SUBMISSION TO
INQUIRY INTO THE ROLE OF SCIENCE FOR FISHERIES AND AQUACULTURE

HEADLINES

- There is a declining trend in enrolments in the field of education Fisheries Studies at both the Bachelor's and PhD course levels.
- Approximately half of the Australian fisheries and aquaculture research work force is employed in State/Territory government agencies (51 per cent). The remainder is employed in Commonwealth government agencies (30 per cent) and universities (19 per cent).
- Investment by the government sector in fisheries and aquaculture research and development underwent a modest decline in real terms between 2004/05 and 2008/09. Research and development expenditure by the higher education sector increased in real terms during 2006-08.
- Australian fisheries and aquaculture researchers are productive and deliver high-impact research publications when compared to global norms.
- The rate of higher-degree research completions in fisheries and aquaculture is significantly less than the estimated retirement rate over the coming 10 to 15 years, threatening the capacity to maintain current levels of research excellence.

INTRODUCTION

This submission provides an analysis of the higher education enrolment statistics and several measures of research funding and research excellence to provide a picture of the *health* of fisheries and aquaculture sciences in Australia. The data sources and analytical methods have been described and applied more broadly in the recent Health of Australian Science report (Office of the Chief Scientist, 2012). This report can be downloaded from the Office of the Chief Scientist website http://www.chiefscientist.gov.au.

HIGHER EDUCATION TRENDS

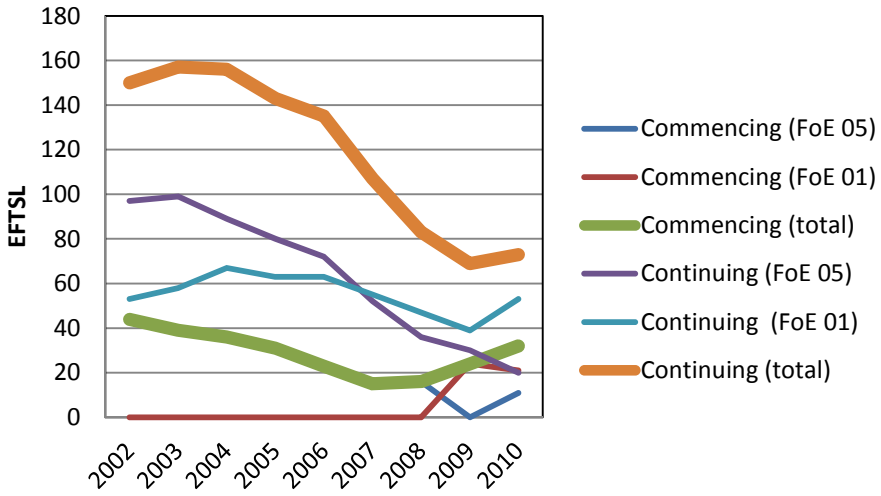
The broad field of education Agriculture, Environmental and Related Studies (ASCED Code 05) contains the narrow field of education Fisheries Studies (ASCED Code 0507). Students enrolled in the broad field of education Natural and Physical Sciences (ASCED Code 01) also enrol in subjects classified as Fisheries Studies. While course level[1] enrolment and completions data for the broad fields of education are available, they do not show the number of students that have enrolled in and completed subjects classified as Fisheries Studies.

The only way of quantifying in any reliable way the potential number of students with a Bachelor's degree containing a minor[2] or a major in fisheries or aquaculture is to consider the equivalent full-time student load[3] (EFTSL) within the narrow field of education Fisheries Studies. Figure 1 shows the trend in total commencing and continuing EFTSL in Fisheries

[1] Course levels include the following degrees: Bachelor's (pass), Bachelor's (honours), Master's by coursework, Master's by research, and doctorate (PhD).
[2] Subjects taken to the second year of a Bachelor's degree are referred to as a minor and subjects taken to the final year are referred to as a major.
[3] One EFTSL is the load a standard full-time student would take in a calendar year.

Studies at the Bachelor's course level during the period 2002-10. The commencing[4] load declined 34 per cent during the period (33 EFTSL in 2010) whereas the continuing[4] load declined 52 per cent (74 EFTSL in 2010). While both have undergone significant decline during the entire period, a small upturn in the commencing load in 2008 appears to have also translated to the continuing load.

Figure 1: *Domestic equivalent full-time student load (EFTSL) at the Bachelor's course level during 2002-10 in the narrow field of education Fisheries Studies. Total commencing and total continuing EFTSL are shown. The EFTSL divided between the broad fields of education (FoE) 01 Natural and Physical Sciences and 05 Agricultural, Environmental and Related Studies are also shown.*



Source: See Office of the Chief Scientist (2012); data derived from the DEEWR Higher Education Statistics-Student Collection.

The trend in load shown in Figure 1 has also been separated according to which broad field of education a student's overall Bachelor's course is classified. The only two broad fields that include students undertaking Fisheries Studies are: 05 Agricultural, Environmental and Related Studies (Bachelor of Agriculture or similar) and 01 Natural and Physical Sciences (Bachelor of Science or similar). Prior to 2009 most of the commencing EFTSL was undertaken by students enrolled in a Bachelor of Agriculture or similar whereas in 2009 and 2010 most were enrolled in a Bachelor of Science or similar. The switch from predominantly Bachelor of Agriculture students to predominantly Bachelor of Science students taking Fisheries Studies at the continuing level occurred in 2007. This means that recent graduates with a minor or major in Fisheries Studies will probably have been taught a different mix of

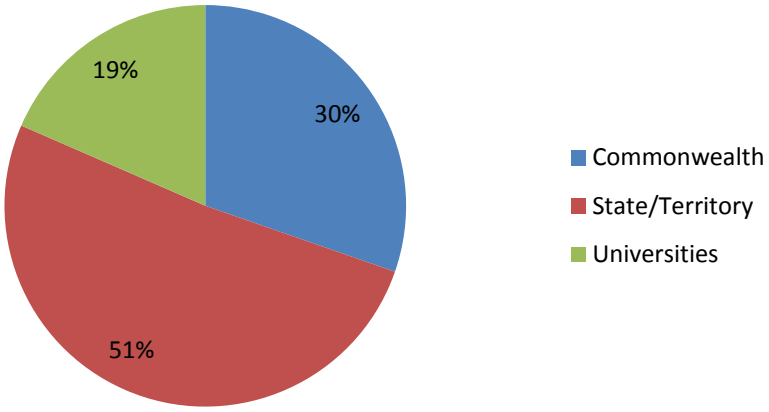
[4] Commencing EFTSL represents load or subjects taken in a student's first year of their course enrolment, whereas continuing EFTSL represents load taken in a student's second and final year. Typically a single subject in a semester would represent 0.125 EFTSL. One commencing Fisheries Studies EFTSL therefore represents a maximum of 8 students completing a one-semester first-year subject relating to fisheries and aquaculture. If any of those students enrolled in an additional first-year subject in that narrow field of education then that one commencing EFTSL would represent fewer actual students. This logic cannot be extended to determine the maximum number of individual students who undertake a minor or a major in Fisheries Studies, because continuing EFTSL are an aggregate of second- and final-year students who might have undertaken any number of individual subjects classified as Fisheries Studies in the final 2 years of their degree.

additional subjects compared to those graduating prior to 2007. It is not clear what this change reflects or means for the future workforce in fisheries and aquaculture.

RESEARCH WORK FORCE

A recent study estimated a total of 531 full time equivalent (FTE) staff engaged in fisheries and aquaculture research in Australia. Most of these are employed in State and Territory agencies and in Commonwealth agencies (Figure 2).

Figure 2: *Distribution of the 531 full-time equivalent staff engaged in fisheries and aquaculture research across Commonwealth agencies, State and Territory agencies and universities.*

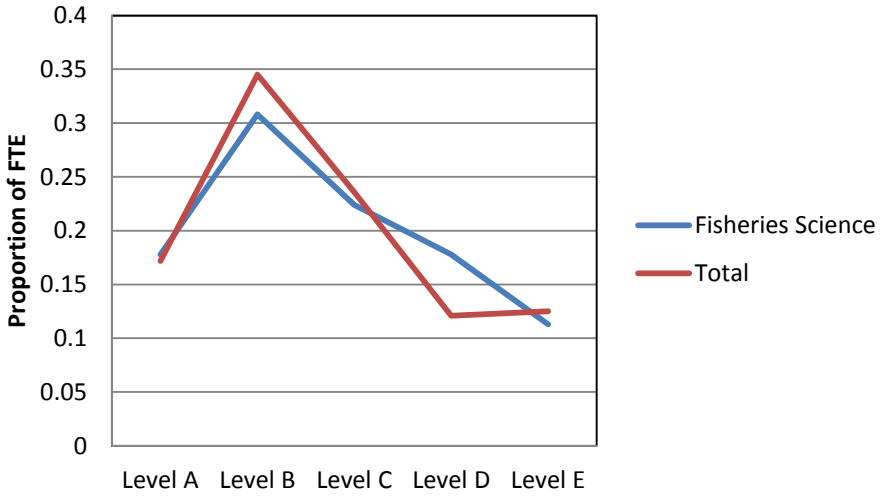


Source: Data derived from Rural Development Services (2010).

The age profile of Australia's fisheries and aquaculture research work force is not available, however, a surrogate profile of the university work force engaged in the field of research Fisheries Sciences (ANZSR code 0704) is available from the 2010 Excellence in Research for Australia audit (Australian Research Council, 2011). The distribution by academic level of the 101 FTE university staff engaged in fisheries and aquaculture research is shown in Figure 3. The distribution of the total university FTE staff across all fields of research is shown for comparison. The profile for Fisheries Sciences is indicative of an aging work force that is not being completely replenished; there are relatively fewer junior Level B academics and relatively more senior Level D academics than the norm.

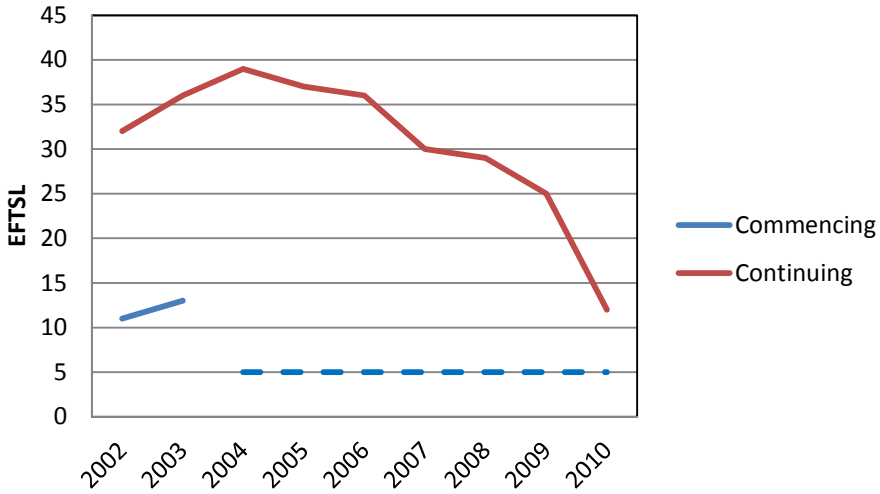
The pipeline into the fisheries and aquaculture research work force is students enrolled at the PhD course level. The trend in PhD EFTSL during the period 2002-10 is shown in Figure 4. At this course level one EFTSL can be reasonably expected to represent one student. Since 2003 the precise number of commencing PhD students in Fisheries Sciences is not available (to preserve confidentiality), but it has declined from a low base of 13 in 2003 to be <10 for the remainder of the period. Since a peak in 2004 the number of continuing students has declined 69 per cent to 12 EFTSL in 2010.

Figure 3: *Proportion of total university FTE staff in Fisheries Sciences (ANZSR code 0704) across academic levels A through E. The proportional staffing profile across the total university sector is also shown.*



Note: Level A is associate lecturer, Level B is lecturer, Level C is senior lecturer, Level D is associate professor and Level E is professor.
Source: See Office of the Chief Scientist (2012); data derived from Australian Research Council (2011).

Figure 4: *Domestic equivalent full-time student load (EFTSL) at the PhD level during 2002-10 in the narrow field of education Fisheries Studies. Total commencing and total continuing EFTSL are shown. The dashed proportion of the commencing record is not precisely known as the statistics are recorded as <10 EFTSL (to preserve confidentiality).*



Source: See Office of the Chief Scientist (2012); data derived from the DEEWR Higher Education Statistics-Student Collection.

If it is assumed that the age profile of the university work force in fisheries and aquaculture (indicated in Figure 3) is broadly indicative then roughly 28 per cent of the total fisheries and aquaculture work force (531 FTE staff; Figure 2) are at the age of Level D and E academics and will be retiring over the next 10 to 15 years. That is on average between 10 and 15

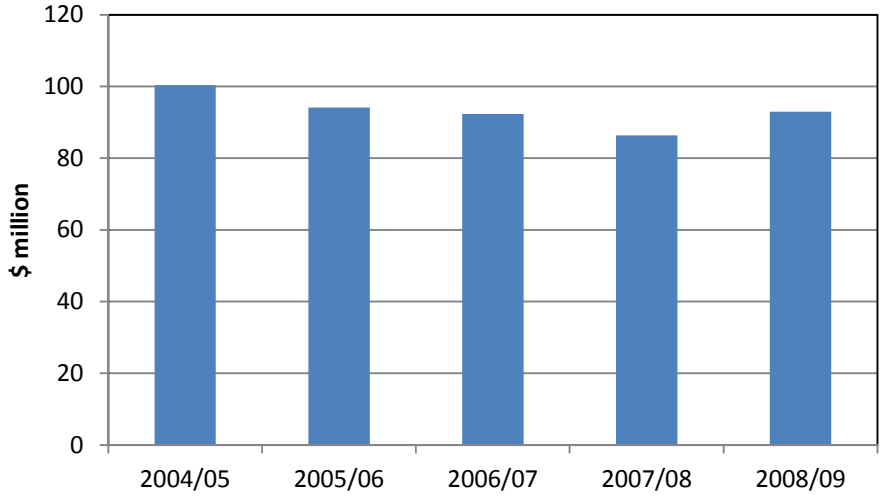
retirements per year. The trend shown in Figure 4 indicates the rate of incoming researchers from within the Australian university system over the coming decade will fall well short of the retirement rate.

RESEARCH AND DEVELOPMENT FUNDING TRENDS

The Australian Bureau of Statistics' tables describing gross expenditure on research and development (GERD) do not distinguish fisheries and aquaculture from the broader agriculture classification, so estimates of R&D investment have been sourced elsewhere and are incomplete. In particular, investment by the business sector is not quantified.

Rural Development Services Australia (2010) provides information on investment from most of the relevant organisations in the Commonwealth and State/Territory government sectors[4] (Figure 5). During the period 2004/05 to 2008/09 Rural Development Services Australia (2010) concluded that the total investment in fisheries and aquaculture (including legislative requirements) matched CPI increases over the period, so was static in real terms. Figure 5 shows the picture, excluding investment in legislative requirements, and there was a decline in the investment devoted to scientific research of 7 per cent in real terms.

Figure 5: *Total investment in fisheries and aquaculture research by specified organisations[5] during 2004/05 to 2008/09.*



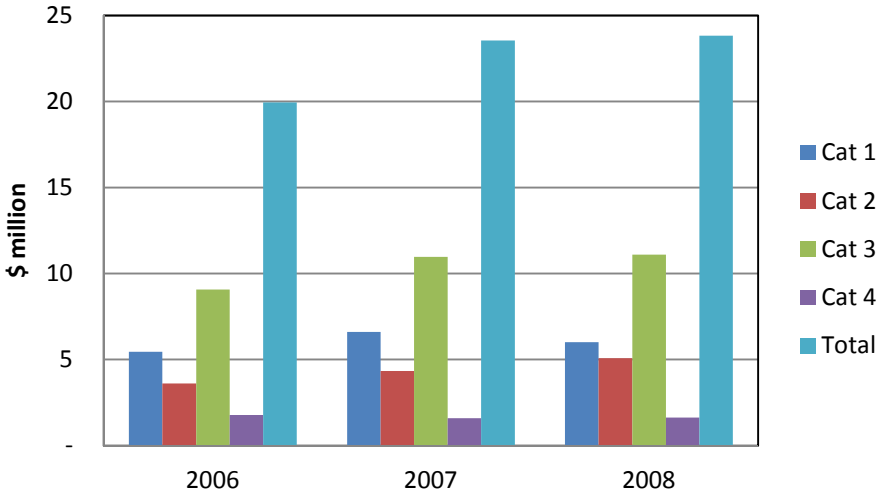
Note: Investment adjusted to 2008/09 dollars.
Source: Data derived from Rural Development Services (2010).

Details of the research income to universities over the latter part of this period are available from the 2010 ERA audit (Australian Research Council, 2011). The total amount of university research income to Fisheries Sciences (ANZSR code 0704) is shown in Figure 6

[5] The organisations are: Australian Fisheries Management Authority; Department of Agriculture, Forestry and Fisheries; Fisheries Research and Development Corporation; Seafood CRC; Reef and Rainforest Research Centre; Australian Bureau of Agricultural and Resource Economics; CSIRO Marine; Bureau of Rural Science; CSIRO Livestock; Australian Institute of Marine Science; State/Territory Fisheries Agency in Western Australia, South Australia, Victoria, New South Wales, Queensland and Northern Territory; James Cook University; and University of Tasmania.

by source. Total income grew in real terms by 20 per cent between 2006 and 2007 and was then steady. Across all years the primary source of income was industry and international research income (category 3) followed by Australian competitive grants research income (category 1).

Figure 6: *Amount of university research income by category during 2006-8 in the narrow field of research Fisheries Sciences (ANZSR code 0704).*



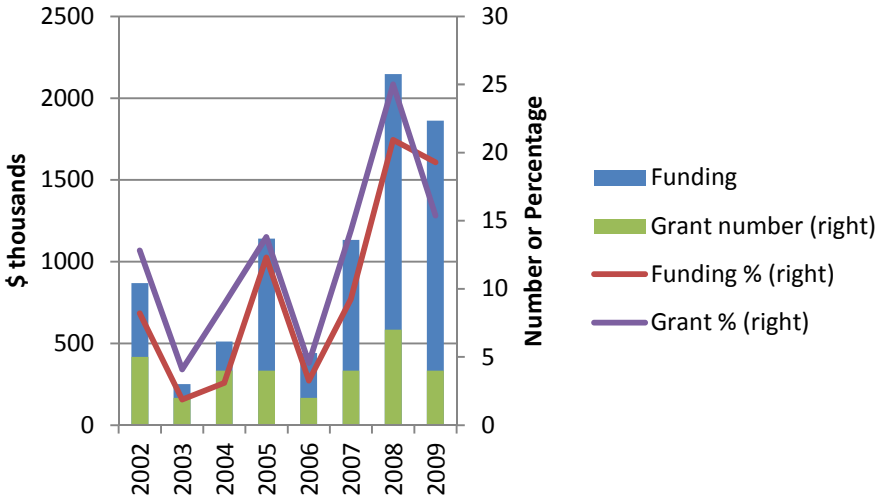
Note: Category 1 is Australian competitive grants research income, as listed on the Australian Competitive Grants Register; Category 2 is other public sector research income; Category 3 is industry and international research income; and Category 4 is CRC research income.
Income adjusted to 2008 dollars.
Source: See Office of the Chief Scientist (2012); data derived from Australian Research Council (2010).

The trends in Australian competitive research grants and funding awarded to universities in the research field Fisheries Sciences (ANZSR code 0704) is shown in Figure 7. During the period 2002-09 the number of grants was relatively constant with an average of 4 grants per year. At the same time grant funding awarded increased by 114 per cent in real terms. Fisheries Sciences increased its relative success in attracting competitive research grants during the period, as indicated by its increased percentage of the total grants and funding awarded to the broad field of research Agricultural and Veterinary Sciences (ANZSR code 07).

RESEARCH OUTPUT AND EXCELLENCE

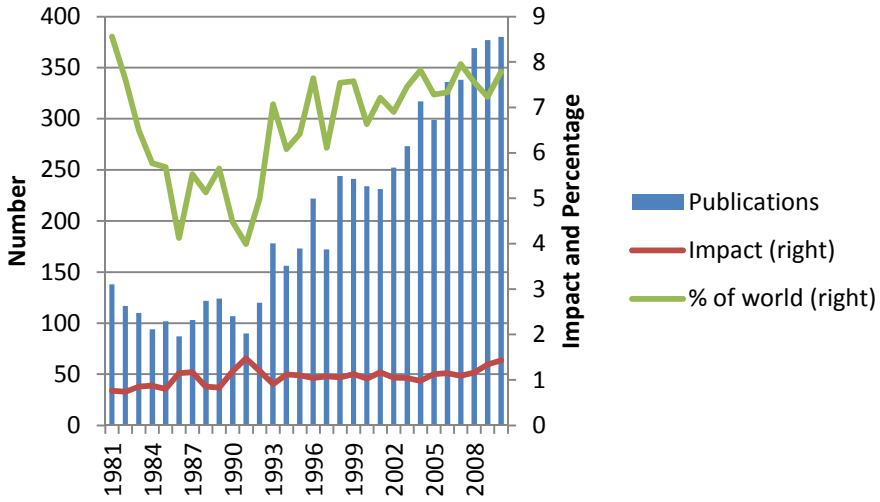
A bibliometric history of Australian publications in the research field of Fisheries Sciences shows that annual output was roughly constant during the 1980's, but since 1990 the annual publication rate steadily increased to over 370 publications in 2010 (Figure 8). This represents about 8 per cent of the world publications in this research field. For most of the period the relative impact of Australian publications in Fisheries Sciences was slightly greater than 1, but in 2010 it climbed to 1.43. This impact factor is larger than the current impact factors for all of the science-related broad fields of research (see Table 6.7.1 in Office of the Chief Scientist, 2012).

Figure 7: *Number of grants and funding amounts awarded in the narrow field of research Fisheries Sciences during 2002-10 by the Australian Research Council's competitive research grants schemes. The percentage of the total funding and number of grants awarded to the broad field of research Agricultural and Veterinary Sciences is also shown.*



Note: The competitive research grant schemes included are Centres of Excellence, Discovery Indigenous Researchers Development, Discovery Projects, Federation Fellowships, Australian Laureate Fellowships, Future Fellowships, Linkage Projects (APAI Only), Linkage APD CSIRO, Linkage Infrastructure Equipment and Facilities, Linkage Projects, Special Research Initiatives, Linkage International, ARC Research Networks, and Special Research Initiatives (Thinking Systems).
Funding amounts adjusted to 2010 dollars.
Source: See Office of the Chief Scientist (2012); data derived from Australian Research Council National Competitive Grants Program Trends Data: http://www.arc.gov.au/general/searchable_data.htm.

Figure 8: *Number of Australian publications in the field of research Fisheries Sciences during 1981-2010, as contained in the InCites™ bibliometric data base. Also shown are these publications as a percentage of world publications in this field of research and their relative impact.*



Note: Relative impact is defined as the ratio of average citations per paper divided by the global average of citations per paper in that field.
Source: See Office of the Chief Scientist (2012); data derived from Thomson-Reuters (2011).

Focussing on university research outputs, the narrow field of research Fisheries Sciences in Australia is classed above world standard based on its ERA rating of 4.2 (Table 1). With only 10 per cent of the research work force contained within the broad field of research Agricultural and Veterinary Sciences, the narrow field of research Fisheries sciences produced 11.6 per cent of the total publications. This is a strong performance considering the small number of FTE staff in Fisheries Sciences and increased marginal productivity typically deriving from a larger critical mass of researchers.

Table 1: *List of university research excellence indicators during 2006-08 for the narrow field of research Fisheries Sciences, which is part of the broad field of research Agricultural and Veterinary Sciences. The excellence indicators are numbers of publications, patents and esteem counts. Also shown is the overall ERA rating and number of full-time equivalent (FTE) staff producing this research.*

	Fisheries Sciences	**Agricultural and Veterinary Sciences**
ERA Rating	**4.2**	**3.7**
FTE	**101**	**1 021**
Total publications	**992**	**8 540**
Books	2	35
Book chapters	51	484
Journal articles	899	6 459
Conference papers	40	1 562
Patents	**0**	**35**
Esteem counts	**3**	**60**

Note: An ERA Rating of 3 is regarded equivalent to world standard. ERA ratings of 4 and 5 are considered above world standard and well above world standard respectively (ARC, 2011). Esteem counts are defined to embody a measure of prestige and are recognised by experts within the disciplines as a highly desired, highly regarded form of accolade or acknowledgement (for example, fellowship of a learned academy) (ARC, 2011). Source: ARC (2011).

CONCLUDING REMARKS

Australian researchers in fisheries and aquaculture are strong performers—they produce 8 per cent of the world's research publications and these publications have a citation impact that ranks them above world standard. The sub-set of these researchers employed in universities are also successful in attracting more than their proportional share (based on FTE) of research income from national competitive grants schemes. This research excellence has been achieved against a recent backdrop of declining research and development expenditure across the Commonwealth and State/Territory government sectors (the total expenditure, including the business sector, was unavailable). It is left to the research sector to argue whether the gross expenditure on research and development in fisheries and aquaculture is sufficient.

It is the conclusion of this submission that research capacity presently existing in the fisheries and aquaculture research work force cannot be sustained by present trends in domestic higher education enrolments. If it is a finding of the House of Representatives Standing Committee

on Agriculture, Resources, Fisheries and Forestry that there is a role for science in Australian fisheries and aquaculture in the future, then this looming capacity deficit must be addressed. Considering the role that sustainable fisheries and aquaculture will probably play in Australia's future food security and their potential contributions to bio-fuel production and carbon management options (PMSEIC, 2010a and 2010b)—it is in the national interest to do so.

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