and contained several allegations made against industry diving practices within the Taskforce document.

- ∞ The new Western Australian OHS&W Act proclaimed in 1988.

- ∞ The industry suffered further setbacks with three (3) pearl diver mortalities during 1990 heightening Industry discussions to adopt a set of common dive standards and minimum requirements for divers. The respective Coroners Reports recommended industry stop diving to its own systems and dive according to known safe standards until such time as it could be proved that the specific pearling industry diving systems were safe.

The PPA formed a working group in 1990 and developed a number of dive profiles for safer diving, with specific dive profiles for each of the different depths up to 35m.

These profiles formed part of the original Pearl Diving Industry Code of Practice developed by the Pearl Producers Association (PPA) that was published and distributed to all members in 1991. This code has been updated regularly since that date.

Fisheries Department of WA funded a pilot research project into the dive profiles and the use of a Doppler ultrasonic monitor in 1990 which was used as a means of detecting and quantifying intravascular gaseous bubbles in divers after hyperbaric exposure.

A series of safety issues drafted by the committee were formally approved by the PPA and approval was also given for a Recompression Chamber to be sourced for installation in Broome. Negotiations were held with the Broome Hospital for the locating, installation, manning and maintenance of the Recompression Chamber which was operational in May 1991 with the first treatment being in August.

In 2000 as part of the finalisation of the 10 years of diving research undertaken by the Pearl Producers Association it was proposed that a review and collation of all available information relating to the development of the pearling industry dive systems and protocols should be undertaken. This was due to the fact that the P.maxima pearl diving protocols are outside of the normal accepted diving parameters as perceived by many interested and concerned parties it is essential that the pearling industry documents the extensive research and processes that have established these protocols as world's best practice.

The review was to document the process by which the pearling industry has developed world's best industry diving practices and to benchmark these practices against current and prospective legislation.

This review will also guide other diving industries as to the processes required to develop safe diving systems in addition to the potential adoption by those industries of the appropriate diving protocols.

The report will also establish a reference point for a proposed long term health monitoring of both current and previous pearling industry divers to ensure there is no late onset of diving related health issues.

NEED

At various periods, the lack of detailed information on the development and application of the pearl industry dive protocols has resulted in criticism of the industry's occupation health and safety performance from Coroners, Unions, Government, Statutory Organisations and other parties.

The review of OH&S processes and finalisation of the pearling drift dive research will present a cogent, defensive argument of the basis behind the Industry's safe diving practices. This will place Industry in a better position to negate the need for unnecessary legislative or Industrial Relations imposts as authorities and the community will be better informed regarding pearling industry occupational health & safety standards.

The diving systems and protocols developed by the pearling industry would be applicable to similar diving industries. Without a review and documentation of the process by which they were developed and the results, it could limit those industries ability to adopt and develop their own appropriate economic and efficient systems of safe diving.

This review will also constitute an element of the required documentation for Worksafe WA to consider, examine and gazette a Pearling Industry Code of Practice. This review will also contribute to the consistency of OH&S across WA fisheries.

There is a crucial need for an objective, factual measure of the safety being achieved by the pearling industry. The drift dive database was the tool used for this measurment, however it had become dysfunctional and required upgrading to supply this measure.

There was also need for setting a benchmark document by which further studies and research on diver health can refer to and build upon.

OBJECTIVES

1. Write a brief history of the pearling industry focusing on the reasons and 'drivers' for the development of the OH&S processes and programs within the industry.

2 Compile, from all previous reports to FRDC & Fisheries, the Final Research Report on the drift diving profile research and summarise in the review report the results and principles applied to establish their safety. This is the Final Report for FRDC project 94/098 - 'Improved Harvesting Efficiency of Pearl Oysters Through Modification of Dive Profiles'

3. Document the development process and implementation of the PPA Diving Code of Practice that was developed in conjunction with Fisheries WA and Worksafe WA.

4. Update the PPA drift dive database and draft a statistical report from the dive data base, which will have logged the total man-hours of drift diving over the past 10 years and correlate the reduction in decompression illness (DCI) incidents to the adoption of the research results.

5. Collect and summarise the international presentation papers of pearling industry systems by Dr. Robert Wong. Briefly describe the fishing industries worldwide that have adopted the principles that underpin the pearl diving system as conveyed by Dr. Wong at international hyperbaric medical conferences.

6. Document the work done by the PPA in support of hyperbaric medicine including the provision, training and support of the recompression chamber facilities in Broome.

7. In support of the above objectives, to collect all source documents regarding OH&S in the pearl diving industry since the inception of the PPA (1989). (Dive mortalities, Incidents, Coroners reports, Code of Practice development, Recompression Chamber Purchase, International Conference papers etc.)

METHODS

There were no scientific or technical methods applied for this project, other than the computer programming skills necessary for the upgrading to an electronic pearling dive database. The report is essentially the finalization of constituent reports, the collection of information and source documents, then summarising in a Review Report.

The methods by which this was achieved were as follows.

Review Report.

The PI produced a review report that summarises and connects all of the OH&S developments within the WA pearling industry so as to document, publicise and connect all of the disparate elements of that development.

History of OH&S development in the Pearling Industry.

The PI researched and sourced all documentation relating to OH&S incidents, developments and provisions that have occurred since 1987 when the PPA was formed. These documents form the basis for the section in the Review Report outlining the history of OH&S developments within the Pearling Industry. This included access to coroners reports, company archives, Fisheries WA records, Worksafe records and Health Department records

Pearling Industry Drift Dive Profiles.

These profiles were finalised by Dr. Wong and the PPA Safety & Training Committee as the results of the drift diving research. They have been presented together with explanations on their application and safety provisions that are required before they should be used.

Drift Diving Profile Research

Incorporates the Final Report for FRDC project 94/098 - 'Improved Harvesting Efficiency of Pearl Oysters Through Modification of Dive Profiles'

The PI has collected all the previous interim research reports on the Drift Diving Profile Research and compiled them into a draft final format which has allowed Dr. Wong, the PI for the diving research project, to make the appropriate changes, corrections and addition of the final research results to complete the report.

Drift Diving Database.

The existing drift dive database software was old and virtually non-functional. As a consequence the dive data entry had fallen behind. A consultant was contracted to update the software and a data entry clerk employed to enter the data. The project enabled the database to be brought up to date to obtain accurate statistical figures about the drift diving safety record. The software upgrade has been distributed to all companies for installation on their vessels and will allow electronic submission of dive data to the database and the Fisheries WA Daily Fishing Log.

The PI produced a statistical section in the review report on the past 10 years of drift diving. This section reflects a decreasing Decompression Illness incident rate that correlates with the improved safety of the drift dive profiles as a result of the drift dive profile research.

The PI has also tabulated a comparison of accepted incident rates associated with other recognised diving tables and related dive industries.

Pearling Industry Code of Practice/Diving Standard.

PPA has developed a generic Code of Practice for diving based on the requirements of the existing Pearl Diving Code of Practice and WAFIC OHS&W Code. With the agreement of the other diving fisheries it can be used as the Fishing Industry Diving CoP.

RESULTS/DISCUSSION

1. History of OH&S development in the Pearling Industry.

The Pearl Producers Association has produced the Review Report as a compact disc inclusive of all appendices, research reports, journals, conference papers, Codes of Practice and historic reference documents. A copy of the CD is included with this final report to FRDC.

2. Electronic Drift Dive Data Base

The Pearling Industry Drift Diving Database has been in existence in various forms for the last 12 years.

The project has established and electronic version of the drift dive database intended to remove much of the duplication of effort occurring previously given:

- ∞ Skipper/Head Diver entering the diving data on the official data log sheets and then also onto their company database;
- ∞ PPA entering on their data base the drift dive data for Dr Wong & PPA analysis for OHS&W workplace purposes
- ∞ Department of Fisheries Compliance entering on their database the catch and quota information to ensure compliance and
- ∞ Department of Fisheries Research entering both fishing and diving data on their database for research purposes.

All required data has been combined onto this one data entry program that the Skipper/Head Diver will fill out as the day progresses. A print-out of the day's diving was approved as the Statutory Fishing Log required by the Dept. of Fisheries during the trial of the electronic database.

A disc/CD copy of the appropriate files can now be sent to the PPA, Fisheries Compliance and Fisheries Research on disc or by email for incorporation directly into their appropriate databases.

The database system has various built in management components to assist the Skipper, Head Diver and Company:

- ∞ It will warn you when a diver is approaching the expiry of his diving license or medical certificate.
- ∞ It has the latest copy of the Drift Dive Profiles built in for reference and automatically loads the appropriate decompression procedures into the dive log as the dive day progresses.
- ∞ It will also keep track of pearl oysters caught for the current neap and year-to-date for easier quota management.
- ∞ It will also act as a quick reference for existing dumps and lines.
- ∞ For on-board the vessel or in the company office, the statistical component will make a useful reference for shell and dive data by vessel, diver, incident, depth, visibility, date or grid and all combinations of these.

The program includes a manual for the operation of the PPA Drift Dive Database. The system is particularly bullet proof in that data is always safe even if the system crashes, so skippers and company executives are comforted to test and use the system while learning.

3. FRDC Project No. 94/098 - *Improved Harvesting Efficiency of Pearl Oysters through Modification to Drift Dive Profiles'*.

The Western Australian pearling industry obtains its supply of pearl oysters from the wild stocks by means of divers operating in depths from shallow water of 2 to 3 metres out to a maximum depth of 35 metres.

In 1987, as a result of an invitation from the Broome District Hospital (Senior Medical Officer) who was concerned with the level of diving incidents, Dr. Robert Wong agreed to come to Broome to present a lecture to pearl divers on diving safety. Dr. Wong was a specialist Anaesthetist at Royal Perth Hospital and a Consultant in Underwater Medicine in the Royal Australian Navy. As a result of this introduction to the pearling industry the need was identified to conduct formal research into the safety of the pearl diving systems, and Dr. Wong was approached to undertake the research.

In 1988 the first meeting of the Pearl Producers Association (PPA) was held with membership consisting of all the licencees to the Western Australian *Pinctada maxima* pearl oyster industry.

The recorded bubbles were graded according to the Kisman-Masurel classification system.

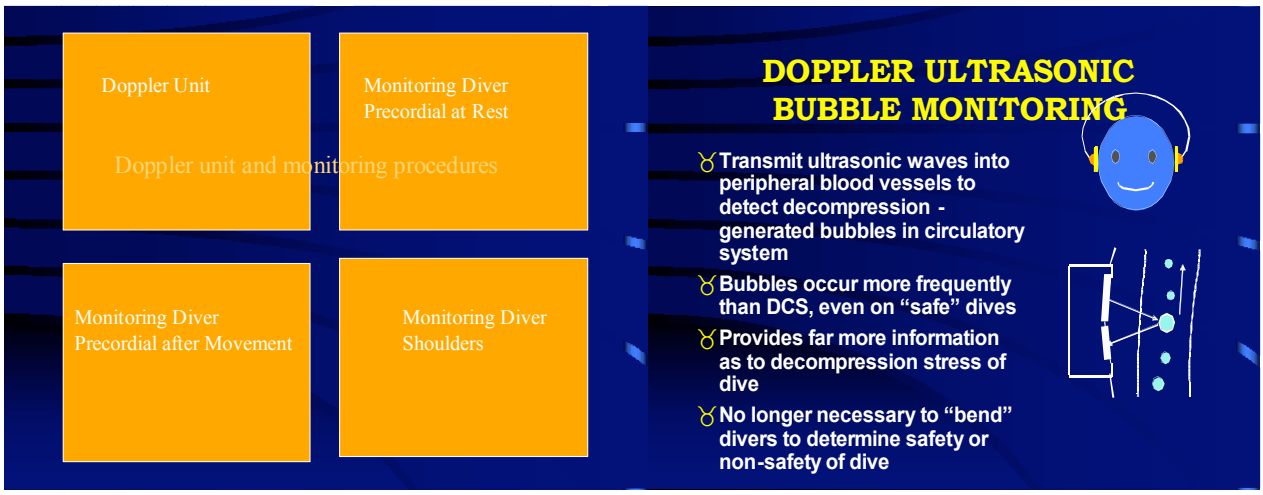

Figure 1 Kisman-Masurel classification system

Subsequent to this, the PPA has directly funded a further 5 years of this research.

The purchase by the PPA of a Recompression Chamber was instrumental in enabling the pearling industry to undertake this research and the industry continues with operational and maintenance responsibility for the chamber together with the Broome Hospital.

The agreed dive profiles were exhaustively tested in the recompression chamber and as a result of those tests each was modified, some more than once, as further refinement took place. A successful testing means that a profile was tested for eight consecutive days without unacceptable bubble grades being recorded in the divers using the Doppler ultrasonic monitor. All of the profiles were tested a minimum of 3 times with 2 different divers each time (of different Doppler readings) to confirm its safety given the variability between divers.

The deeper 19 metre, 21 metre and 23 metre depth categories required extensive modifications to comply with the stringent safety levels expected and still ensure economic efficiency was maintained through adequate bottom time.

The profiles deeper than 23 metres required profiles of a different nature. Two teams of divers now operate on a rotational basis and there is considerably less bottom time per diver. These profiles are much more closely aligned to a traditional Defence & Civil Institute of Environmental Medicine (DCIEM - Canada) Dive Tables in terms of the resulting profiles and consequently have required little modification to achieve safe results.

To evaluate the safety of the pearling industry dive profiles testing was carried out both in the recompression chamber and under working conditions at sea. The Kisman-Masurel classification system evaluates bubbles detected in the circulatory system with a doppler ultra sonic transducer and grades the results from 0 through to IV as an indication of hyperbaric stress.

Grades less than III are considered as demonstrating low stress and are relatively safe. If the dive profile consistently achieved this result across multiple trials and different divers during chamber trials they were considered to be a safe dive profile and not require further modification unless in field incidents demonstrated an adverse trend.

Grade III and above are considered to demonstrate high stress, and there is a greater likelihood of decompression sickness.

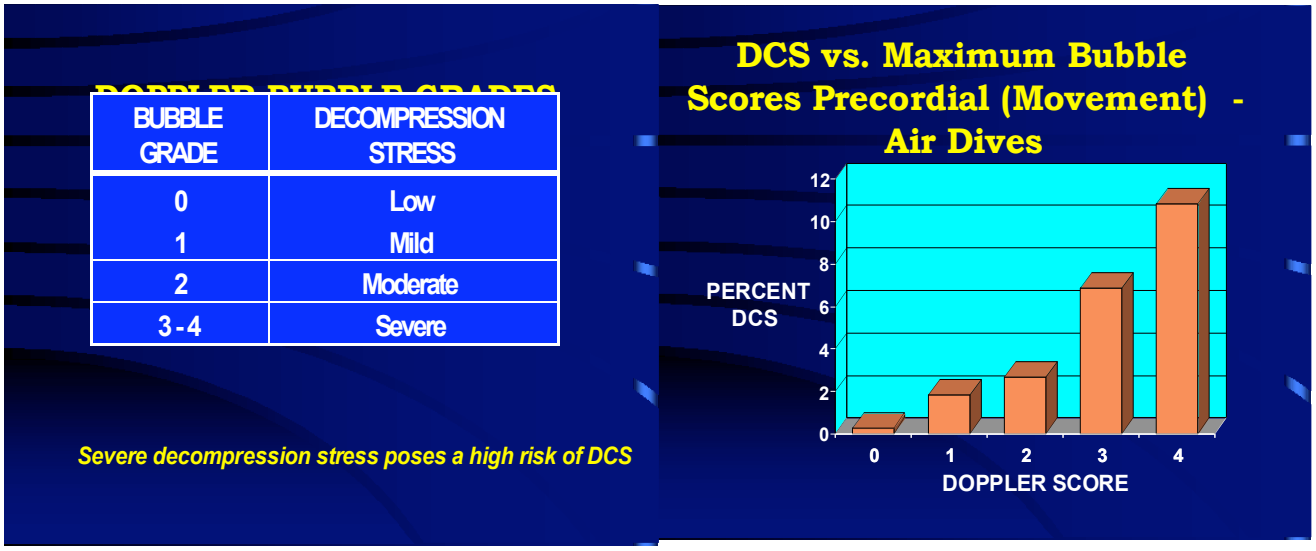

Figure 2 Kisman-Masurel classification system

If a profile being tested in the chamber was tending to record the higher grade bubble levels it was terminated and modified before testing again. The modifications could include a number of variables including shorter bottom time, longer surface interval, more decompression time, greater use of oxygen, a slower ascent rate or any combination of these.

Once a profile achieved acceptable results in the recompression chamber they were circulated to industry members as the acceptable profile that had to be used from then on for that specific depth. The research then moved physically onto the fishing vessels to test the divers in the actual work environment to ensure the profiles performed safely.

As an additional element to the research the ascent rates were tested in the chamber to demonstrate conclusively that the theory of introducing a slower ascent rate was better for the diver than the traditional 18m/min ascent rate.

Results indicated a demonstrably reduced bubble formation in pearling drift divers using the slower ascent rate of 3m/min.

All of the Western Australian pearl industry drift dive profiles have now been tested in the chamber and at sea with a resulting bubble score according to the Kisman-Masurel classification system of being consistently less than Grade III.

At the beginning of the research, bubble grades less than III were stipulated as indicating acceptable safe levels of stress from hyperbaric exposure.

Since the beginning of the dive data collection in 1990, the industry divers have conducted approximately 400,000 dives at an average depth of 13 metres for about 40 minutes per dive to catch the pearl oyster quota. Each year the divers spend around 24,500 hours underwater and breathe 1,780 hours of oxygen at 9 metres while decompressing.

The result for the pearling industry has been the significant drop in Decompression Sickness (DCS), since the initiation of the research and development of the specific Western Australian pearling drift dive profiles. This applied research and modification to the profiles has resulted in the current DCS incidence rate being greatly reduced to less than 0.01% of total dives in the pearling industry.

The number of DCS diagnosed incidents has fallen from 6 per year on average in the early 1990's to less than 1 per year on average for the last 10 years. The DCS incident rate is expected to have been significantly higher prior to the start of data collection in the 1990's. This reduction is solely attributable to the establishment of a unified industry diving management system, training protocols, diving research undertaken by Dr. Robert Wong and the discipline introduced throughout the industry by the uptake of a pearling industry diving Code of Practice developed by the PPA.

As a comparison, the standard US Navy Dive Tables has a stated acceptable incident rate of about a 3% which would mean the PPA Dive Profiles could have up to 600 cases of DCS per year and still be within acceptable limits of the US Navy Dive Tables.

The Commercial Dive Industry (Petroleum & Construction Diving) has a dive incident rate of between 0.1 to 0.5 percent. This would translate into approximately 20 to 100 dive incidents per year based on the pearling industry's 20,000 dives per year.

Given the results from the pearling industry data and the DCS incidence comparisons with other commercial diving systems (set out above), the Pearling Industry Drift Dive Profiles have introduced a level of diving safety that would appear to be at the highest end in achieving dive safety management.

DATA OVERVIEW

Generally there has been somewhere between 70 to 80 divers contracted each year by the companies spending up to 8 days at sea each 'neap tide', between January and June, drift diving for the pearl oysters. Depending on the depth, they dive 9 or 10 times a day and per dive will spend an average of 42 minutes on the ocean bottom at an average depth of 12.9 metres, with an average 23 minute surface interval between dives.

With this diving system the pearling industry drift divers spend on average of 1,470,589 diver/minutes underwater each year.
i.e. 24,510 hours or 1,021 days. ***(This is the equivalent of a single diver spending 2.8 years underwater 24hrs a day.)***

To do this safely the divers consume on average some 106,762 minutes of oxygen per year during the decompression staging at 9 metres.
i.e. 1,780 hours or 74 days on oxygen.

Table No1 **Summary of All Years - 1990 to 2003**

YEAR	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	14 Year Avg.	
Average Depth	14.6	15.5	14.4	14.6	12.0	12.7	14.3	11.4	11.8	10.9	9.9	10.2	12.3	12.6	**12.9**	
Average U/Water Time	47.7	49.4	51.9	52.7	54.5	53.1	52.9	53.9	54.8	55.4	54.6	54.3	56.7	55.6	**53.0**	
Average Bottom time	38.5	39.8	42.9	41.3	45.7	42.2	40.0	42.9	44.4	45.9	45.7	44.8	45.2	46.0	**42.8**	
Average surface interval	20.6	23.9	24.1	24.0	24.1	22.1	27.4	24.5	23.0	23.7	24.0	22.0	22.0	22.7	**23.4**	
																TOTAL
Total U/Water Time	1,752,198	1,841,160	1,630,766	1,394,865	1,429,057	1,361,843	1,352,724	1,940,613	1,503,014	1,080,101	1,187,321	1,617,492	1,364,873	1,132,220	**1,470,589**	**20,588,279**
Total Bottom Time	1,430,362	1,516,059	1,383,360	1,145,052	1,228,604	1,125,193	1,075,244	1,583,648	1,236,364	900,486	1,003,679	1,349,171	1,089,729	951,705	**1,215,618**	**17,018,688**
Total Oxygen Deco Time	110,075	99,690	89,462	119,170	84,599	96,135	122,048	163,926	116,191	80,204	85,116	122,292	137,058	68,707	**106,762**	**1,494,673**
Total Air Deco Time	24,321	8,475	29,831	4,903	6,989	20,439	33,044	36,631	30,057	21,941	19,787	28,680	27,263	20,055	**22,315**	**312,416**
Total Number of Divers	9	106	97	80	85	36	81	73	66	38	71	66	77	27	**65**	
Total Number of Dives	36,707	37,234	31,424	26,467	26,233	25,629	25,559	36,011	27,445	19,489	21,742	29,799	24,073	20,346	**27,726**	**388,158**
Total Number of Incidents	0	0	42	0	0	2	0	21	5	1	14	16	25	0	**9**	**126**

From the data above the pearling industry has conducted more than 388,158 dives over the past 14 years with the equivalent of 343,000 man/hours underwater. *(This is the equivalent of a diver spending 40 years underwater 24hrs a day.)*

All of these dives have been conducted in accordance with the Pearl Producers Association Pearling Industry Drift Dive Profiles as originally developed and subsequently modified over the years as a result of ongoing pearl diving research.

PEARLING DRIFT DIVE DATA 1990 TO 2003.

Since 1990 the pearling industry has been collecting dive data from their fishing operations and entering it on an electronic database system that has been upgraded several times and has just recently been completely redeveloped. This has allowed industry to keep a watchful eye on the rate of dive incidents and changes in the pattern of diving within the industry and supply Dr Wong with up-to-date data for his review processes.

The following report is a plain English synopsis of this data from various points of view.

Pearl diving is carried out in accordance with the pearling drift dive profiles which range from very shallow ('hull scraping on the bottom') to depths of 35 metres. In terms of economic efficiency, the pearling industry is always wanting to maximise diver bottom (fishing) time and so will spend as much time in shallow water as the visibility and catch rates will allow.

The summarised data table below verifies that this is the recent trend with the majority of dives and bottom time in shallow water.

Table No 2: - Bottom Time & Dive Totals & Percentages per Profile from 1990 to 2003

Dive Profile	**11**	**13**	**15**	**17**	**19**	**21**	**23**	**25**	**27**	**29**	**31**	**33**	**35**	**35+**	
Total Bottom Time / Profile	8,160,364	3,257,524	1,659,551	1,258,099	1,396,358	617,641	108,666	101,654	138,610	67,672	75,505	152,230	24,109	705	17,018,688
%Total Bottom Time / Profile	**47.9%**	**19.1%**	**9.8%**	**7.4%**	**8.2%**	**3.6%**	**0.6%**	**0.6%**	**0.8%**	**0.4%**	**0.4%**	**0.9%**	**0.1%**	**0.0%**	**100.0%**
Total Dives / Profile	170,912	71,156	39,920	31,999	35,696	15,810	2,930	3,059	4,311	2,361	2,987	6,040	950	27	388,158
%Total Dives / Profile	**44.0%**	**18.3%**	**10.3%**	**8.2%**	**9.2%**	**4.1%**	**0.8%**	**0.8%**	**1.1%**	**0.6%**	**0.8%**	**1.6%**	**0.2%**	**0.0%**	**100.0%**

WESTERN AUSTRALIAN PEARLING DRIFT DIVE PROFILES.

In 1990 a subcommittee of the Pearl Producers Association was assigned the task of developing a single agreed set of drift dive profiles that all industry members would agree to use when undertaking their drift diving (fishing) activities.

Various companies had their own traditional dive management systems, protocols and techniques that had been developed 'in-house' over the earlier years, stretching back to the hard hat diving years. While the methods used were intrinsically similar, the dive times and decompression times were in many cases quite different particularly as some companies were employing the new in-water oxygen decompression techniques. The negotiations between companies to come up with a unified system of pearl diving system were considerable and it was incumbent on the PPA subcommittee to structure the profiles in such a way that Dr. Wong was confident that they were a scientifically safe starting basis as the focus of his proposed research project.

The dive profiles were developed in consultation with Dr. Wong who undertook a research project to validate the safety of the profiles, including recompression chamber dive testing. It was agreed that each profile would be applicable to a two-metre range of depth - for example 9 to 11 metres would be classed as one depth profile.

The first set of Drift Dive Profiles was approved by the PPA members in June 1990 and became the basis for the Drift Diving Research Program.

Table No 3: Original Pearling Industry Drift Dive Profile - 1990

Depth Profile	Bottom Time (max)	Surface Interval	Total Bottom Time (Max)	Max No Dives	Air Deco @ 9m	O2 Deco @ 9m & Ascending
Non Rotation Dive Profiles						
0-11	90	15	500	10	nil	nil
11-13	50	20	500	11	10mins - last dive @ 5m & ascend @ 3mins /m	nil
13-15	40	20	400	10	nil	10mins - last dive & ascend
15-17	40	20	400	10	nil	10mins - last dive & ascend @ 2mins /m
17-19	40	20	360	10	nil	15mins - last dive & ascend @ 2mins /m
19-21	40	20	360	10	nil	5 mins - 5th dive 15mins - last dive & ascend @ 2mins /m
21-23	40	20	360	10	nil	10min - 5th dive 15mins - last dive & ascend @ 3mins /m

0-11 metre profile has:- ***a minimum accumulated surface interval requirement of 135 minutes***

Table No 3: Original Pearling Industry Drift Dive Profile – 1990 contd.

2 Team Rotation Dive Profiles - Deep Water						
Depth Profile	**Bottom Time (max)**	**Surface Interval**	**Total Bottom Time (Max)**	**Max No Dives**	**Air Deco @ 9m**	**O2 Deco @ 9m & Ascending**
23-25	35	D1 - 60min D2 - 70min D3 - 80min D4 - 90min	175	5	0	D1 - nil to surface; D2 - 5 mins; D3 - 10 mins; D4 - 15 mins; D5 - 20 mins & ascend 3m/min on O2
25-27	30	D1 - 60min D2 - 70min D3 - 80min D4 - 90min	150	5	0	D1 - 5 mins; D2 - 10 mins; D3 - 15 mins; D4 - 20 mins; D5 - 25 mins & ascend 3m/min on O2
27-29	30	D1 - 60min D2 - 70min D3 - 80min D4 - 90min	150	5	0	D1 - 5 mins; D2 - 10 mins; D3 - 15 mins; D4 - 20 mins; D5 - 25 mins & ascend 3m/min on O2
29-31	25	D1 - 70min D2 - 80min D3 - 90min D4 - 100min	125	5	0	D1 - 5 mins; D2 - 10 mins; D3 - 20 mins; D4 - 25 mins; D5 - 30 mins & ascend 3m/min on O2
31-33	25	D1 - 70min D2 - 80min D3 - 90min D4 - 100min	125	5	0	D1 - 5 mins; D2 - 10 mins; D3 - 20 mins; D4 - 25 mins; D5 - 30 mins & ascend 3m/min on O2
33-35	25	D1 - 80min D2 - 90min D3 - 100min	100	4	0	D1 - 10 mins; D2 - 15 mins; D3 - 20 mins; D4 - 25 mins & ascend 3m/min on O2

Note: - Assent rate is 5 metres per minute up to 21 meters and then 3 meters per minute from 21 meters to the surface.

BENEFITS and ADOPTION

This review report, in conjunction with the updated database systems, protocols and research results, provides the pearling industry with a comprehensive and proven safe set of drift dive profiles that all the pearling companies now use for pearl oyster drift diving.

The report substantiates conclusively the safety of the pearling industry drift dive profiles and protocols drawn up into a single document.

The report will reassure Government and other stakeholder interests that OH&S issues in the pearling industry have been professionally addressed and that processes have been set in place for continuous improvement in the management of pearl diving. This will help ensure there unnecessary, uninformed actions taken for legislative or industrial relations solutions.

The report provides a documented history of research, diving systems, dive times, divers, protocols and profiles as a reference base for long term health monitoring of pearl divers.

The report can be adopted in principle and by other diving fisheries as a basis for development of their own dive systems and protocols or adoption and modification of the pearling systems.

The report completes the PPA responsibility for a Final Drift Dive Research Report for both FRDC and Fisheries WA. (FRDC project 94/098 - 'Improved Harvesting Efficiency of Pearl Oysters Through Modification of Dive Profiles')

The project has produced an upgraded drift dive database to all companies so that data can be supplied to the PPA electronically thus saving the expense of data entry. It is also intended that this database will supply printouts of the statutorily required Daily Fishing Logs for Fisheries WA reducing significant costs in data entry and printing costs of the current paper based log system.

International Adoption of Pearl Diving Principles have been promoted through Dr. Wong who has been presenting papers at International Hyperbaric Medical Conferences for several years concerning the results of this research into the drift diving systems of the pearling industry. Many of the diving medical experts at these conferences have seen the value of the pearling systems and principles in relation to the interests of other dive fisheries around the world. Consequently many of these fisheries have adopted the principles and applied them in the context of their diving environment with much success in reducing diver injury and incidents.

The Report briefly describes the fisheries that have adopted the underlying pearl diving principles and what impact it has had on diver health and safety.

FURTHER DEVELOPMENT

The report and associated database systems, protocols and research systems will allow ongoing review and update of the pearl diving safety systems by providing a reference base for long term health monitoring of pearl divers.

PLANNED OUTCOMES

The planned outcomes contained in the FRDC project application were as follows: -

1. A final set of Dive Profiles that all the pearling companies will use for drift diving.

2. Substantiate conclusively the safety of the pearling industry drift dive profiles and protocols in a single public document.

3. Reassure Government and Union interests that OH&S issues in the pearling industry have been adequately addressed and that processes are in place for future management of these issues. This will help ensure there isn't a requirement for legislative or Industrial Relations solutions.

4. Have a documented history of research, diving systems, dive times, divers, protocols and profiles as a reference for long term health monitoring.

5. Produce a report and documentation that can be used by other diving fisheries as a basis for development of their own dive systems and protocols or adoption and modification of the pearling systems.

6. Complete the PPA responsibility for a Final Drift Dive Research Report for both FRDC and Fisheries WA. (FRDC Project 94/098 - 'IMPROVED HARVESTING EFFICIENCY OF PEARL OYSTERS THROUGH MODIFICATIONS TO DIVE PROFILES')

7. Supply an upgraded drift dive database to all companies so that data can be supplied to the PPA electronically thus saving the expense of data entry. It is also intended that this database will supply printouts of the statutorily required Daily Fishing Logs for Fisheries WA, saving the printing costs of the current logs.

The outcomes from the review meet all the planned outcomes:

1. A Review Report on OH&S issues in the Pearling Industry from 1987, which includes:

(a) A documented history of the OH&S developments in the WA pearling industry since 1987.

(b) A final version of the pearling industry Drift Dive Profiles.

(c) A Pearling/Fishing Industry Code of Practice for presentation to Worksafe WA.

(d) A Pearling Industry Diving Standard.

(e) A statistical report on the last 10 years of drift diving in the pearling industry.

(f) Catalogued copies of all documents referred to in the report and attached as appendices.

2. A Final Report on the 10 years of drift diving research under FRDC Project -*'Improved Harvesting Efficiency of Pearl Oysters through Modification of Dive Profiles' (94/098)*

3. An updated computer based drift dive database for distribution to all companies and Department of Fisheries.

The Extension process will be as follows: -

- ∞ The Pearl Producers Association has produced the review report as a compact disc inclusive of all appendices, research reports, journals, conference papers, Codes of Practice and historic reference documents.

- ∞ CD's will be sent to Fisheries WA, FRDC, WAFIC and Worksafe WA, all members of the PPA, those diving industries who may be interested in the PPA diving systems & protocols.

- ∞ Fisheries WA, FRDC, Worksafe WA and WAFIC will be requested to publish articles in their respective magazines/journals indicating that this review report has been completed and available on CD to interested parties.

CONCLUSION

At various periods, the lack of detailed information on the historical development and application of the Western Australian *Pinctada maxima* pearl industry dive protocols has resulted in criticism of the industry's occupation health and safety performance from Coroners, Unions, Governments, statutory organisations and other parties.

Due to the fact that the pearl diving protocols differ from the existing accepted diving parameters around the world, it was deemed essential by the pearling industry that it document the extensive research and processes that has established these protocols as world's best practice.

The documenting of pearling OH&S processes and the drift dive research carried out in support of these processes presents a cogent, supportive history of the pearling industry's safe diving practices. It provides a benchmark document by which further studies and research upon which pearl diver health can be referred and maintained.

The diving systems and protocols developed by the pearling industry are also applicable to similar diving industries which can adopt and develop their own appropriate systems of safe diving. It covers the years from 1987 through to 2003.

The objective of this project was to produce a history of the pearling industry focusing on the reasons and 'drivers' for the development of the OH&S processes and programs within the industry as a benchmark for all stakeholders.

This was to include the Final Report for FRDC project 94/098 - *'Improved Harvesting Efficiency of Pearl Oysters through Modification of Dive Profiles"*

The report was to document the process and implementation of the PPA Diving Code of Practice developed in conjunction with Fisheries WA and Worksafe WA as well as update the pearl drift dive database to produce a statistical report of the past 14 years dive results to demonstrate the reduction in decompression illness (DCI) incidents within industry.

The report was also required to collect and summarise the international presentation papers of the WA pearling industry systems by Dr. R. Wong and to describe the fishing industries worldwide that have adopted the principles that underpin the pearl diving system. Furthermore the report was to document the work done by the PPA in support of hyperbaric medicine including the provision, training and support of the recompression chamber facilities in Broome.

This review report met all these objectives by producing documentation that provides:

- ∞ Substantiation conclusively of the safety of the pearling industry drift dive profiles and dive management protocols in a single public reference document with capacity for continual updating.

- ∞ Reassurance to Government and other interests that OH&S issues in the pearling industry have been professionally and scientifically tested addressed and that processes are in place for ongoing management and assessment of these issues.

- ∞ A set of Pearl Drift Dive Profiles that all the pearling companies now use for drift diving.

- ∞ A documented history of research, diving systems, dive times, divers, protocols and profiles as a reference for long term health monitoring in the pearling industry.

- ∞ Establishment of an electronic drift dive database and daily fishing logs to all companies so that data can be supplied to the PPA and Department of Fisheries resulting in significant saving in the expense of data entry.

- ∞ A report and documentation that can be used by other diving fisheries as a basis for development of their own dive systems and protocols or adoption and modification of the pearling systems. (eg abalone, beche-de-mer)

REFERENCES
Nil

Appendix 1 – Intellectual Property
Nil

Appendix 2 – Staff engaged in Project

Mick Buckley	Pearling Dive Consultant
Brett McCallum	PPA Executive Officer, Perth
Paul Cookson	PPA Safety & Training Officer, Broome

Appendix 3 – Other relevant material.

Nil