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# Oyster Information Portal- a user-group focused 'Coastal Google' for the future

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**Abstract**

Catchment managers and estuarine seafood industries have highlighted the need to consolidate natural resource and industry information that currently exits but that is dispersed and inaccessible. Accessing and interpreting this information will contribute to better understanding and responding to catchment processes and change; thus increasing the potential for long-term healthy catchments and the viability of local industries that they support.

The oyster industry is a cornerstone of the NSW seafood industry that recognises the importance of good water quality and catchment management. Thus, this industry has prompted the development of a user friendly spatial information portal where data is collated, consolidated and delivered through a centralised point – the Oyster Information Portal (OIP). This prototype has been developed in a GIS environment and delivered through an online website with graphical interpretation of temporal environmental data. The data and information categories were prioritised by catchment managers and industry members through meetings and industry workshops. Of importance was that top priority categories of information were the same for industry and catchment managers alike. Priority data includes water quality, catchment impacts and oyster industry management practices that form the base of the current OIP prototype. Additional information on climate projections, governance and research outputs also form part of the OIP to provide a more holistic and integrated synthesis of information related to the catchment.

The OIP prototype has been developed for 4 NSW Local Government Areas (Camden Haven, Hawkesbury, Shoalhaven and Pambula). The relevance of the OIP to applied outcomes will be presented through case study scenarios. The OIP facilitates catchment stakeholders to engage with catchment processes, patterns and trends. In the long term the intention is that the OIP concept can better facilitate adaptation to catchment and environmental change.

**Keywords**

focused, coastal, group, portal, google, information, oyster, future, user

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# OYSTER INFORMATION PORTAL: A USER-GROUP FOCUSED 'COASTAL GOOGLE' FOR THE FUTURE

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## Abstract

Catchment managers and estuarine seafood industries have highlighted the need to consolidate natural resource and industry information that currently exits but that is dispersed and inaccessible. Accessing and interpreting this information will contribute to better understanding and responding to catchment processes and change; thus increasing the potential for long-term healthy catchments and the viability of local industries that they support.

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## Introduction

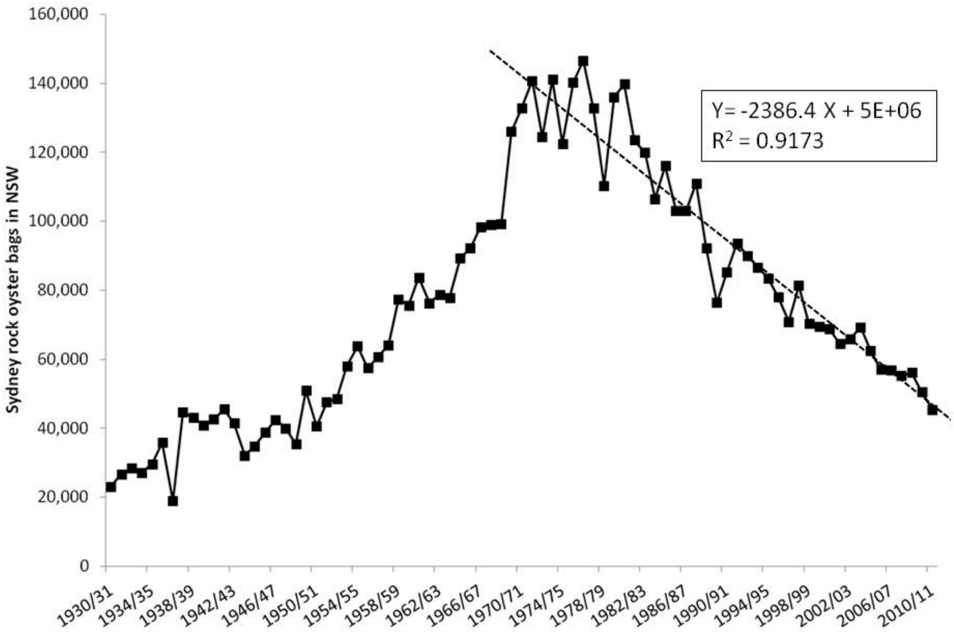
### *NSW Oyster Industry*

The oyster industry recognises that its success is intimately tied to the environment and healthy waters from the catchment and ocean. As such, the industry is vulnerable to both changes in the catchment and in the ocean characteristics as a result of global warming. During the last four decades, the oyster industry in NSW has been competing with increasing activity in the coastal catchment areas for space on land and in water, and has suffered degradation in water quality and increasing frequency of disease outbreaks. This has been reflected in their annual production for the last few decades (Figure 1). Sydney Rock Oyster (*Saccostrea glomerata*) production in NSW reached its peak in the mid 1970's producing around 140,000 bags of oysters/year. Since then, annual production has been in a state of steady decline and the industry currently produces around 45,000 bags/year valued at $31.5M (NSW DPI, 2011). The annual rate of decline has been approximately 2,400 bags (~3.2 million oysters) since 1970. Despite 32 estuaries in NSW producing Sydney Rock Oysters, most of the historical production was associated with a few large oyster producing estuaries such as Port Stephens, Georges River, Wallis Lakes and the Hawkesbury River. For instance, two of these rivers: the Georges River (1995) and the Hawkesbury River (2005) have been affected by QX Disease that completely wiped out the production of Sydney Rock Oysters in these rivers (Adlard, 1996). Other diseases like Winter Mortality have also threatened the industry through time (Nell, 2007). However, in most cases impacts from these diseases are still not accurately quantified and linkage to potential environmental degradation is yet to be established. Overall, even when production data from QX disease highly-impacted estuaries are removed from the overall oyster production data for NSW, the declining trend is still apparent, indicating that there are other aspects impacting oyster production (Figure 1).

Up to now no specific causes have been attributed to the overall decline in oyster production. A series of alternative causes have been proposed such as the introduction of feral oyster species (Pacific Oysters, *Crassostrea gigas*) competing for resources with the Sydney Rock Oysters, degradation of water quality caused by anthropogenic catchment activities, invariant market prices of oysters despite inflation and poor oyster management practices. Over time there has been also a reduction in active lease areas, which in some cases has been attributed to environmental degradation (White, 2001).

The last 12 years has seen a small reduction in the rate of decline of production compared with the rate calculated in 2001 (3,000 bags/year, ~3.6 million oysters (White, 2001)). This early indication of improvement might be associated with recent governance initiatives in managing the industry. Since 2006, priority oyster leases have been protected by the NSW Government under the Oyster Industry Sustainable Aquaculture Strategy (OISAS) in order to support the long term sustainability of the industry (NSW Department of Primary Industries, 2006). But threats to oyster production that relate to water pollution, in particular human faecal contamination, cannot be addressed through prioritising lease areas alone. Since 2003-2005 (depending on the estuary), most of the oyster producing estuaries have been classified under the NSW Shellfish Quality Assurance Program (SQAP); each estuary classified under a specific harvesting management scheme according to historical pollution events, localised rainfall patterns and catchment processes and development. In addition, a significant number of on-ground catchment works and improved oyster industry practices (i.e. implementation of estuary-wide oyster industry Environmental Management Systems) have been recently implemented.

**Figure 1: NSW SRO production through time. Linear regression fitted to decline in production from 1970 to current (data source: NSW DPI annual aquaculture reports)**




***The oyster industry under a changing climate and environment***

In addition to catchment related impacts to the oyster industry, there are potential future risks associated with climate change. In NSW there are already measureable changes to air and water temperature (The Climate Commission, 2011). These changes, along with catchment stressors, will affect salinity regimes, catchment run-off as well as changes to the incidence of harmful algae blooms and changes in the length and frequency of opening and closure periods for oyster harvest areas. As a result, the oyster industry in Australia may face unprecedented challenges in the future. A better understanding of climate change impacts is vital so that the industry is better informed to manage risks (knowledge action), adapt and minimise negative impacts. Adaptation will not only require better knowledge of the natural resources, but a framework to integrate knowledge of the whole socio-ecological system within which the oyster industry operates, including bio-physical, industry and governance sectors.

The oyster industry has recently identified key climate change related challenges that are likely to affect their industry (Leith and Haward, 2010). As part of this study, the oyster industry highlighted the need to access existing environmental monitoring data and to relate it to industry operations historically and into the future in order to better manage changes. A lack of integration between bio-physical knowledge and industry knowledge currently constrains effective management of the oyster industry. There is currently no uniform framework with which to deal with the diversity of coastal monitoring initiatives and provide available information to the oyster industry. Consequently the development of a proof of concept for an Oyster Information Portal (OIP) has been under development in NSW since early 2011.

### *Need for an Oyster Information Portal (OIP)*

The concept of collating information in data portals is relatively recent and facilitated by technological developments; however there is much activity in this field and many top-down strategies do exist to support the management and access to data. Some extensive environmental networks that have been developed in the last decade are starting to disseminate and provide access to information through data portals (AODN, TERN, ALA, CSIRO Coastal Research, ABIN, etc). However most of these data portals target researchers and sometimes governance at the top level, but are rarely relevant or useful to on the ground stakeholders. Sharing information across institutions and making it publically available is a relatively new endeavor that faces the challenges of the legacy of historical data acquisition and management systems; often at the very small and local scale. It is anticipated that an increasing number of data portals that amalgamate data will emerge in the next of few years, but major constraints are overall poor data management systems by the data custodians as discussed later on.

## Framework of the OIP

### *Sites and data selection for the proof of concept*

At this proof of concept stage, a selection of four oyster growing areas were chosen along the NSW coastline; Camden Haven Inlet, Lower Hawkesbury River, Shoalhaven River and Pambula Lake (Figure 2). These areas represent diverse geographical features, catchment processes and activities, as well as variable levels of oyster production, different species (Sydney Rock Oysters and Triploid Pacific Oysters) and industry size. A project partnership was created with representative local government, natural resource managers, state government agencies and other catchment stakeholders from each of the areas. Most of these stakeholders are involved in environmental monitoring programs and are the custodians of data that have contributed to the majority of the information contained in the OIP. The Local Government Authorities (LGA) are responsible for the regular water quality monitoring of estuaries and coastal water bodies towards the local scale of the State of the Environment Reporting. Additional water quality monitoring is undertaken by the NSW Food Authority, responsible for food safety through the NSW Shellfish Quality Assurance Program (SQAP monitoring investment ranging from $17,000-$43,000 per estuary). The SQAP involves regular and intensive sampling of the waters and oysters in an estuary. For example the presence of harmful algae blooms is monitored fortnightly to manage the risk of toxic shellfish events. As a result of the industry’s diligence with this monitoring, extensive data sets that are relevant to the industry and natural resource managers, exist. However, at present there is no tool for the industry to explore these data sets in a temporal (i.e. trends through time) and spatially (i.e. across sampling sites) way. In addition there are diverse monitoring points within estuaries for hydrology monitoring, local research initiatives and monitoring of catchment effluents and sewage treatment plants.

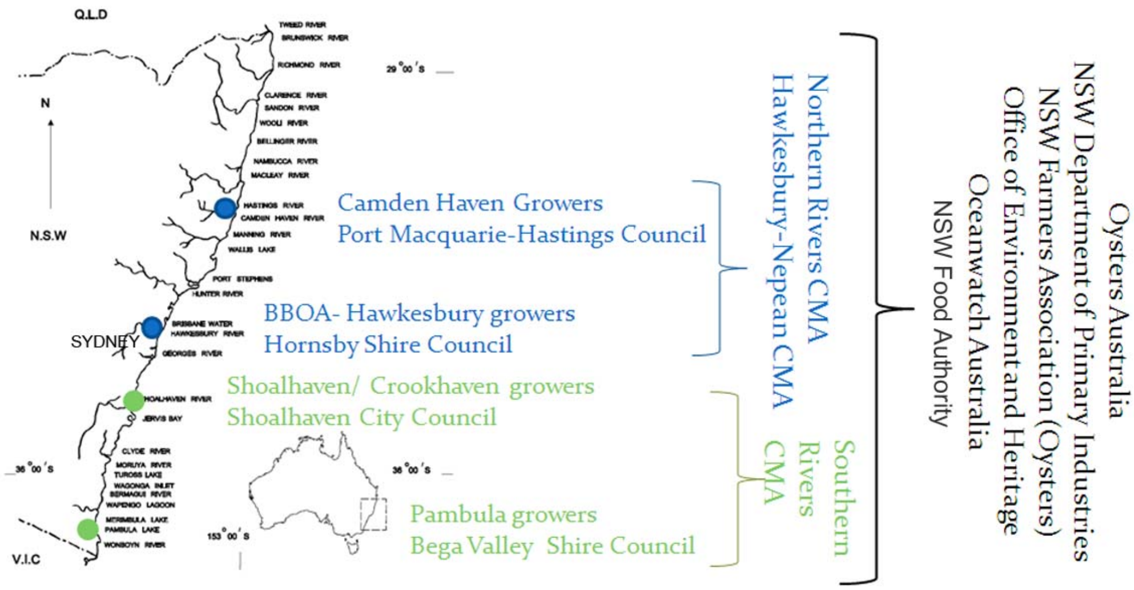
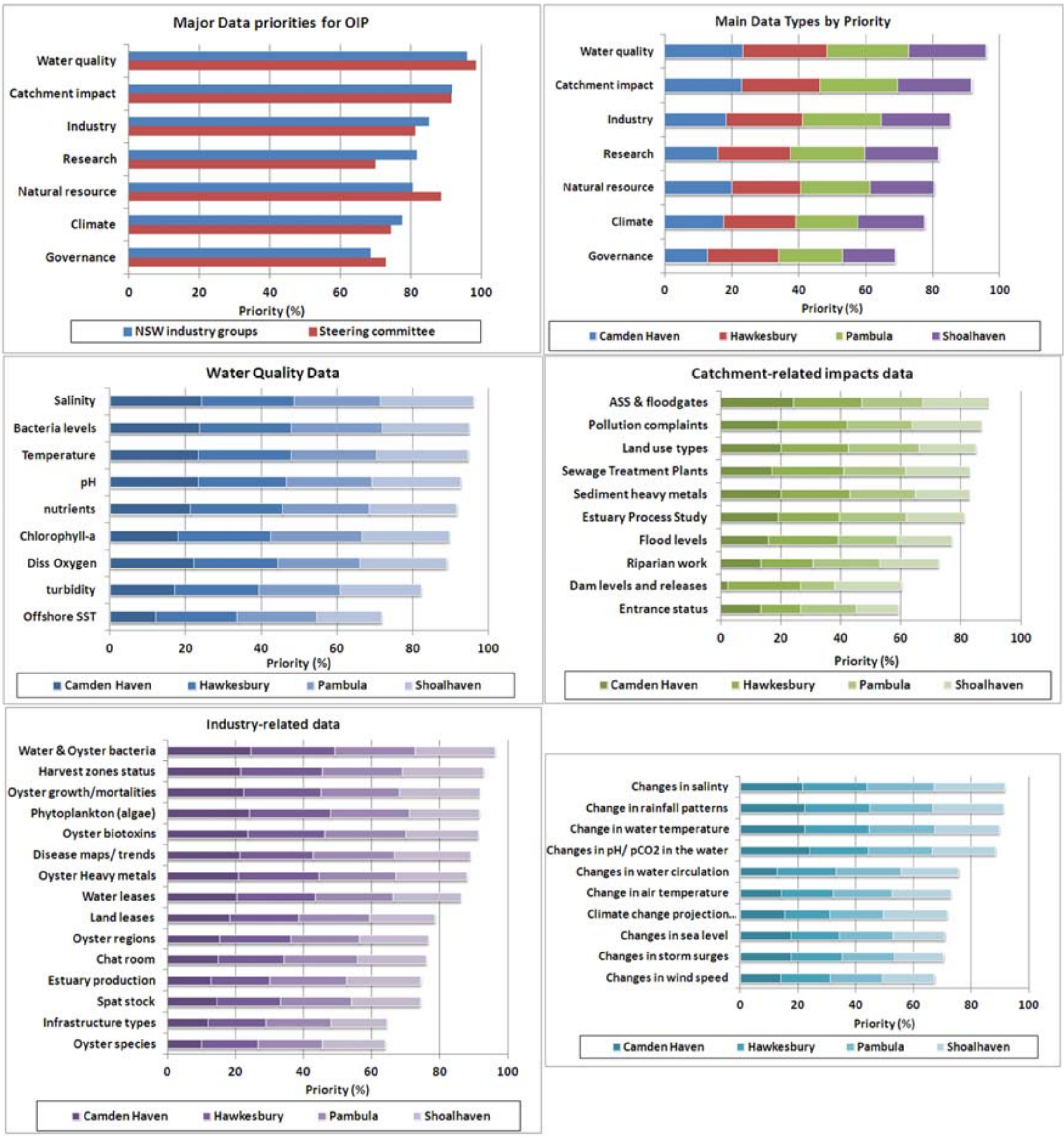



**Figure 2: Geographical distribution of the OIP study sites and key stakeholders**

Considering the vast amount of relevant information that already exists and that could be included in the OIP, a subset of priority data sets (Figure 3) and information was selected for the proof of concept of the OIP. Data was prioritised by representatives of the oyster industry and catchment managers at 8 NSW industry workshops and one national workshop. Overall, priority information categories were related to temporal trends of chemical, biological and physical parameters of water quality. Second to this was information related to catchment impacts and then information collected by the NSW oyster industry through the NSW SQAP (Figure 3). Priorities ranking of the different information data sets within a data category were consistent across oyster regions. A few exceptions in priorities resulted from unique and localized activities affecting the industry in the estuary; for example dam releases (i.e. environmental flows) and water extraction were important only at the Shoalhaven and Hawkesbury Rivers. In addition to consistent information needs across oyster regions, the priority data/information needs were found to be consistent with governance agencies (Figure 3). As such, data related to water quality, catchment impacts and oyster industry management have formed the base of the OIP in its prototype phase.



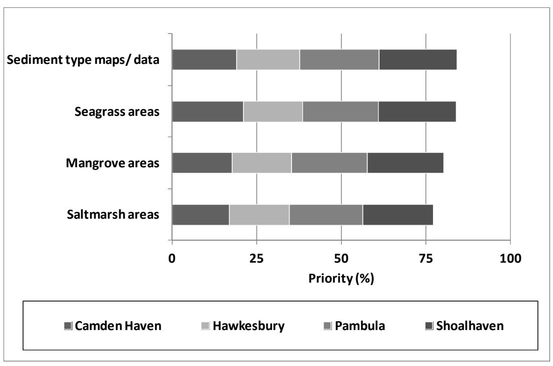




**Figure 3: Data categories and variables ranked by the oyster industry and stakeholders at consultation workshops to be included in the OIP**

### *Oyster Information Portal workflow*

Data custodians included steering committee members of the project or other catchment stakeholder groups. In general custodians were keen to share the data for this proof of concept, however in order to address privacy or confidentiality some of the data needed to be aggregated and could not be provided as raw data. Data sets received from the various custodians were catalogued in a data management system (Figure 4).

Spatial information was processed and amalgamated spatially and hierarchically through ESRI products for visualization. Temporal environmental data sets were plotted and/or aggregated in summary tables for display of the data range, changes and variability. The outputs of the environmental data sets were linked, where relevant, to the spatial layers of information, but of necessity maintained within categories of custodianship. This information was then transformed into a scalable vector graphic (SVG) format that could easily be transferred to an online website to deliver a web-mapping data portal (http://www.oysterinformationportal.net.au, Figure 4).

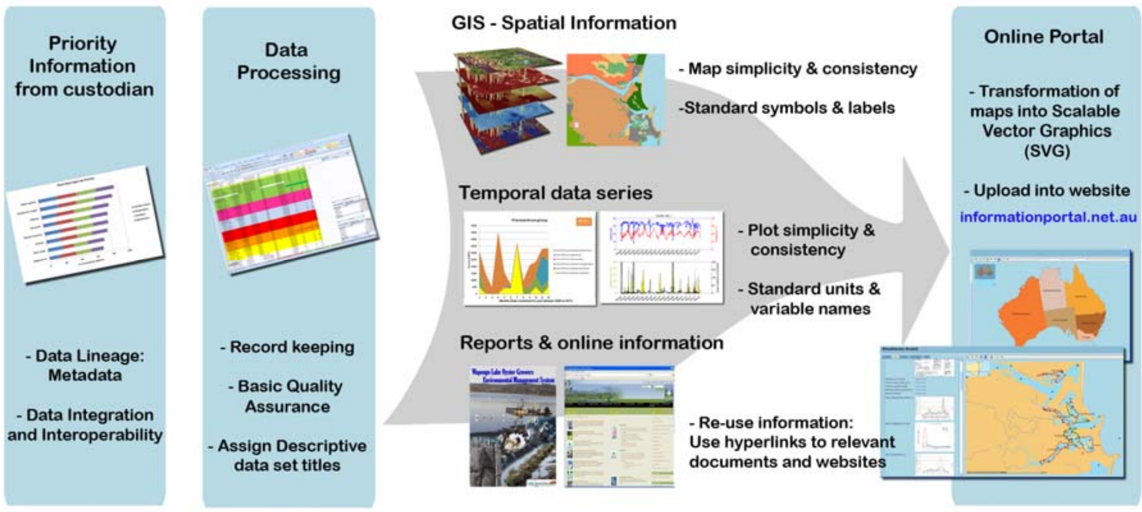



**Figure 4: Schematic of the Oyster Information Portal workflow**

## Outcomes of the OIP

Based on the feedback received from industry workshops, stakeholder meetings and recent online surveys, the OIP prototype has received broad approval as a tool that will be able to assist the oyster industry in their future planning and adaptation to a changing environment. In particular, by accessing the information included in the portal, industry members can now understand environmental and catchment data relevant to oyster production. Industry members are able to foresee the use of the portal as a central repository for knowledge sharing that will assist them in continuing to develop the information and communication needs of the industry.

### *OIP as a management tool- an industry perspective*

Through the first series of workshops, industry members ranked the top priorities affecting the long-term sustainability of their industry. Results were unanimous across industry members (N=44 industry members). The highest priorities identified in order of importance were: 1) impacts on water quality, 2) disease outbreaks; 3) sales and marketing including branding, product quality and prices and 4) unreliable access to hatchery seed supply. The current prototype of the OIP is particularly significant for the first two priorities as it contains extensive data to benchmark each growing area based on water quality parameters and oyster performance, including growth and mortality levels from specialized monitoring programs (Nash and Rubio, 2012). Currently the environmental triggers resulting in oyster diseases are poorly known for most diseases. Certain environmental stressors have been shown to suppress the immune response of oysters, which in turn have resulted in oyster infections and large mortalities. Ultimately by providing access to environmental data, oyster industry members are able to start identifying relationships with oyster performance that will be useful in managing disease or improving productivity. An example of this is explained below:

*Case Study: Oyster performance based on environmental conditions*

Farmers are aware of many of the relationship between the environment and oyster lease productivity. However, a lack of integration between bio-physical knowledge and industry knowledge currently constrains effective management of the oyster industry. As such, farmers are often left with unanswered questions or anecdotal information to account for the causes of changes in productivity from year to year. Based on results from a researcher-state government-industry partnership oyster monitoring program, growers have been able to characterize some growing areas within selected estuaries and to quantify changes in oyster performance during their first year of monitoring (Nash and Rubio, 2012). Through sustained monitoring a baseline for oyster performance can be established from which temporal and spatial changes in growth and mortality can be determined. In addition, by linking these results to existing water quality data that they collect through the SQAP and which local councils collect as part of their State of the Environment Reporting, preliminary links have been established between oyster growth and water temperature. These findings can assist growers in adjusting their husbandry techniques. For example in Pambula Lake during the winter months, oyster stocks can be moved to areas where the water temperature is above known low temperature thresholds. By taking this information into consideration it was shown that a grower could increase their annual profit by 7.6% (Nash and Rubio, 2012). Water temperature is not the only parameter known to influence oyster performance. Through greater understanding of the drivers modulating oyster performance and increased monitoring effort, the oyster industry will be in a better position to respond to unexpected events and to develop more diverse adaptation options (Leith and Haward, 2010).

### *OIP as a management tool- a catchment management perspective*

The overarching consensus across researchers, coastal and natural resource managers is that the coastal zone is at high risk for the full range of climate change impacts from land and sea (Simms and Woodroffe, 2008). In addition, recent coastal and urban development has resulted in major modifications in land use and catchment activities. This has been shown, in some areas, to significantly affect the water quality and coastal sensitive aquatic ecosystems. As a result, there has been an increased effort in monitoring the factors that affect water quality and river health as an indirect measure of management effort/outputs of land, vegetation and rivers (DEC, 2004). In particular local council and state government departments play a major role in monitoring the health of the catchments. Consequently extensive monitoring networks exist and there is a need to consolidate this information in order to achieve practical and adaptive solutions to changing environments. For this reason the development of the OIP has been supported by key catchment stakeholders in NSW estuaries that recognize the need for a tool that integrates existing information and informs on responses.

The down side is that available information is rarely streamlined according to national standard procedures for data management (Hook *et al.*, 2010) that already exist. Managing data incurs a large overhead in any institution. In addition, there is a general lack of metadata created at the time of data collection, in particular for environmental programs. Metadata for the data sets used in the OIP was created for or with data custodians according to ISO standard metadata proforma like ANZLIC Met tool. These are all obstacles in the development of data portals that unless addressed by adopting standard practices, will slow the process of information dissemination.

Most of the data sets included in the OIP belong to relatively new monitoring programs as data custodians found hard to access historical data because it was not stored in a readily accessible format in most instances. This is a result of a lack of clearly defined procedures with respect to how and where to upload data and metadata within the NSW data management framework; as such data are often collected but remains inaccessible. As part of a data gathering exercise, the final repository for the data should be clearly indicated at the outset and these protocols are slowly being established in government agencies across NSW. Consequently the streamlining process required to upload a data set to a public data storage server was explored as part of this project:

*Case Study: Establishing a stakeholder bottom-up contribution to top-down strategies for environmental information system;*

A challenge for data portals with a top-down strategic initiative is to become relevant and accessible to small and medium user groups that make up the majority of stakeholders at the local level. Therefore it is important that bottom up approaches identify and take advantage of top-down strategies and structures to deliver at the Commonwealth level areas of relevance. Included in this, is the delivery of tools and solutions to legislative challenges such as the sharing of spatial data, as well as logistical and infrastructural challenges of data management and storage facilities. This is a pre-requisite to progressing the concept of the OIP to greater scales and scope of information, and requires that the legislative conditions and framework be established at first, and that data can be collected, stored and accessed.

In this project a water quality data set collected in the Hastings LGA was used as a case study to investigate the process to be undertaken by the different data custodians involved in the management of such resource. The Terrestrial Ecosystem Research Network (TERN - http://tern.org.au.html), and specifically its Australian Coastal Ecosystems Facility (ACEF - http://tern.org.au/Australian-Coastal-Ecosystems-pg17732.html, Figure 5) were selected as one of the current storage points were to upload data sets so that the information becomes accessible for the purpose of reporting and decision making. Licensing options for the data set were explored according to privacy conditions. Currently the majority of data is by default functionally present at security level 1 – confidential information, despite it being publicly funded and invested in for public good. This is primarily a legacy of the historical logistics of data collection and management, but also to a degree of uncertainty regarding the responsibilities, sensitivities and legal consequences of making data publicly available.

Recently, however, there has been a general movement and acknowledgement of the need to make environmental data accessible across diverse agencies for purpose of reporting, but also decision making and predictions based on monitoring trends in the data. Therefore Creative Common licensing (http://creativecommons.org.au/learn-more/licences) approaches are being established for diverse types of marine community data and the TERN facility solution to Creative Commons Licensing is comprehensive and flexible, but still operates under the broad premise that data should be publicly available and useable. In addition, systems have been developed to identify data sets in a way similar to that achieved through peer-reviewed publications. This is in part achieved through the provision and identification of data sets and / or metadata with digital object identifier (DOI) codes. These codes are unique and can be used in the same way as journal citations.

By uploading a State government data set to a public data portal storage facility and by informing the steps involved in the process it is expected to generate significant interest among other data custodians to follow the initiative.

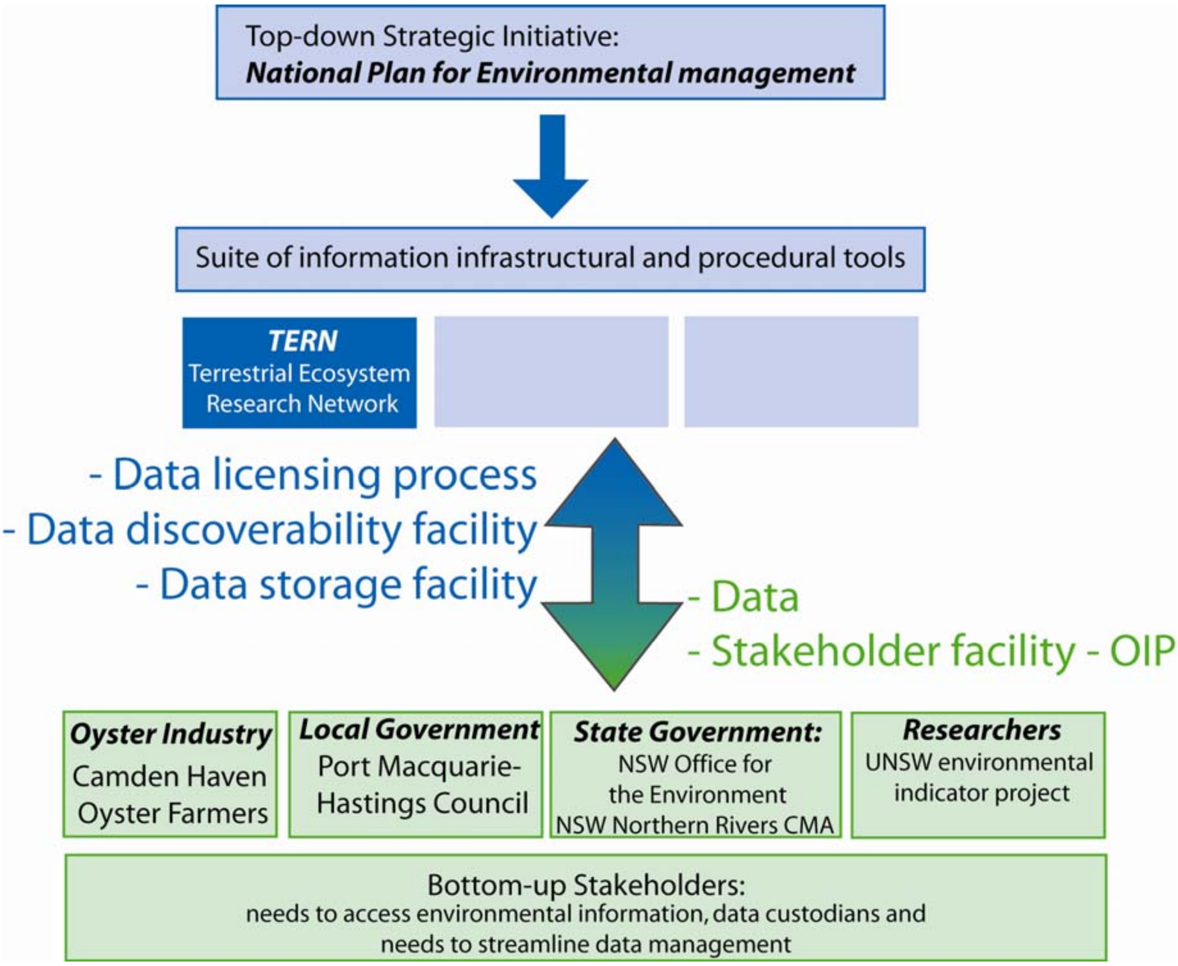



**Figure 5: Data management across organizations at the national and state level**

***OIP as a monitoring tool – value adding to the investment in shellfish monitoring programs***

Shellfish Quality Assurance programs are a spatially and temporally extensive data collection programs invested in by the NSW Food Authority; a program not well recognized amongst natural resource managers. This data is currently only used for real time responses to threats to human health by the consumption of contaminated oysters. One of the key concerns in these shellfish monitoring programs is the presence of harmful algae or phytoplankton, and toxic shellfish poisoning. Phytoplankton are of importance to the oyster industry in a multitude of ways.

- Phytoplankton deliver the food and energy required by filtering species such as oysters
- Phytoplankton take up and affect the types of nutrients available in estuaries which dictates the trajectory of trophic composition
- Phytoplankton respond rapidly to specific environmental queues (e.g. sunlight, temperature and nutrient availability) and as such less desirable species have the potential to bloom and close shellfish industries due to toxic health effects on

consumers (e.g. *Alexandrium* spp.) or less frequently detrimental effects on the health of the oysters themselves.

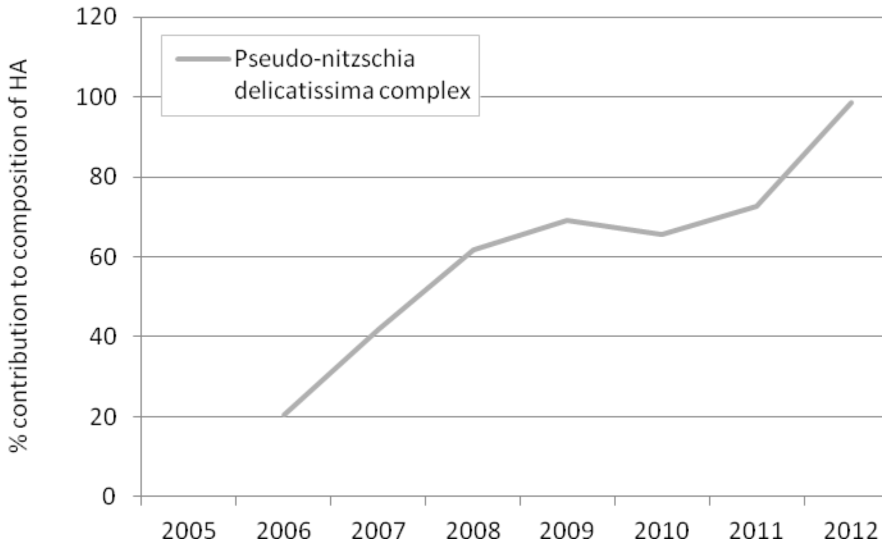
These programs typically sample water for phytoplankton on fortnightly schedules and throughout the year delivering detailed reports on species level resolution of harmful algae. Despite this data being abundant and regular and quality controlled under NSW Food Authority training and authorisation procedures, it has, until recently, only been utilised towards managing the health risks to humans from seafood without any long term analysis of the data. Recently, Ajani et al. (2012) analysed extensive data sets of this data of harmful algal bloom species data in a rigorous evaluation of spatial and temporal patterns. This study analysed 45 taxa from 31 estuaries in NSW and showed evidence for discrete harmful microalgae communities from the upper reaches of estuaries compared to the lower estuary. This suggests that factors such as salinity may be key drivers of microalgae diversity. In addition there was an increase in HAB species abundance with increasing latitude (decreased water temperature), suggesting that increased water temperatures may be linked to reduced risk of harmful algal blooms, but that modified catchments and low turnover estuaries maintained a higher abundance of HABs, suggesting that not all rivers require the same amount of time to recover from HAB events.

Considering that the non-harmful algae are an important food source for the industry and that changes to climate are predicted to affect the composition of primary producers such as microalgae, it seems pertinent that the monitoring program data is analysed further for trends in time and space for both oyster industry benefits as well as for natural resource managers.

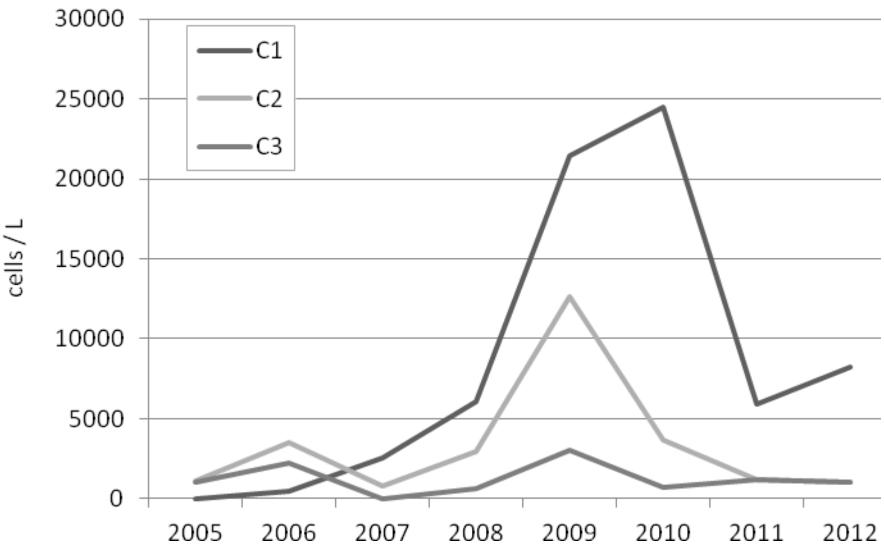
*Case Study: Identifying trends in the Clyde River Shellfish Quality Assurance program*

Our findings from the analysis of Shellfish Quality Assurance Program data within the Clyde River showed that the composition of Harmful Algae shifted primarily across seasons within sites and that this was related to the abundance of species rather than the composition of phytoplankton assemblages. Within the Clyde at 3 sites there was little evidence of differences in harmful algae composition as was reported by Ajani et al. (2012).

Further examination of temporal and spatial patterns revealed a compositional trend in the last two years of sampling across all sites, and the Pseudo-nitzschia delicatissima complex was identified as the driver of this trend (Figure 6). Further analysis revealed that contribution of this taxonomic complex to the overall harmful algae composition increased steadily and consistently during the last decade, although the total abundance varied across with some indications of recent blooms at all three sites in the Clyde River. This is a surprising trend to be identified over a decade and may be linked to either catchment or climate change effects or a combination of both. However the identification of this trend from the SQAP data demonstrated the importance of long term monitoring and analysis of the data as the Total Pseudo-nitzschia' group has been identified as the taxon contributing most to harmful algae exceedances in some of the NSW estuaries (Ajani et al., 2012; Trainer et al., 2012). It is therefore recommended that more be learned about this group of diatoms which may be an indicator of change in NSW estuaries for natural resource managers as well as a prime concern for the viability of the NSW oyster industry.




(a)




(b)

**Figure 6: (a) Percentage contribution of the *Pseudo-nitzschia delicatissima* complex to the composition of harmful microalgae in the Clyde River across three sampling sites across 8 years, (b) the abundance of *Pseudo-nitzschia delicatissima* complex (cells / L) at three sampling sites in the Clyde River over 8 years.**

## Future of the OIP

The OIP developed in this study was a proof of concept to explore the need for amalgamation of existing data and as a tool to "decrease sensitivity" or improve the resilience of the oyster industry to climate change through a better understanding of the natural resources the industry relies upon, as well as "build adaptive capacity" by indentifying natural resource trends to prepare for informed response and thus adaptation to change. Now that this concept is fully supported by industry and catchment managers, alternative technology and working platforms for the development of interactive, fast process data portals is currently being explored. Therefore, the OIP for the Shoalhaven River is currently being re-developed by the researchers at the SMART facility of the University of Wollongong using modern technological architecture, which is powerful and low cost, based on the principles of Free and Open Source Software and which is based on International Standards Protocol for data management (ie metadata). SMART researchers are trailing the use of the Yellowfin Business Intelligence Solution that integrates all the data sources and report, analyse and present data on trends and main findings through a wide range of formats.

With the current support of the oyster industry and catchment stakeholders, it is envisaged that the OIP will be developed using above technology and working platform. Stage-2 of the OIP can expand its geographical coverage to the rest of the NSW coastline potentially expanding to a national scale, since good feedback has been received from industry members in other states.

## Conclusion

In summary, the proof of concept of the OIP has shown to have the potential to better distribute information that already exists (i.e. estuary and oyster health monitoring and reporting). The OIP has also provided industry members and natural resource managers and other industry and catchment stakeholders to access existing information and interpret it with relevance to their industries and catchment processes. In addition, the OIP has been demonstrated to assist the governance framework of the industry to be better informed to make decisions in relation to climate change and to facilitate the long term viability of the industry. Overall the OIP has been seen to be able to assist with a better research and communication engagement.

## Acknowledgements

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