Title Australia's Census of Antarctic Marine Life project in collaboration with France and Japan

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Question 3 Project Information

3.1 Objectives

3.1.1 Project Objectives

State the project objectives

This proposal is the Australian contribution to the Census of Antarctic Marine Life (CAML) for the 2007-08 IPY season. This application is being made two years in advance and the details of scientific work to be undertaken are still incomplete. In principle approval is required in order to validate ship time allocation in 2007/08. This application will assist collaborative partners in this proposal to gain support within their own national programmes and also for continued development with other nations participating in the CAML and Census of Marine Life (CoML).

The CoML is an international cooperative programme, aimed at understanding and explaining the diversity, distribution, and abundance of marine life in the oceans -- past, present, and future. CAML is one of 14 field projects in CoML and its main objective is to study the evolution of life in Antarctic waters to determine how this has influenced the diversity of the present biota, and to use these observations to predict how it might

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respond to future change. CAML is the newest project in CoML, having started in early 2005. As such, many aspects of the project are currently under development. This process is directed by the Scientific Steering Committee of ten international experts, appointed by the Scientific Committee on Antarctic Research (SCAR), and assisted by a number of specialist working groups. Survey areas, common sampling methods, and protocols for the processing and identification of samples, are expected to be finalised by the CAML Scientific Steering Committee and its working groups by May 2006.

While planning for the specific science projects within the CAML is still under development, the census will investigate:
1. The use of powerful new genetic and molecular tools to determine the extent to which the circum-Antarctic marine fauna and flora is homogeneous or differentiated. This will enable regional predictions to be made of the consequences of future climate change.
2. The future adaptability of a flora and fauna which evolved in an environment free from the pressures of current global warming. This will inform predictions of species survival to the observed rate of change.
3. The likely effects of environmental change on the provision of ecosystem services. This will be estimated from comparison of data collected in the 2007/08 field season with data published from previous expeditions, such as the *Challenger* and *Discovery* voyages, and from taxonomic analysis of existing museum collections.
4. The environmental consequences of ice-shelf collapse, enabling predictions to be made of the impact of further dissolution of this uniquely polar habitat to ecosystem services.
5. The importance of the Southern Ocean as a source of marine speciation. If, as has been suggested, Antarctic waters are a launching pad for speciation, change in circulation and physical characteristics of Antarctic waters will have far-reaching effects.

3.1.2 Scientific Relevance

Explain the scientific relevance of these objectives.
Polar regions experience greater rates of climate change than elsewhere on the planet. The fauna of these regions is uniquely adapted to the extreme environments in which they exist, and may be vulnerable to shifts in climate. There is an urgent need to establish the state of these communities, and in particular their diversity, if we are to understand the impact of climate change. Current knowledge of Antarctica's marine biodiversity is patchy. For the most part almost nothing is known about the mesopelagic, bathy/abysso-pelagic and benthic fauna of the slopes and deep-sea abyssal plains. Practically nothing is known about the tiny organisms (bacteria, archaea, eukarya, viruses, nanoplankton) in the sea wherever they occur and in whatever habitats, or about the faunas associated with hydrothermal vents, cold seeps, and seamounts.

The CAML is a five year project that will focus the attention of the public on the ice-bound oceans of Antarctica, reaching its peak of activity during the International Polar Year (IPY) in 2007/08. It will be conducted under the auspices of the Census of Marine Life (www.coml.org). CAML aims to show what is known, unknown and probably unknowable about the Southern Ocean and to determine how evolutionary processes have influenced the diversity of the present biota, and to use these observations to predict how

it might respond to future change. The project will integrate knowledge across all regions, biomes, habitats and fields of study to strengthen our knowledge of ecosystem dynamics in this high latitude, ocean system, and only through a multi-scale level of investigation will a better understanding of the diversity and status of Antarctica's marine life be obtained.

CAML will provide a benchmark for tracking future change in the Antarctic marine environment. With reference to earlier "Discovery" voyages some assessment can be made of faunal changes occurring over the past 60–70 years. The CAML will leave legacy sites for future comparability studies. It will employ modern genomic scientific techniques and contribute to the Barcode of Life project, as well as integrating with other Census of Marine Life projects. In particular, the CAML will interact very strongly with the Arctic Ocean Diversity project ArcOD, IPY EoI 64 and the Canadian ArcOD, EoI 713, drawing comparisons between differences in ecological structure and dynamics between the Arctic and Southern Oceans.

The Australian contribution to the Census of Antarctic Marine Life will be centred around a collaborative Australian-French research cruise to investigate the plankton, fish and benthic biodiversity, ecology and interactions on the continental shelf and slopes off the Terre Adelie and George Vth coast of eastern Antarctica. Most of this work will be undertaken from the Australia research vessel *Aurora Australis,* and may be supplemented with some studies from the French vessel *L'Astrolabe*, which has been conducting an inshore monitoring program as part of "Ichtyologie côtière en Terre Adélie" (ICOTA) project. Belgium will also participate through its association with ICOTA, since 2004, as part of its study of the pelagic diversity of the Southern Ocean (PELAGANT). The Japanese Antarctic programme will also be operating five research vessels to study the oceanography and pelagic ecology of this region during IPY in a collaborative project with Australia providing extensive seasonal ecological studies as well as contributing to the pan-Antarctic census.

The survey area has been identified by these nations as a region that has been poorly studied compared to the Atlantic and Indian Ocean (Prydz Bay region) sectors, yet offers some of the best conditions to study the effects of sea ice dynamics on the biota of the region, especially on krill-salp-plankton interactions and flow on effects to fish, penguins, seals etc (Nicol *et al* 2000). This region is also useful for studying variation in plankton and protistan communities which have an effect on climate through dimethyl sulphide production and absorption of atmospheric CO2 and links with previous Australian-Japanese studies, Australian-French monitoring of biogeochemical processes, and Australian-Belgian-French studies of fish larvae and plankton in this area.

Below 200 m depth, the ichthyological biodiversity and environmental parameters in the Terre Adélie sector are essentially unknown, except for studies in the bay around Pointe Géologie archipelago since 1996. These need to be investigated and compared with similar studies in other sectors of the Antarctic Ocean, for example in the Ross Sea (MacMurdo, Terra Nova Bay), Prydz Bay and in the Atlantic sector (Peninsula, Weddell Sea). Some important differences in the composition of the fish fauna (dominant species)

as well as striking interspecific differences at cytogenetic level have already been observed in the coastal fish fauna (from 0 to 200m depth), suggesting important divergences between populations. In this study, it is therefore proposed to investigate the diversity of the ichthyofauna (from gene level to fish habitats) in different oceanographic sectors from Terre Adélie to the Mertz Glacier. Antarctic fish communities are associated with specific water mass characteristics (mesopelagic fishes), bathymetry and stress from iceberg impacts. Ecological specialisation in species habitat and trophic relationships might explain phylogenetic shifts among species. Identified target fish groups include the Zoarcidae and *Pleuragramma* (an important prey species) in the pelagic/mesopelagic zones and benthic species such as *Trematomus* spp, deeper-living species of Channichthyidae, Artedidraconidae, Bathydraconidae and Liparidae.

The proposed fish component aims to answer the following key questions:

1. What is the composition of the epipelagic, mesopelagic and benthic ichthyofaunas between the Antarctic Divergence and the coast at Dumont d'Urville?
2. How does the physical and biological structure of the water column, conditions of ice-cover and bottom topography influence the composition and distribution of these ichthyofaunas?
3. What changes in the community structure of the benthic ichthyofauna as a result from the passage of large icebergs?

Commensurate with the paucity of knowledge of deep-water fish there have been almost no studies of the benthos of eastern Antarctica except for very limited trawling between Prydz Bay and Enderby Land and very localised inshore sampling, e.g. Human Impacts programme at Casey and some studies conducted in the 1960s in the coastal zone of Terre Adélie (e.g the studies by Arnaud, 1973). Knowledge of the composition and community structure of the benthos is essential to help explain the distribution of bottom and near-bottom dwelling fish and the impacts of commercial trawling. However, there is inherent value in studying the benthos to understand the evolution of the communities and how they have adaptated to the unique Antarctic environment, which has long been isolated from other continental systems. Some groups are poorly represented in the Antarctic or absent, e.g. decapods and specifically brachyurans, whereas for other groups there is a very high general and localised species endemism (Arntz *et al.* 1997; Gage, 2004), especially for Amphipoda, Echinodermata, Echinoidea, Pycnogonida, Isopoda, Tanaidacea, Holothuroidea and Polychaeta (White, 1984; Clarke and Johnston, 2003). The Antarctic benthos is noted for its high degree of species diversity, high biomass and gigantism among some groups. Improving our knowledge of species compositions in different benthic habitats from shallow to the abyssal plains, as well as the patterns of biodiversity at different spatial scales will be essential in addressing further key questions on:

1. What are the ecological and historical factors affecting benthic diversity?
2. How will benthic communities respond to change? We do not know how sensitive the Antarctic benthic communities are to global climate change, or to localised environmental change as seen in the Antarctic peninsula area, or to the impacts of

increased trawling. We have no benchmark to compare the effects of change, although the effects of iceberg scouring and rate of recovery/re-colonisation will serve as a useful analogy for trawling perturbation.
3. What are the links between Antarctic and other faunas? This includes benthic-pelagic coupling, the benthos as a foraging zone for higher predators, and through the Antarctic Circumpolar Current - connections with other southern continents.

A particular advantage of working in the George V Land area is the detailed knowledge we have of the bottom topography and sediment type arising from the work of Dr Phil O'Brien, Geoscience Australia. This will be a significant advantage in the planning of the survey and interpretation of results.

The macrozooplantkon of the upper water column (surface to 200m) have been moderately well-sampled in eastern Antarctic waters between 30ºE and 160°E through a series of large scale, mesoscale and some localised fine scale surveys (Hosie, 1994a,b; Hosie and Cochran, 1994; Beaumont and Hosie, 1997; Hosie *et al.,* 1997, 2000, 2003). Most of these studies have been conducted during and since the BIOMASS years. The main target of the research was Antarctic krill *Euphausia superba,* and consequently coarse mesh nets were used, e.g. 4.5 mm. Macrozooplankton caught in these nets were studied often more as a by catch, but detailed diversity and community ecology studies were undertaken (Pakhomov, 1993; Hosie, 1994a,b; Hosie and Cochran, 1994; Beaumont and Hosie, 1997; Hosie *et al.,* 1997, 2000, 2003; Boysen-Ennen and Piatkowski, 1988; Hubold et al., 1988; Siegel and Piatkowski, 1990). Smaller mesozooplankton, such as small copepods of *et al.,* 1986; Hosie *et al.,* 1987, 1991), yet very high species diversity was observed. Many of the recorded species supposedly have bipolar distributions or common to all deep waters, while others collected could not be identified reliably or were to be described, particularly so for gelatinous zooplankton. The mesopelagic zone is a region where there is high mortality of Antarctic krill larvae during their deep-water developmental ascent. This study, together with the wider CAML program, will specifically target the mesozooplankton using finer meshed nets, gelatinous zooplankton and particularly deeper zooplankton, groups which have been consistently identified by CAML, CoML and CMarZ planning committees as needing significantly more attention. This will provide information on the availability of prey items for the fish in the region and we will also be able to address the following key issues:

1. The impact of climate change on the plankton. The pelagic ecosystem in the Southern Ocean has taken the brunt of human impact in the region and there is evidence that it is already responding to the effects of global climate change. Plankton is particularly sensitive to climate change and change in their biodiversity is expected to have serious ramifications through the rest of the ecosystem including the survival of higher predators. Some species are adapted to cold waters of Antarctic where some are supposedly cosmopolitan. Which will survive global warming? For how long will there be an Antarctic marine ecosystem?
2. Consequences of environmental change driven by past and current exploitation of living resources in the region, e.g. current scale fish and krill fisheries, fishery by-catch species, recovery of whales and seals.

3. “Ecosystem services” - The role of Southern Ocean plankton as source of human food (krill fishery or other) carbon draw down/mediation, bio-climate feedback though dimethyl sulphide production, bioproducts, sensitive indicators of ocean health, and foundation of the Antarctic marine ecosystem – no plankton, no ecosystem.

Continuous plankton recorders will be towed en route between the Australia and the survey areas, as well as between the survey areas. The CPR is a proven tool for quickly mapping variation in plankton biodiversity over large ocean basins and is particularly suited for sampling mesozooplankton. CPR tows through the planned survey area of this project will also complement the traditional net hauls. The CPR tows are part of an existing international programme, the Southern Ocean CPR survey (ASAC PN 472), which has its own specific objectives. This survey has been running since 1991. A separate pan-Antarctic CPR is being developed by the SO-CPR Survey in support of CAML and will also address the following specific questions, as well as improving our ability to understand longer term patterns especially in relation to climate change.

- What are the current spatial and temporal patterns of variation? While the survey already covers a very large area, CAML will provide the first opportunity to get a circum-Antarctic synoptic view of the Southern Ocean zooplankton composition. This can then be compared with the existing data set, while establishing a new baseline for future studies of large scale change in the region.
- What are the seasonal patterns of variation? Before we can detect inter-annual or longer term changes we need to understand and distinguish seasonal variation. A series of repeat tows along 140° E in 2001-02 provided useful information on seasonal variation south of Australia. 2007-08 provides another opportunity to conduct repeat transects along 140°E, again through collaboration with Japanese vessels.
- Is species composition consistent within bands of the ACC?

In November-December 1999, 3 near simultaneous transects were conducted south of Africa, Western Australia and Macquarie Island. Results showed consistency in species composition and similar abundances in the three transects south of the Polar Front, indicating minimal spatial variation with a zone. Tows conducted during this study will contribute to a series of tows around Antarctica during CAML. This will test this hypothesis over a greater part of the region and if proved correct will allow us to predict species composition in areas not sampled.

In support of the pelagic, demersal and benthic sampling, we will also be conducting complementary oceanographic sampling at each sampling site, measuring temperature, salinity, oxygen concentrations and chlorophyll concentration, through CTD profiling and the use of instrumentation on nets where possible. This information can be assessed against past oceanographic sampling in the survey areas and help determine which water masses are being sampled. 30 litre niskins with the CTD will also allow sampling of deep-water heterorophic protists. The euphotic zone phytoplankton and protists have been well studied and the recently published text on Antarctic Marine Protists by Scott and Marchant (2005) is already a major contribution to CAML and CoML. Little is no about the protistan community below the euphotic zone, the “twilight zone”, that is supporting the deeper zooplankton and other mesopelagic species.

3.1.3 Relevance to Science Strategy

*Indicate **how** this research will contribute to the Science Strategy and the season work plan*

The proposed work conforms to the Science Strategy 2004/05-2008/09 in the programmes Adaptation to Environmental Change, Southern Ocean Ecosystems, and Ice, Ocean, Atmosphere and Climate.

Priority programme: 'Adaptation to Environmental Change':

The three questions asked in the Strategic Plan are a) What are the consequences of Antarctic environmental change and how will/do high latitude ecosystems, communities and species respond to change? b) What are the consequences of environmental change on biodiversity?, and c) What effect will predicted climate change have on natural ecosystems?

A detailed inventory of existing biodiversity is required at ecosystem, community and species level in order to determine the existence and extent of any impact. An important part of the CAML project will be the re-analysis of past data and samples to define a previous benchmark of diversity. There have been some studies of the benthos of coastal Terre Adélie in the 1960s and plankton studies in the general region during the BANZARE expedition. Genetic analyses will help define species radiation and how species will respond and adapt to change

A number of species, particularly in the pelagic and mesopelagic zones are believed to be cosmopolitan and thus most likely to survive global warming. Proper taxonomic and genetic assessment will determine if these species are truly cosmopolitan. Genetic analysis will also help determine how homogeneous are the various gene pools and how likely groups, particularly the benthos and bentho-pelagic fish can survive subtle climate change

Defining the current biodiversity will provide the benchmark to assess future variation, either natural environmental patterns or through anthropogenic forcing. Comparison with past data sets and samples will assist with this – also genetic analysis of old samples

Detection of any future invasion of non-indigenous species, and mapping the extent of the impact, will only be possible if have an inventory of current diversity and through future re-assessment of legacy sites, as well as the establish or routine monitoring sites and transects . The occurrence and extent of the impact of non-indigenous plankton and also harmful blooms in the North Sea, would not have been possible without the UK based CPR program first establishing the plankton biodiversity of the region and then regular survey changes in plankton patterns.

Priority programme 'Southern Ocean Ecosystems'

Two of the three questions asked in the Strategic Plan are: a) How are Southern Ocean ecosystems structured? and b) What are the main sources of natural and anthropogenic

variability of the Southern Ocean and how do they exert their effects on biological productivity?

CAML will provide a detailed as possible inventory of the region's diversity and hence structure of the ocean's ecosystems, in the pelagic, mesopelagic and benthic zones This will meet one of the objectives of the CCAMLR Convention in determining the requirements of "dependent and related species" as well as the well-being of the harvested species. In particular, an understanding of the biology and survival of iconic species, birds, seals and whales, will not be possible without a similar understanding of the pelagic and benthic communities supporting them.

As stated in the Science Straegy "Global warming and other environmental changes can be expected to have a major direct effect on the region's physical systems and it is thus important to develop a capacity to understand the likely consequences of these changes on the marine ecosystems so that their effects can be taken into account when developing management strategies." It will not be possible to identify or quantify the anthropogenic activity unless there is a sound reference of natural variation. Before we can achieve that we need a through understanding of the existing of the biodiversity of the region, and the structure and function of the ecosystems. CAML seeks not only to define the biodiversity of the region but to also simultaneous collect environmental data that will help determine what governs were species/communities occurs, or do not occur.

Priority programme: 'Ice, Oceans, Atmosphere and Climate'

One of the questions asked in the Strategic Plan is: What is the magnitude and current uptake of atmospheric carbon dioxide by the Southern Ocean, and what processes control this? The Plan states: "The oceans south of 40°S contain roughly 40% of the global oceanic inventory of CO2 and a small change in this can have a significant effect on atmospheric CO2."

Southern Ocean protists are responsible for a major percentage of the global CO2 drawn down. Variation in their composition and activities in response to environmental change will immediately affect this draw down. Metazoan zooplankton affect the composition of the protistan community through top-down control (grazing). Major compositional change in the zooplankton, spatially, temporally or in response to anthropogenic change, will have an effect on the composition of CO2 mediating protists. Various metazoan and protozoan zooplankton, such as thecosome pteropods and foraminiferans, are directly affected by CO2 variation and ocean acidification through their need for aragonite and calcite for their shells/tests. Increase in water temperature and pH through increase in dissolved CO2 will result in the decrease of aragonite and calcite. This process of acidification is also presumed to have an impact on the benthic fauna, as has recently been pointed out by the Royal Society of London Report on Ocean Acidification (June 2005). CAML will provide a reference point for future studies of ocean water pH.

3.2 Public Summary

All applicants must answer this question.

This project is a part of the international "Census of Antarctic Marine Life" (CAML) which is to be conducted during the International Polar Year. It is a collaborative contribution by Australia and France to understand the biodiversity of the oceans surrounding Antarctica, with particular emphasis on the fishes of the eastern part of the Australian Antarctic Territory. The biodiversity data, when added to that obtained by all other nations participating in the CAML, will serve as a robust reference for future examinations of the health of the Southern Ocean, and assist in the conservation and management of the region.

3.3 Design

3.3.1 Methods and Data Collection

Provide details of how, when and where data will be collected.

This proposal is still under development as the sampling methods, protocols for the processing and identification of samples, and subsequent data analysis and storage are still being refined by the working groups of the CAML Scientific Steering Committee. These groups are seeking to develop uniform methodologies for the collection and analysis of samples that can be used by all participating nations. This will streamline international cooperation and reduce any redundancy in sampling. The chosen methods will harmonise with traditional methodologies for comparison with current and past surveys, but also new survey instrumentation and genetic/molecular techniques will be used to find and identify new species. In this regard, CAML works closely with CoML and the SCOR New Technologies Group. A symposium of these three groups will be held in Frankfurt in November 2005, in conjunction with the annual meeting of all the CoML field projects.

Survey areas:

Three areas will be investigated in:

- the continental shelf, shelf break and north towards the Antarctic Divergence north of Dumont D'Urville (140°E) where foraging areas of penguins have been investigated and where the impacts of icebergs on fish and benthic habitat will be studied.
- the Mertz Glaciers/Adelie Depression which strongly influence the distribution of water masses, and where there is a high diversity of benthic habitats from shallow banks to deep canyons, 144° to 146° E, 66° 30'S to the coast
- the plateau of about 200 metres depth between Port Martin and Commonwealth Bay, 141° to 142° 30'E and 66° 30' to 66° 45S

The areas are listed in order of priority; contingencies of weather etc may determine the level of sampling in each area. Useful background information has already been gathered for the DDU survey area by France in relation to fish, plankton and predator prey studies in coastal water, and via the Japanese-Australian collaborative multi-ship time series study of the ecology of sea-ice zone along 140°E in the 2001/02 and 2002/03 seasons. The 140°E transect into the area is WOCE SR3 transect, so we also have detailed

oceanographic information from numerous CTD surveys, and will be repeated during IPY. The Mertz Glacier survey area has been the subject of summer and winter oceanographic surveys, placement of a sediment and oceanographic moorings, winter glaciology and biology survey, and detailed geoscience survey in February-March 2000, which has pre-defined a number of distinct biogeomorphic substrates at various depths in the area, useful for designing the demersal/benthic sampling. The middle survey area, between Port Martin and Commonwealth Bay, is a 200m bank that will also be useful for studying the impact of icebergs on bottom communities, as well as a comparison with deep water depressions and canyons.

Survey Design:

Pelagic sampling

Pelagic sampling will be conducted along three transects, 140°E, 142°E, 144° 30'E leading into each of the three survey areas, starting north of the Antarctic Divergence at ~63°S. Sampling sites on each transect will be spaced at approximately 15' of latitude (15 nautical miles), with closer spacing of sites near the continental shelf edge where change in composition are anticipated with depth. At least 15 sites are planned per transect. Oblique trawls will be conducted at each station through different depth strata, using an IYGPT midwater trawl for fish, and zooplankton will be collected by RMT 1+8 combined midwater trawl Baker *et al.,* 1973). Likely sampling strata are 0-200m as per previous pelagic surveys, 200-500 and down to 1000 or 1500m, the limit for trawling by RSV *Aurora Australis.* The IYGPT net has approximate mouth dimensions of 5.5m high x 12m wide when fishing, with mesh of 100mm in the front, then tapering through 80mm-40mm-20mm to 10mm mesh in the cod end. RMT 1 has a mesh of 300 µm and a nominal mouth area of 1 m2 suitable for mesozooplankton collection and the RMT has 4.5 mm and a nominal mouth area of 8 m2 and will be used for collecting larger zooplankton. The RMT 1+8 has an opening-closing electro-mechanical system plus real time depth and environmental recording system. A large conical net (2m2, 300µm) will hauled vertically and slowly from 1000m to target gelatinous zooplankton plankton. The smaller WP2 (200 µm mesh) net has often been used in the past in this region from *L'Astrolabe*. Some WP2 hauls may also be conducted to compare with previous *L'Astrolabe* collections.

Demersal fish trawls/Benthic sampling

The *Aurora Australis* is also capable of deep demersal trawling and benthic sampling but cannot be rigged for all equipment at the same time. Consequently, within each of the three survey areas there will be two passes over the sites. The first pass will be with lighter gear, e.g. benthic sleds, beam trawls and grabs, to collect bottom living fish, macrobenthos, and meiofauna. The beam trawl dimensions are 3020mm wide x 1390mm high at the mouth, and 57mm (2 1/4") mesh. The sled has an overall length of 2300mm with a 1260mm internal diameter. The sled is fitted with a net of 1220mm wide x 630mm high mouth with mesh 5mm knotless. The cutting edge is 700mm from the front. Sleds will be towed for 10 minutes on the bottom and 30 minutes for the beam trawl. Visual exploration of the bottom by ROV or towed video system will be conducted where possible to study the composition and habitats of the deep-water ichthyofauna and macrobenthos, especially in regions subject to the passage of large icebergs. The second

pass will be dedicated to trawling with the heavier otter trawls for demersal fish. The bottom trawl has mouth dimensions of approximately 4.5m high x 12m wide when fishing, with mesh of 152mm (6") in the front, tapering from 114mm (4.5") to 102mm (4") in the cod end with a 51mm (2") liner. These tows will be 30 minutes on the bottom.

Sampling sites for the trawls and benthic sampling will be determined by random stratified design. Dr Phil O'Brien, Geoscience Australia, has provided detailed assessment of the substrate and geomorphology of the Mertz Glacier/Adelie Basin survey, showing 5 major biogeomorphic zones and at least 10 sub-zones. Three to four sites will be randomly positioned in each of the 10 sub zones, depending on the area available, providing up to 40 sites overall. Less is known about the topography of the DDU area, but 5 sites area expected each in four strata. The middle survey area is a more uniform 200 m plateau and 10 sites on the plateau should be sufficient.

CTD and protistan sampling
CTD-Niskin bottle rosette casts will be conducted at each pelagic and benthic site to profile the water column structure and to sample the protistan community. Casts will be made to the lower limit of pelagic sampling off the shelf, 1000 or 1500m, or to the near bottom on the shelf. A camera will be mounted on the CTD to take images of the bottom. A high resolution video system can also be attached to provide footage of larger zooplankton.

Sampling and ship time estimates (times shown are totals for each activity for all sites).
1. Pelagic sampling
15 sites per transect each with
3 x IYGPT nets 65 hrs
3 x RMT 1+8 nets 38 hrs
Large conical net 15 hrs
CTD cast 19 hrs
Transect length 210 nautical miles @ 10 kts 21 hrs
Total 158 hrs
Total 3 transects 20 days

2. Benthic/Demersal sampling
Adelie Basin 40 sites each with
Otter trawl 63 hrs
Beam trawl 42 hrs
Sled 36 hrs
Grab 14 hrs
ROV/Video imaging 30 hrs
Change over of gear 10 hrs
Transit length ~200 n miles @ 10 kts by 2 passes 40 hrs
Total 235 hrs 9.8 days

DDU area 20 sites each with

Otter trawl 32 hrs
Beam trawl 21 hrs
Sled 18 hrs
Grab 7 hrs
ROV/Video imaging each stratum 20 hrs
Change over of gear 10 hrs
Transit length ~100 n miles @ 10 kts by 2 passes 20 hrs
Total 128 hrs 5.3 days

Port Martin plateau 10 sites each with
Otter trawl 10 hrs
Beam trawl 8 hrs
Sled 7 hrs
Grab 4 hrs
ROV/Video imaging each stratum 20 hrs
Change over of gear 10 hrs
Transit length ~100 n miles @ 10 kts by 2 passes 20 hrs
Total 79 hrs 3.3 days

Additional transit between areas 300 nMile @ 10 kts 30 hrs 1.25 days

Total sampling, transit time + weather time @ 20% maximum 48 days

A minimum of 48 days are required on sites for sampling, plus an additional 12 days of transit time to and from Hobart based on 10 kts – total time of 60 days. Preferred time of year is January and February 2008 when there is minimal ice cover, which will permit safe trawling.

Continuous Plankton Recorder
CPR tows will be conducted *en route* between Australia and the survey areas, as well as between the survey areas to complement the zooplankton net sampling and also in support of the SO-CPR Survey ASAC PN 472. The CPR can be deployed and retrieved at normal ship speed, so no additional ship time is required. See PN 472 for full sampling and analytical methodology.

Genetics
An important part of this project's contribution to CAML and to the CoML is the use of powerful new genetic and molecular tools to help identify and "barcode" each species, and also to determine the extent to which the circum-Antarctic marine fauna and flora is homogenous or differentiated. Further, much of the Southern Ocean plankton comprises species adapted to the cold conditions, whereas many other species supposedly have bipolar or cosmopolitan distributions, especially among the deep zooplankton and many micro-organisms. Some benthos also have bipolar distributions. Modern genetic analysis will help prove if those species are truly cosmopolitan bipolar and to what degree of

differentiation due to adaptation to the Antarctic environment has occurred. The use of genetic/molecular tools will enable regional predictions to be made of the consequences of future change.

The extent to which modern molecular techniques, and classical taxonomy will be used in CAML is the subject of discussion within the Scientific Steering Committee. Standard protocols are being developed. The discussion should be resolved by Easter, 2006.

CCAMLR
The Scientific Committee of CCAMLR has recognised the opportunity offered by the CAML to collect a synoptic series of samples of interest to CCAMLR during the IPY. Since CAML is likely to consist of a series of pan-Antarctic meridional transects, the Scientific Committee has suggested that standardised measurements be made that include scientific acoustics, krill demographics, samples for genetic analysis of populations of krill and other key pelagic organisms, standardised physical and biological oceanography and ship-based surveys for mammals and birds. WG-EMM will provide standard protocols to CAML for each of these measurements.

Acoustic systems will be running during this voyage to aid in assessment of bottom topography and trawling of midwater species, with 12 kHz (single beam), and 38, 120, 200 kHz (split beam) transducers. Krill will be kept for morphometrics but will not be measured by this team, and genetic samples of krill and other pelagics will be taken as a normal part of this study (as above). Standard physical and biological oceanography sampling is scheduled, primarily CTD-bottle castes, as well as underway marine environmental and meteorological data. Opportunities for mammal and bird observation may be possible subject to the availability of berths.

3.3.2 Data Analysis

Detail how the analysis and interpretation of the data will be undertaken, including field and Australia based analysis, where appropriate.
Protocols for the processing, and identification of samples and collection of material for genetic analysis will be determined by the CAML Scientific Steering Committee and CoML, as well as the requirements for final data entry in various databases, Antarctic Biodiversity Database, SCAR's Marine Biodiversity Information Network (SCAR-MarBIN) and the Ocean Biogeographic Information System (OBIS) the information component of CoML. Details are still to be finalised by the CAML Scientific Steering Committee, but examples of matters that need to be considered include:

- Which participating institutes will be responsible for the processing of which group of samples
- Storage of samples and lodging of type and voucher specimens; images and videos for scientific analysis
- Who will be conducting the genetic/molecular genetic analyses
- Identifying taxonomic experts to describe new species and identify unconfirmed specimens

The SCAR-MarBIN project (IPY EoI 817) constitutes the information component of CAML and the Antarctic node of OBIS. The SCAR-MarBIN project aims at establishing

and supporting a distributed system of interoperable databases, which will form a coordinated network, placed under the aegis of SCAR. SCAR-MarBIN will compile the existing information and manage new information by co-ordinating, supporting, completing and optimizing such databases networking. SCAR-MarBIN will integrate these efforts in order to give a single and easy access to the marine biodiversity information and to maximize the exploitation and retrieval of information from these resources using relational queries. This network will leave a highly valuable legacy for future generations, in the form of a powerful information tool, which will provide a baseline reference for comparison with the future and past.

Procedures for this proposal

Sorting and identification of biota will begin on board ship. This will be particularly important for those organisms that are easy damaged or difficult to preserve, eg. gelatinous zooplankton and some soft bodied benthos. Pigmentation can be an aid in identification but can be lost during fixation. Photographs will be taken to aid in later identification but also for release to the public as part of the Education and Outreach component of CAML, hence the need for an experienced wildlife photographer in the research team. Most of the material for genetic/molecular research will be taken while on board. Sorting, identification and analysis of results will continue after the voyage at specified institutes.

Zooplankton and Krill Analysis

Zooplankton samples will be initially processed at the Australian Antarctic Division, but our experience with the high biodiversity encountered in deep trawls suggests that a large number of the specimens will need to be sent to taxonomic specialists outside of Australia to confirm identification. The appropriate specialists are yet to be selected and their assistance confirmed, a matter being pursued by the administration of CAML.

Antarctic krill collected for the study of krill demographics, morphometrics and genetic analyse for the CCAMLR component will be processed by the Southern Ocean Ecosystem group at AAD. Associated acoustic data for determining krill biomass and distribution will also be analysed at the AAD, primarily using the 120 kHz acoustic data in accordance with internationally-accepted analytical methods. These methods were developed at WG-EMM-99 (SC-CAMLR 1999, p.155-156) prior to a multinational, multiship synoptic krill survey in Area 48 (CCAMLR-2000 Survey), and reviewed after the survey during the B0 workshop (SC-CAMLR 2000, p.216-224).

CPR samples collected during this and all other CAML voyages, will be processed in partner SO-CPR laboratories, AAD, NIPR/TUMSAT Tokyo, AWI Germany, following the sample processing protocols established by the SO-CPR Survey. Preferably, all samples will be processed at the AAD to ensure the consistency in processing. New plankton species found will be forward to the appropriate specialist. All analysis of the CPR data will be supervised by AAD based CPR team. PhD students will be encouraged to participate in the survey and use the data set.

Zooplankton data from nets and CPR will be analysed by cluster analysis and non-metric

multidimensional scaling (NMDS) ordination to define community structure and associations. Complete details of the multivariate data analysis techniques, which have been successfully applied to Antarctic zooplankton patterns previously, have been described in Hosie (1994) and Hosie et al., (2000), and are based on modified methods of Field et al., (1982) and Kruskal and Wish, (1978).

Mesopelagic and Benthic Fish
France and Belgium will take the lead in the processing of fish and in addition to the identification of fish will also be focussing on the study of the mesopelagic fish and fish larvae assemblages in relation to water masses and biotic parameters such as the availability of phytoplankton and zooplankton. Condition indices will be studied by the use of histological techniques and biochemistry (e.g. lipids) in relation to diet and prey availability. Data will be mapped by the mean of a geographic information system GIS and the use of geostatistics. Geostatistics will help to interpolate abundances in the three dimensions (latitude, longitude and depths) by the use of ISATIS software.

Benthic fish data will be incorporated into the ICOTA Database which holds data on all fish collected in this area since 1960. Habitat modelling of the main species in relation to environmental factors (bathymetry, temperature, salinity, habitat type etc) will be done by the mean of statistical procedures, e.g. generalized additive models, regression uantiles, multivariate analysis) and by the use of GIS. Collaboration with Dr Julian Gutt, Alfred Wegener Institute, and other benthic biologists, plus prior previous information on habitat type and geomorphology from Geoscience Australia, will help to classify fish habitats in relation to benthic communities and stress linked to iceberg impact.

Benthos
Processing of benthic samples and analysis will be the responsibility of France in association with Germany. Analysis of the impact of icebergs on benthic communities and on benthic fish assemblages will be undertaken by Dr Julian Gutt AWI.

Protists
Our knowledge of the protists in the upper pelagic zone has been greatly improved by the newly published text on Antarctic Marine Protists by Scott and Marchant (2005). Identification of protists residing deeper in the water column will take higher priority and is like to undertaken by Belgian colleagues. Phytoplankton pigment data will be interpreted using CHEMTAX II software (Wright *et al,* in prep) at the AAD laboratories, which will assist in the interpretation of the zooplankton and pelagic fish distributions. Protist species abundance data shall be analysed using multivariate techniques listed for zooplankton data above, as previously applied to phytoplankton data (Scott *et al.*1994, Waters *et al.* 2000).

Genetics
The Steering Committee of the CAML is considering the role that molecular genetics can, and should play in the Census of Antarctic Marine Life. There are many questions of a fundamental nature that can be resolved by the use of rapid throughput genomic techniques. These include the homogeneity of apparently circum-Antarctic species,

including species such as krill, and some whales, as well as molluscs and other benthic fauna. They also include the microbial ecology of parts of the Southern Ocean dominated by krill or salps. Data derived from genetic studies are of great value in ocean management activities and for predicting the consequences of future climate change. There is currently much ongoing discussion about the interrelationship between molecular techniques and 'classical' taxonomy and the balance between the use of the two in the CAML will be determined during the next 12 months.

Multivariate Analyses of Combined Datasets
The census involves more than just determining the species diversity of the region. It also seeks to define the environmental and biotic relationships that determine where species occur, or do not occur, and the species associations that form communities. The individual multivariate analyses of the plankton, fish and benthic assemblages described above are important methods in determining these relationships, as will be an overall analysis of the combined datasets, especially studying pelagic-benthic coupling. A number of the investigators (Wadley, Koubbi, Hosie) are well skilled and published in multivariate analysis. However, analysis of the combined datasets will most likely be conducted first at the AADC using techniques such as neural network analysis, which has proved useful in analysing data of widely different formats, gathered by quite different sampling methods. The analyses of combined and individual data sets will help define species, population and community patterns and associations which will serve as the benchmarks against which future change can be reliably assessed. The proposed survey areas will then form part of the set of legacy sites around Antarctica for future comparability studies.

The next level of analysis will involve the data from this study combined with all other CAML data for regional comparisons. SCAR-MarBIN will play the central role in allowing and coordinating such analysis. SCAR-MarBIN will provide the link between CAML data and other related IPY projects data resources, which will subsequently allow the exploitation of data emerging from what will be matchless multi-scale investigation efforts. This will lead to a better understanding of the actual diversity and status of Antarctic marine life.

3.3.3 Rationale

What scientific justification (practical and/or theoretical) would you cite for selecting this research design to meet your objectives? Include a justification of the methodology proposed.
As noted above, the actual sampling, processing and analytical methods are still being determined by the various specialist working groups of the CAML Scientific Steering Committee. The working groups are developing uniform methodologies and sampling/survey equipment that can be used by all participating nations. This will streamline international cooperation and reduce any redundancy in sampling. It is essential that the methodologies and equipment selected allows proper qualitative and quantitative comparison with past surveys and results. The working groups are also mindful that traditional sampling gear have not been successful in adequately sampling all biota. For example, traditional midwater trawls and plankton nets do not catch

gelatinous or other soft bodied zooplankton very well, whereas squid are notably difficult to catch. Benthic organisms are often damaged by nets or sleds and nets are difficult to use amongst sea ice, so organisms living in close proximity to the under side of sea ice are almost impossible to catch. Consequently, CAML is working closely with CoML and the with the aim of including new sampling techniques and equipment to catch or observe organisms *in situ* that have not been properly collect before, as well applying new molecular techniques to help identify new species and confirm the identification of other taxa that have been in doubt. A symposium of these three groups will be held in Frankfurt in November 2005, in conjunction with the annual meeting of all the CoML field projects. Any new technologies/methodologies recommended by CAML will adopted into this project.

The methodologies identified in this application are likely to be accepted by CAML as part of the suite primary sampling and analytical tools. They are well proven techniques that have been widely used for numerous surveys over the last two to three decades and have been accepted by the Antarctic research community as standard survey methods. For example, the RMT 1+8 net system was the main krill and zooplankton sampling system used during the BIOMASS surveys and subsequently for all CCAMLR related surveys. Augmenting the traditional sampling methods with new technology and instrumentation under consideration by the CAML working groups and the SCOR New Technologies Group, will enhance our census capabilities as will new molecular techniques improve species identification and our knowledge of species radiation. Current numerical-multivariate analytical techniques coupled with new numerical relational query techniques applied to the SCAR-MarBIN data system will then improve our understanding of the relationships between biota and their environment.

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3.4 Work Plan

- *Provide details for each year the project is to be undertaken.*
- *Provide details of the tasks to be undertaken by each person engaged in the proposed project.*
- *Justify the number and duration of stay for all field participants.*
- *Fully identify and explain the role of all researchers / field personnel. If students are involved in the field component, specify the level and type of supervision that will be provided. If personnel details are 'To Be Advised' later (TBA) indicate the level of qualifications of each person being sought (e.g., student, technician).*

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2007-08 Season - Principal sampling year, first season of IPY. A minimum of 48 days are required on sites for sampling, plus an additional 12 days of transit time to and from Hobart based on 10 kts – total time of 60 days. Preferred time of year is January and February 2008 when there is minimal ice cover, which will permit safe trawling.

2008-09 Season - Processing and identification of samples/specimens, collation, and analyes of results and transmission of data, images and video to SCAR-MarBIN and other data bases.

Chief Investigator, Prof. Michael Stoddart – Administrator, Census of Antarctic Marine Life

Co-investigator, Dr Graham Hosie – Assisting the Chief Investigator in the development and implementation of this project (2792). Chief Investigator of the Southern Ocean Continuous Plankton Recorder Survey (PN 472), which will contribute a circum-Antarctic CPR survey to CAML. Investigator of zooplankton and pelagic

communities.

Co-investigator, Dr Victoria Wadley - Project Manager, Census of Antarctic Marine Life. Assisting the Chief Investigator in the development and implementation of this project (2792)

Co-investigator, Dr Philippe Koubbi – Investigator of pelagic fish and pelagic communities, and leader of French team.

Co-investigator, Dr Catherine Ozouf-Costaz – Investigator of demersal fish and benthic communities. Liaison with European /benthic community colleagues.

Co-investigator, Dick Williams – Fish research and liaison with French colleagues.

Shipboard personnel required.

Fish (4)
Zooplankton (4)
Benthos (4)
Protists (4)
Oceanography (4)
Gear officer (2)
Hydroacoustics (1)
Electronics (1)
Computing (2)
Wildlife photographer – Education & Outreach (1)
Science Journalist – Education & Outreach (1)

Approximate numbers of people for each task are shown in parentheses. This is the minimum standard scientific complement for a voyage of this type (catching and processing samples) and duration, in order to provide two teams operating in 12 hour shifts. Numbers are likely to be higher with additional personnel undertaking process studies to complement the main CAML component.

3.5 Resources

3.5.1 Details of Shared Resources

Where any component of this project is shared with, or dependent upon, another project, provide a full explanation of how the projects are linked. If personnel will be working on joint projects, indicate the time to be spent by each person on each project.

A significant sharing of resources will occur at the international level amongst CAML participants particular in use of ships in support of CAML, exchange or personnel and equipment, and exchange of samples for processing and identification. Realisation of such a breadth of study over such a large area would not be possible without the

cooperation of the National Antarctic programs, coordinated through COMNAP. The forthcoming International Polar Year (IPY) provides an essential platform for wide-scale logistical cooperation between nations, and many are already planning ship-time for the CAML. CAML's Expression of Interest to IPY has been selected as a lead proposal in the Marine Biodiversity cluster. It has recently been submitted as a full proposal to SCAR, coordinating 20 smaller EoIs in the inclusive spirit of CAML and IPY. Australia has taken the lead in CAML - as a consequence, considerable international recognition of our science is likely to accrue. Supporting the coordination of CAML is a grant from the Alfred P. Sloan Foundation of US$1.4 million over 5 years. This includes full-time support for the Project Manager.

CAML will also share resources and logistics with other IPY projects including:
- CASO (EoI 1109) - Role of Antarctica and the Southern Ocean in Past, Present and Future Climate: A strategy for the International Polar Year 2007-2008 (CASO (Climate in Antarctica and the Southern Ocean)), which is studying climate and oceanography of the region and will assist in the understanding of the distribution of the biota and oceanographic data collected during CAML and specifically the current application will contributed to CASO.
- ANDEEP-SYSTCO (EoI 111) - ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns - SYSTem COupling.
- CCAMLR 2008 Survey (EoI 148) - International CCAMLR 2008 synoptic survey of krill , pelagic fish and plankton biomass and biodiversity in the South Atlantic (Area 48). As noted in section 3.3.1, specimens will be collected during CAML cruises to study krill demographics, and genetic analysis of populations of krill and other key pelagic organisms.
- ICED (EoI 417) - Integrated Analyses of Circumpolar Climate Interactions and Ecosystem Dynamics in the Southern Ocean. There is considerable overlap with ICED and CAML in understanding the distribution and role of various biota in the Antarctic marine ecosystems. ICED is scheduled to continue beyond IPY and the results from CAML will greatly assist in attempts by ICED to understand ecosystem dynamics.

For this application, collaboration with France also provides access to other European institutes providing additional expertise and resources in protistan, fish and benthic studies; these include:
J.H. Hecq (Univ. Liège Belgium) - marine ecology, modeling
Marino Vacchi (Italy) - fish biology, systematics
Julian Gutt (AWI, RFA) – benthic communities

Our proposed survey areas off Terre Adélie and George V Land correspond with Target Area C of Japanese Antarctic Research Expeditions. The Japanese lead institute National Institute of Polar Research (NIPR) will also be operating a number of vessels in that area during IPY and contribute resources and data through their planned pelagic biota and oceanographic studies, as well as being a research partner in the Southern Ocean CPR Survey.

At a national level, collaboration is being developed with Dr Bob Ward, CSIRO, to

undertake DNA barcoding of Antarctic and to incorporate the information into the Australian fish barcode database and then to the Barcode of Life.

3.5.2 Participating Institutions

Provide details of any international links including the level of resources which will be provided. Identify if they are:

- *Multilateral - part or all of the Australian contribution to a multilateral agreement (eg a CCAMLR project);*
- *Bilateral - involving formal agreements between governments or institutions; or*
- *Other - informal international links or other arrangements.*

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CAML directly linked to SCAR as an IPY project, COMNAP through the coordination of logistics, and CCAMLR through shared resources. CAML directly involves 22 nations in the project:
Argentina Australia Belgium Brazil Canada Chile
China France Germany India Indonesia Italy
Japan Korea Malaysia New Zealand Norway Poland
Russia UK Ukraine USA

This application directly involves Australia, France, Belgium, Germany, Italy and Japan.

Further, CAML's Expression of Interest to IPY has been selected as a lead proposal in the Marine Biodiversity cluster. It has recently been submitted as a full proposal, coordinating 19 smaller EoIs in the inclusive spirit of CAML and IPY.
Marine Biodiversity Cluster EoIs:
1. **Role of Antarctica and the Southern Ocean in Past, Present and Future Climate: A strategy for the International Polar Year 2007-2008** (CASO CClimate in Antarctica and the Southern Ocean)), EoI #109 led by Dr Steve Rintoul, Australia.
2. **ANDEEP-SYSTCO (ANtarctic benthic DEEP-sea biodiversity: colonisation history and recent community patterns - SYSTem COupling)** (ANDEEP-SYSTCO), EoI #111 led by Prof Angelika Brandt, Germany.
3. **International CCAMLR 2008 synoptic survey of krill , pelagic fish and plankton biomass and biodiversity in the South Atlantic (Area 48)** (CCAMLR - 2008 Survey), EoI #148 led by Dr Volker Siegel, Germany.
4. **Cenozoic bryozoans in West Antarctica - taxonomy, biogeography and evolution** (Cenozoic bryozoans), EoI #153 led by Dr Urszula Hara, Poland.
5. **Internationally coordinated studies on Antarctic environmental status, biodiversity and ecosystems.** (Environmental, Biological, and Ecological Studies in Antarctica (EBESA)), EoI #189 led by Prof Roberto Bargagli, Italy.
6. **Seasonality of the Drake Passage pelagic ecosystem: Biodiversity, food webs, environmental change and human impact. Present and Past** (DRAKE BIOSEAS), EoI #192 led by Dr Viviana Andrea Alder, Argentina.
7. **Biological and functional diversity of microbial communities in ecologically distinct polar environments** (Biological and functional diversity of microbial

communities in ecologically distinct polar environments), EoI #205 led by Dr Irene Kit-Ping Tan, Malaysia.
8. **Effects Of Isolation On The Genetic Biodiversity Of Shallow Coastal Benthic Communities In Antarctica** (Effects Of Isolation On The Genetic Biodiversity Of Shallow Coastal Benthic Communities In Antarctica), EoI #219 led by Prof Zulfigar Yasin, Malaysia.
9. **Antarctic Marine Mammal Ecology using Passive Acoustic Monitoring** (Marine Mammal Passive Acoustic Monitoring (MMPAM)), EoI #236 led by Dr John Hildebrand, USA.
10. **Winter algal communities: year-round phytoplankton studies at Palmer Station** (Pal-Flow), EoI #330 Maria Vernet, USA.
11. **Comparative Studies Of Gentoo Populations** (GOSGEN), EoI #379 led by Dr Volodymyr Bezrukov, Ukraine.
12. **SCAR-MarBIN: the information dimension of Antarctic Marine Biodiversity** (SCAR-MarBIN), EoI #817 led by Dr Bruno Danis, Belgium.
13. **Study of Antarctic Sea Ice Ecosystems** (SASIE), EoI #818 led by Academician Igor Melnikov, Russia.
14. **The coastal and shelf ecosystem of Maritime Antarctica (Admiralty Bay, King George Island)** (CSEMA), EoI #863 led by Prof Rakusa-Suszczewski Stanislaw, Poland.
15. **A study, using Autosub, of the influence of sea ice and sea-ice algae on the winter distribution and abundance of Antarctic krill off East Antarctica** (Antarctic krill and sea ice), EoI #949 led by Dr Andrew Brierley, UK.
16. **Polar Microbial Observatories in Antarctic and Sub-Antarctic coastal zones** (POLMICROBS), EoI #953 led by Dr Jean-Francois Ghiglione, France

Other linked EoIs:

1. **U.S. GEOTRACES: Biogeochemical cycles of trace elements in the SW Pacific Sector of the Southern Ocean** (U.S. GEOTRACES in the Southern Ocean), EoI #271 led by Dr Robert Anderson, USA.
2. **Integrated Analyses of Circumpolar Climate Interactions and Ecosystem Dynamics in the Southern Ocean -IPY** (ICCED –IPY), EoI #417 led by Dr Eugene Murphy, UK.
3. **CANADA #59: Canadian Census of Marine Life Arctic Ocean Biodiversity Program** (Canadian Arctic Census of Marine Life), EoI #713 led by Mr Paul Snelgrove, Canada.

3.6 Conditions

3.6.1 Commercial implications

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