

**Transforming the AERD and US AMLR Program: a Planned Response to
Recommendations from the Division's Recent External Review**

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George Watters, Director
Antarctic Ecosystem Research Division
Southwest Fisheries Science Center
National Marine Fisheries Service

Introduction

The SWFSC's Antarctic Ecosystem Research Division (AERD) and its implementation of NOAA's U.S. AMLR Program were recently reviewed by an external panel of experts (hereafter referred to as the Panel). The review was conducted from 31 August-2 September, 2009, and, on 15 September 2009, the Panel submitted a short, comprehensive report of their collective views and recommendations related to the AERD's science enterprise. I thank the Panel for their invaluable advice, and, in consultation with the staff of the AERD, have developed this Response Plan to demonstrate my sincere interest in charting a prosperous, secure, and relevant future for the division and U.S. AMLR Program (or simply AMLR).

I agree with the Panel's conclusion that "business as usual" is no longer an option for AMLR. Here I aim to devise a new business model for AMLR, a model that continues scientific support of U.S. policy interests in the Antarctic (particularly those within the remit of the Commission for the Conservation of Antarctic Marine Living Resources, CCAMLR) and simultaneously increases NOAA's contribution to ecosystem and global climate-change research. As noted in the Panel's report, such a business model requires a coherent strategy, priority setting, and flexibility. The outline of such a strategy, identification of priorities, and the sketch of a new, more flexible, "order of operations" for AMLR are described here. The remaining section headings of this Response Plan are quoted from the Panel's report (which is appended to this Response Plan) so that readers may easily cross reference to it.

The Panel recognized the "remarkable success" of AMLR to date, concluded that the program is a "crown jewel of Antarctic science," and provided its advice with the intent to help AMLR "move to the next level of excellence." I developed this Response Plan with AMLR's significant, positive record of scientific accomplishment and stewardship of its financial and personnel resources in mind -- the aim of this Plan is not to correct errors. Rather, the aim of this Response Plan is to capitalize on the advice of the Panel and provide a practical blueprint for how AMLR can evolve along with the evolution of its mandates and requirements to provide scientific advice. In parallel with the Panel, I envision a blueprint that continues and strengthens AMLR's excellence. During the course of the review, staff members within the AERD presented the Panel with a forward-looking, but relatively unprioritized, summary of AMLR's needs and requirements for addressing its mandates and providing scientific advice. I view the Panel's advice as a suggested prioritization for AMLR's future work and scientific emphases. This

Response Plan simply outlines how I intend to address these suggestions; this document should not be interpreted as commentary on problem areas within AMLR.

Strategic Framework

Following the Panel's recommendation, I developed a concise vision statement that will guide AMLR into the future. I also developed a set of implementation principles that determine how the vision should be achieved.

Vision

The AERD will provide scientific evidence needed to advance U.S. policy objectives in the Antarctic and implement precautionary, ecosystem-based management of living marine resources in the Southern Ocean. The Division will improve knowledge about the structure, function, and dynamics of the Antarctic marine ecosystem by observing the ecosystem, interpreting observed changes within the context of fishing and climate change, and predicting the potential impacts of fishing and climate change in the future.

Implementation Principles

The AERD will

- maintain key time series and conduct project-based studies that fill critical information gaps;
- use new and improved sampling technologies to extend the scope of its research;
- integrate and synthesize data using best practice analytical approaches;
- anticipate future needs for advice and threats to the sustainable use of Antarctic living marine resources;
- work proactively to address these needs and mitigate these threats;
- participate in scientific committees, working groups, and collaborative partnerships;
- train and mentor young scientists;
- communicate effectively with stakeholders and decision makers; and
- act transparently and impartially.

This strategic framework hinges on organizational changes to AMLR; revised priorities and increased flexibility are implicit within this organization. By realigning the responsibilities of key personnel, restructuring travel schedules, and increasing the Program's contributions to the general (non-Antarctic or non-polar) scientific community, I intend for personnel and expertise to be deployed so that present and emerging mission requirements (e.g., respective support of U.S. Antarctic policy and

climate-change research) can be addressed. I envision changes that will involve practically all personnel associated with AMLR.

Director and "Executive Officer" -- Regardless of my own interests, the Director of the AERD must generally play a greater role in AMLR science. The Director must function as an active scientist and make time to analyze and synthesize data, write papers, mentor students and post docs, and generally guide the science enterprise of the division. I will therefore authorize a permanent employee of the AERD to act as an "Executive Officer" who is responsible for day-to-day operational decisions such as approving leave and certifying timecards, responding to data calls, approving "ordinary" acquisitions, tracking budgets, etc. As Director, I will maintain responsibility for strategic decision making and general supervision of AMLR personnel, and I will act to further my professional development so that this work can be accomplished efficiently. To fulfill the Director's duties as US Representative to the Scientific Committee of CCAMLR, I will also maintain wide-ranging involvement and participation in all of CCAMLR's scientific work and continue to connect with the wider Antarctic Treaty System (e.g., through regular participation in the Committee for Environmental Protection). In general, I plan that the division of labor and responsibilities between the Director and the Executive Officer will be similar to that between a Science Center Director and his or her Deputy. An Administrative Assistant will continue to support both the Director and the Executive Officer, and I will foster a culture in which the Director is not expected to participate in field work every year (for example, I did not participate in the 2009/2010 field season).

Permanent Principal Investigators -- I agree with the Panel's recommendation that the AERD's PIs need to increase their contributions to the general scientific community while maintaining their commitment to support CCAMLR and U.S. Antarctic policy. To achieve this balance, I plan to adjust the PIs annual calendars and travel schedules. I will also decrease the PIs' administrative workloads and emphasize the production of peer-reviewed papers over the production of CCAMLR working papers. I will endeavor to shorten the average length of time that the AERD's PIs spend in the field. Although requirements for field work are governed by external factors like permit requirements, contracting limitations, and ship availability, the PIs can likely spend less time in the field if other personnel (including permanent employees, contractors, and expert volunteers) are trained and empowered to manage AMLR field operations. I will also revise the annual travel calendars for the PIs so that, on average, they attend CCAMLR meetings every other year and give oral presentations at general science symposia or participate in meetings that support coordinated research in the Southern Ocean (e.g., SCAR, SOOS, ICED, and SOS) in alternate years. I expect that work to prepare oral presentations for general science symposia will provide the foundations of manuscripts which will be submitted to peer-reviewed journals and tabled to CCAMLR meetings in preference to other working papers. I will also task one or more PIs to increase AMLR's involvement in coordinated, Southern Ocean research initiatives. This general scheme will be modified on a case-by-case basis so that the PIs may,

when appropriate, continue to provide leadership and address key topics within the CCAMLR working groups (which generally require respective commitments to attend meetings annually and submit targeted working papers). Finally, I will minimize administrative workloads for the PIs, particularly those related to contracting. As much as possible, I intend for such administrative work to be shifted to the Executive Officer and Administrative Assistant.

Permanent Scientific Staff -- I believe that the balance of the AERD's permanent scientific staff will need to assume even greater responsibilities, and I will act to provide these individuals with opportunities to become the next generation of PIs (e.g., by supporting their education and fostering broad collaboration on division-level research projects), Cruise Leaders and Camp Managers (e.g., by training and empowering personnel to manage field operations), and delegates to CCAMLR working groups (e.g., by mentoring new individuals to participate in these groups).

Data Manager -- There is strong demand (both internally and externally) for AMLR data, and these data must be managed and made available in ways that facilitate synthesis and catalyze new ideas. I think a dedicated data manager will be required to conduct these tasks in a timely manner (and the Panel intimated this point). I will therefore seek to secure a new, dedicated Data Manager for the division. I will support the Data Manager by developing division-level policies that aim to decrease limitations on data accessibility (e.g., data will be made publicly available within two years of its collection or immediately after it is utilized in a peer-reviewed publication, whichever occurs first).

Graduate Students and Post-Doctoral Researchers -- I recognize that the US AMLR Program can be strengthened and expanded by graduate students and post-doctoral researchers; I intend to invest in young scientists. I will therefore aim to develop and sustain a revolving corps of young researchers by elevating the priority of student and post-doctoral opportunities in budget planning and requests for additional support. I will ensure that grants, contracts, and other awards that originate from the AERD are evaluated on their ability to support young researchers and prioritize awards that can provide such support. This will include considering whether some of the Program's "usual" contracting requirements can be met by an increased investment in students and post-docs.

Contractors -- I expect that AMLR may contract with fewer individuals in the future. Administrative hurdles and budgetary constraints may require AMLR to fill many of the roles that previously supported contractors with students and post-docs. I also aim to fill some of these roles using seasonal appointments. Despite these changes, AMLR will continue to require the expertise and experience of contractors who have worked in the Antarctic and been associated with the program for many years.

In my opinion, AMLR would benefit from increased scientific collaboration among the members of its permanent staff, and I will facilitate collaborative research by developing a

laboratory culture that regularly prioritizes scientific discussion over administration and logistics. Whenever possible given their travel schedules, the staff of the AERD will celebrate "AMLR Science Fridays." These days will kick off with a lab meeting during which the staff will discuss and share their current research, outline joint analyses and manuscripts, debate hypotheses, deliver practice seminars, etc. During the remainder of each Science Friday, I will authorize the staff to exempt themselves from administration and logistics (this may require advanced planning to meet key deadlines), but this exemption will only apply to staff who spend the day working at the SWFSC. I expect that fostering greater collaboration within AMLR will catalyze even stronger ties with colleagues outside of AMLR (e.g., contract and academic researchers as well as individuals supported by the NSF and other national Antarctic programs) and ultimately lead to increased synthesis.

Achieving the Vision: Action over the Next 1-3 Years

The Panel recommended several short-term actions that I will make the highest priorities for the US AMLR Program. My plans to address many of these priorities were outlined in the organizational plan described above. These include plans to "re-evaluate the frequency of AERD Director's field work," "provide a program of professional development for the AERD Director," "make AMLR data widely available," and "invest in analyzing AMLR data" (quotes are from the Panel's report). Here I address plans to secure a research vessel, publish more widely in the non-polar peer-reviewed literature, assess whether all of the monitoring activities conducted within the AMLR Program require an annual commitment, and develop new avenues of inquiry.

Under my direction, the AERD is pursuing three options to secure a research vessel for the 2010/2011 field season and beyond: contracting a private vessel (for 1 base year plus 4 option years as with previous charters), collaborating (e.g., through an MOA) with the NSF Office of Polar Programs, and collaborating with SIO/UNOLS. All three options may ultimately require increased financial support for the AMLR Program, and the AERD is coupling its pursuit of a research vessel with simultaneous consideration of how the AMLR Program might better link to other NOAA funding initiatives (e.g., initiatives to support polar research or climate-change research more generally) and achieve significant cost savings (e.g., by contracting a vessel that normally home ports in the southern hemisphere). Securing a vessel for the long-term may also require increased flexibility in the timing of AMLR field operations, and I am evaluating whether ship-board operations normally conducted in February can be conducted later in the calendar year. Flexible timing may increase AMLR's ability to coordinate vessel usage with other research programs (e.g., the Palmer LTER program). A new Statement of Work (SOW) to solicit for a private vessel has been drafted and submitted to NOAA's Western Acquisition Division for processing. The new SOW is substantially revised from previous SOWs and was purposefully designed to provide opportunities for a wider range of vessels to compete for the contract. I have also initiated and continued discussions with individuals from both NSF and SIO. The potential for collaboration with NSF will partly be determined by the logistic needs of Palmer Station. If logistic support for Palmer can be provided by a dedicated vessel, the NSF may have increased flexibility to use its research vessels in

collaboration with AMLR, particularly during the austral summer. The potential for collaboration with SIO/UNOLS may be determined by whether other, non-AMLR research projects can be scheduled in the region immediately before/after the AMLR field season (thus transit and mobilization costs would not be borne exclusively by AMLR), and I have submitted a UNOLS Ship-time Request to initiate discussions about the potential for conducting field work on board a Global Class vessel.

I agree "it is a high priority that AMLR participants publish more extensively in the general ecological literature" and have identified a number of papers that will be produced in the near future (Table 1). All of the PIs and myself will be responsible for authoring at least one of these papers, and another paper will be authored by a graduate student trainee within the AERD. In general, I will direct the division to prioritize publication in the peer-reviewed literature over the submission of working papers to the CCAMLR's scientific working groups (although the papers for peer-reviewed journals will generally be tabled to the working group meetings). Beyond 1 Oct 2010, I will lead the AERD to prioritize development of a draft manuscript that synthesizes AMLR data to provide insight on how ecosystem structure and function around Elephant Island, the South Shetland Islands, and the Antarctic Peninsula may respond to climate change. The aim of this effort would be to publish a paper that could be cited within the *Intergovernmental Panel on Climate Change Assessment Report 5*. I will also lead the AERD to draft synthesis papers that address topical issues such as the design of ecosystem observing systems and spatial management.

The Panel recommended "an assessment of which monitoring activities can be undertaken less frequently than on an annual basis." While this issue requires further thought, I have developed the following initial conclusions. Given the present budget and staffing levels of the AERD, increased flexibility and cost savings can be achieved by cutting (either permanently or intermittently) major components of the existing program rather than cutting the frequency of specific observation series. For example, substantially greater flexibility and cost savings can be had by conducting one cruise leg per season rather than cutting all phytoplankton observations while maintaining the usual two legs per season. Similarly, substantially greater flexibility and cost savings can be had by closing (again either permanently or intermittently) an entire field camp (the AERD operates two camps) rather than by, say, cutting the suite of observations on chinstrap penguins from a single camp. Cutting major components of the AMLR field program will involve difficult tradeoffs. For example, cutting back to one cruise leg will make it impossible to update key time series on krill and oceanography and conduct project-based studies that address key uncertainties in a single field season (one or the other would have to be cut). To close a field camp, we must consider the tradeoff between making observations at a camp that is adjacent to an historically important krill fishing area (where monitoring may indicate the indirect impacts of fishing on krill predators) versus making observations at a camp where some of the penguins use sea-ice habitats in the winter (where monitoring may indicate the impacts of climate change). Many other difficult tradeoffs would be involved in restructuring the AMLR field program, and more time will be needed to evaluate how structural changes to the field work will impact the AERD's ability to support U.S. Antarctic policy. The CCAMLR's Scientific Committee has agreed that a full review of the CCAMLR Ecosystem Monitoring Program (CEMP) is required to ensure that results from the CEMP can usefully inform ecosystem-based management of Antarctic fisheries. At the earliest, this review will occur in the

fall of 2011, and a redesign of the CEMP is likely to require monitoring at "treatment" and "control" sites. The two field camps currently operated by AMLR may offer such contrast. Since the AERD commits a substantial amount of its monitoring effort to support the CEMP, it seems sensible to await the outcome of this review before making substantive changes to the AMLR monitoring effort. Nevertheless, staff within the AERD are currently evaluating the suite of AMLR monitoring activities, and I am willing to direct revisions of the field research in an effort to balance the maintenance of key time series (which, in my view, are critical for assessing the impacts of fishing and climate change) with the conduct of project-based research to address topical issues and resolve key uncertainties. For example, the AERD is currently planning to revise the suite of observations collected during the AMLR krill surveys and add coincident observations on pelagic fishes (we are uncertain about the relative importance of these fishes as both predators and prey); the division is also endeavoring to collect information on the winter distributions and habits of krill predators (AMLR research has demonstrated the importance of winter processes).

Consistent with three recommendations from the Panel, I am actively directing the AERD to develop and implement an integrated assessment model for Antarctic krill, support marine spatial planning for the Antarctic Peninsula area, and strengthen links with the NSF and British Antarctic Survey (BAS). A new stock-assessment scientist joined the AERD as a permanent employee on 29 March 2010, and that individual's first priority will be to initiate the development of an integrated assessment model for krill. Initially, I plan to support marine spatial planning by making the construction and compilation of a relevant geo-referenced data set the first priority for the division's new Data Manager. Finally, I continue to pursue collaborations with the NSF (particularly the Palmer LTER) and BAS and have initiated dialogues with individuals from both organizations to discuss holding one or more joint workshops that would set the stage for increased integration, across all three organizations, of scientific data and knowledge about the Antarctic Peninsula region and Scotia Arc.

Achieving the Vision: Action over the Next 3-5 Years and Action Beyond 5 Years

The Panel recommended several actions over the medium and long terms, and I believe that these recommendations generally have merit. In fact, I have endeavored to develop a strategic framework and address the Panel's short-term recommendations in ways that will prepare the AERD to successfully achieve many of the longer term recommendations. The organizational changes and immediate priorities identified previously address

- development of a regional study for the IPCC Assessment Report 5 (see the plans for drafting peer-reviewed manuscripts)
- expansion beyond krill-based studies (note the plans to integrate pelagic fish sampling into our usual "krill cruises")
- sustenance of a graduate student and postdoctoral program (see the organizational plan), and
- engagement with the broader Southern Ocean scientific community (see the organizational plan).

I will reassess the Panel's recommendations for new positions within the AERD (physical oceanographer, pelagic fish biologist, and observer coordinator) when successful achievement of AMLR's short-term priorities yields additional physical (e.g., office space) and financial support for the program.

Conclusion

I conclude this Response Plan by reaffirming my intent to chart a prosperous, secure, and relevant future for the AERD and U.S. AMLR Program through the development and implementation of a new business model for AMLR. I feel that the business model described within this Plan strikes an appropriate balance between maintaining and supporting those aspects of AMLR that have made it internationally recognized and successful (e.g., the conduct of comprehensive ecosystem surveys and field research coupled with the provision of scientific advice and leadership within CCAMLR) and developing broader contributions to and wider engagement with the general scientific community. In short, my plan to strike this balance relies on reprioritizing the work and travel of nearly every staff member within AMLR to increase the program's emphasis on publishing papers in the peer-reviewed literature and participating in coordinated, international research. To facilitate this re-prioritization, I will work to train and empower other staff members to manage the AMLR field operations while simultaneously developing and sustaining a corps of graduate students and post-doctoral researchers to energize and expand AMLR research. I will also emphasize data synthesis and data availability as these will be key to the program's success. The Review Panel recommended another review of AMLR in four years. I look forward to that review and feel confident that, by adopting the business model described here, AMLR can evolve to become even more successful.

Table 1. Papers for submission to peer-reviewed journals. Some aspects of the proposed work are still to be determined (TBD).

Topic	PI (funding mechanism)	Target Journal	Schedule
Detection of vulnerable marine ecosystems	Jones et al. (internal)	<i>Frontiers in Ecology and the Environment</i>	Submission by 1 July 2010
Ecosystem-based risk assessment of management strategies for the krill fishery	Watters et al. (internal)	<i>Ecological Monographs</i>	Submission by 1 July 2010
Winter energy budgets for gentoo penguins	Hinke et al. (internal)	<i>Marine Ecology Progress Series</i>	Submission by 1 July 2010
Penguin trends in the Scotia Sea	Trivelpiece et al. (internal)	TBD (<i>Proceedings of the National Academy of Sciences?</i>)	Submission by 1 October 2010
New insights on krill-predator interactions	Reiss et al. (internal)	TBD (<i>Ecology?</i>)	Submission by 1 October 2010
Demographics of Antarctic fur seals with comparisons to other Otariids	Goebel et al. (internal)	TBD (<i>Journal of Animal Ecology?</i>)	Submission by 1 October 2010
Comparative life histories of Adélie penguins and impacts of climate change	Hinke et al. (internal)	<i>Global Change Biology</i>	Submission by 1 January 2011
First record of nesting behavior by an Artedidraconid and its relevance to the evolution of Antarctic fishes	Jones et al. (internal)	<i>Journal of Fish Biology</i>	Submission by 1 January 2011
New perspectives on the life history of Antarctic krill	TBD (post-doctoral researcher to be mentored by Watters et al.)	TBD	Hire by Summer 2010, submission(s) beginning Summer 2011, final submission(s) Summer 2012
Demonstration of the effectiveness of AMLR's approach in the context of EBFM and climate change	Watters et al. (internal)	TBD (<i>Trends in Ecology & Evolution?</i>)	Outline by 1 January 2011, submission by 1 July 2011

**Review of the US Antarctic Marine Living Resources Program (US AMLR),
Antarctic Ecosystem Research Division (AERD), Southwest Fisheries Science
Center**

15 September 2009

Marc Mangel (Chair), Eileen Hofmann, Denzil Miller, Polly Penhale, Phil Trathan*

*Marc Mangel is Distinguished Professor of Mathematical Biology, Director of the Center for Stock Assessment Research, University of California Santa Cruz and Chair of the U.K. Special Committee on Seals (msmangel@ucsc.edu)

Eileen Hofmann is a Professor of Oceanography at Old Dominion University, Chair of the Southern Ocean Global Ocean Ecosystems Dynamics Program and Vice Chair of the Scientific Committee on Antarctic Research Group of Experts on Oceanography (hofmann@ccpo.odu.edu).

Denzil Miller is Executive Secretary of the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR), Honorary Research Professor at the University of Tasmania, and was Chair (1997-2001) of the CCAMLR Scientific Committee (denzil@ccamlr.org)

Polly Penhale is Environmental Officer, Office of Polar Programs U.S. National Science Foundation, U.S. Representative to the Committee for Environmental Protection, Antarctic Treaty, and Member, U.S. Delegation to CCAMLR (ppenhale@nsf.gov)

Phil Trathan is Head of Conservation Biology and Project Leader for Ecosystem Structure and Biodiversity, British Antarctic Survey and Member, U.K. delegation to CCAMLR (pnt@bas.ac.uk)

Executive Summary

•The U.S. Antarctic Marine Living Resources (AMLR) Program at the Southwest Fisheries Science Center, La Jolla, CA has achieved remarkable success over its approximately 25 year history. This success includes: (i) contributions as part of the U.S. Delegation to the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR) and its Scientific Committee (SC-CAMLR), and (ii) development of an almost unique program of data collection and analysis for Ecosystem Based Fishery Management. The AMLR Program is now mature and has reached a point where its past successes, recent change in leadership, and prevailing circumstances have mandated consideration of its future. In this respect, business as usual cannot continue.

•AMLR requires a vision and strategic but flexible framework to allow prioritization of activities, scientific products, and support for U.S. Southern Ocean and Antarctic policy. This vision should be to undertake a program of scientific research on Antarctic marine living resources to improve knowledge of ecosystem dynamics and function and to provide scientific advice on Ecosystem Based Management of Antarctic ecosystems, including: (i) enhancing ecological understanding of Antarctic harvested, dependent and related species; (ii) identifying and assessing changes in these species due to human based activities, natural variability, and climate change; (iii) providing high quality scientific evidence, from an ecosystem-based perspective, to support the sustainable harvesting and precautionary management of Antarctic marine living resources, and (iv) promoting scientific excellence in the research of Antarctic marine living resources through collaboration consistent with national policy priorities and provision of scientific innovation and leadership.

•To achieve the program's strategic goals, AMLR and NMFS need to undertake actions at three time scales. Such actions are relevant to the immediate needs of the AMLR Program and to the integration of AMLR science into developing future national and international Southern Ocean programs. Over the shortest time scale (1-3 years) AMLR should among other things: (i) develop a long-term plan for sustained access to a research platform(s) for ship-based studies; (ii) make its unique datasets widely available; (iii) greatly increase the rate of peer-reviewed journal publications; (iv) initiate an integrated stock assessment framework for estimating krill abundance; and (v) continue and advance marine spatial planning. In the medium range time scale (3-5 years), among other activities, AMLR should: (i) sustain a program of graduate student and post-doctoral training; (ii) develop relationships with scientists associated with the Intergovernmental Panel on Climate Change (IPCC), for including analyses of AMLR data in Climate Change Assessment Report 5 (IPCC AR5). On the scale of 5 years and beyond AMLR should: (i) expand its staff base to include another oceanographer, a fish biologist, and a logistics coordinator, and (ii) increase engagement with the broader Southern Ocean scientific community both nationally and internationally.

•To assess progress in meeting the above goals, the next review of the AMLR Program should take place in September 2013, four years hence.

Introduction

This report represents the conclusions of the panel convened to review the U.S. Antarctic Marine Living Resources (AMLR) Program of the Antarctic Ecosystem Research Division (AERD), Southwest Fisheries Science Center. We generally use “AMLR” or “AMLR Program”, recognizing that some of our recommendations may refer to AERD and not AMLR. We regard a single report as the most efficient way to consolidate our discussions and to provide more focus to our recommendations.

Based on two intensive days of presentations and discussions, we found that the AMLR Program is at a crucial point in its development. It is now time to consolidate gains and reflect on previous accomplishments as a basis for developing a strategy for the future of the Program. Indeed, the non-availability of the previous research vessel, while a crisis, is also an opportunity to rethink and set priorities for AMLR activities.

It became very clear during the review that AMLR scientists face a wide range of tradeoffs for their time, expertise, and funding. Dealing with such tradeoffs requires prioritization and flexibility to modify Program needs and goals, as well as the ability to adjust to current circumstances and to set future directions.

We begin by assessing the AMLR Program’s current status, then continue with a strategic vision for the Program. Recommendations for action on time scales of 1-3, 3-5, and beyond 5 years are provided. We end with a brief conclusion.

Assessment of the Current Status of the AMLR Program

The 1980 Convention on the Conservation of Antarctic Marine Living Resources (CAMLR Convention), which came into force in 1982, forms part of the Antarctic Treaty System. It is implemented in the United States through the U.S. Antarctic Marine Living Resources Convention Act of 1984. The Act established a directed research program, known as the U.S. Antarctic Marine Living Resources (U.S. AMLR) Program. The Antarctic Ecosystem Research Division (AERD) of the Southwest Fisheries Science Center has managed the AMLR Program since 1990.

Scientists in the AMLR Program conduct a broad range of research activities focused on the Antarctic marine ecosystem, including a field program consisting of physical and biological oceanographic studies that incorporate research on Antarctic krill (*Euphausia superba*, henceforth simply krill, although there other species of *Euphausiids* in the Southern Ocean), krill-dependent predators, finfish and benthic invertebrates. These studies are conducted at two land-based field camps on the South Shetland Islands and on-board ship during an annual field program in the oceanic waters around the South Shetland Islands.

Modeling studies and stock assessments are also a strong component of the AMLR Program. These produce analyses and advice that form critical contributions to the wider body of scientific advice upon which the Commission (CCAMLR) set up under the

CAMLR Convention bases its management decisions. Within the broader international CCAMLR scientific community, scientists in the AMLR program have played a major leadership role in the CCAMLR Scientific Committee (SC-CAMLR), as well as in its working groups, subgroups, and scientific workshops.

A current AERD staff of eleven full-time employees plus an officer from the NOAA Corps conduct an ambitious program of scientific research, including the development of scientifically-based management advice. This work draws on a variety of established and productive collaborations with students and scientists at a wide range of national and international institutions. The responsibility for the Program's funding, planning and conduct rests with the AERD. The demands of logistics planning and the time required to conduct a lengthy annual (up to six months) field program consumes a major part of each annual work cycle. The time devoted to the planning and preparation of papers for SC-CAMLR and its working group's meetings also takes up a significant amount of time. Participation in several related Antarctic meetings further adds to the AMLR Program's crowded annual calendar.

The time demands outlined above, the Program's past successes and a change in its leadership and prevailing circumstances (i.e. potential loss of a sea-based research platform) have mandated consideration of its future. In this respect, and because of the accumulation of ever increasing amounts of data, the AMLR Program has reached a point where "business as usual" is no longer an option. Other contributory factors include increasing opportunities to take advantage of technological advances in data collection, as well as the emergence of critical new areas of field research and scientific analyses to which AMLR is poised to contribute (e.g., climate change, marine spatial planning).

In the past, the AMLR Program has been very successful in accruing a solid and diverse body of scientific knowledge. It has provided scientific input to the development of U.S. Antarctic Policy, which is firmly based on the conduct of science in Antarctica and the Southern Ocean. AMLR has also made unparalleled contributions to the development of a mature SC-CAMLR. However, while the AMLR Program is well known and respected within CCAMLR, it is virtually unknown in the broader scientific community. This includes not only the U.S. and international academic community, but also includes related NOAA research programs. Furthermore, the AMLR Program is generally not producing peer-reviewed papers that reach the non-polar community and participation in non-polar scientific meetings has not been a priority. Thus, opportunities for making a broader scientific and societal impact have been limited.

We are confident that the intellect and datasets exist within the AMLR Program to improve the situation outlined above and better meet the Program's goals. The 2009 Program Review therefore provided an opportunity for pause and reflection to facilitate the development of long and short-term priorities by the AMLR Program. Strategic planning and priority setting, including the *status quo*, and enhanced funding scenarios, provide the opportunity for the AMLR Program to move to the next level of excellence. We are convinced that AMLR program is uniquely poised to make this leap if it is given the needed resources and support.

Strategic Framework

We believe that the AMLR program will benefit from a concise statement clearly outlining its purpose and function. Such a statement should on the AMLR Program's overall objectives and provide a basis for developing operational goals against which outcomes. The objectives and goals should focus on the time-series and project-based elements. The strategic framework should encompass past achievements, anticipate future strategic needs and indicate that:

The primary purpose of the U.S. AMLR Program is to undertake a program of scientific research on Antarctic marine living resources to improve knowledge of ecosystem dynamics and function and to provide scientific advice on the ecosystem-based management of Antarctic ecosystems.

This research should:

- Enhance ecological understanding of Antarctic harvested, dependent and related species;
- Identify and assess changes in these species arising from human based activities, natural variability, and climate change;
- Provide high quality scientific evidence, from an ecosystem-based perspective, to support the sustainable harvesting and precautionary management of Antarctic marine living resources; and
- Promote scientific excellence in the research of Antarctic marine living resources through collaborations consistent with national policy priorities and provision of scientific innovation and leadership.

Finally, the strategic framework should provide a basis for affording priorities to AMLR-sponsored activities, taking account of a need for flexibility in responding to changing national and international priorities. Periodic review of AMLR Program results should be factored into the framework to measure the Program's operational performance with respect to its objectives and goals.

Achieving the Vision: Action over the Next 1-3 Years

There is no doubt that the AERD would benefit from a large infusion of financial support. That said, there are many things that can be done quickly, with a modest amount of new funds, by prioritizing current activities. We consider the most important priorities to be:

Develop a Long-term Plan for Sustained Ship Availability. The current lack of a suitable platform for AMLR ship-based field program underscores the vulnerability of the Program. We consider it essential that the AMLR Program, with support and guidance from NOAA NMFS and NSF Office of Polar Programs, develop a plan for

maintaining long-term sustained access to a ship(s) with adequate facilities to support the necessary at-sea measurements and projects.

Make AMLR Data Widely Available. This includes ship-based (e.g. krill net and acoustic, physical environment) and terrestrial (e.g. penguin population and life history) data. If doing this in a timely manner requires the addition of a data manager to the staff, then one should be appointed. It is essential that the data are not only accessible, but that they are widely advertised as well.

Publish in the Peer-Reviewed Ecological Literature. There is no better advertisement than peer-review publication, the primary currency of science. We consider that it is a high priority that AMLR participants publish more extensively in the general ecological literature. This includes, at the minimum, a major modeling paper on the Krill Predator Fishery Model, a major field paper on penguin ecology, and a shorter review paper (e.g. aimed for *Science* or *Trends in Ecology and Evolution*) as a demonstration of the effectiveness of the AMLR approach in the context of Ecosystem Based Fishery Management and the International Panel on Climate Change (IPCC) assessments.

Re-Evaluate the Frequency of AERD Director's Field Work. The two points above are extremely important to the AMLR Program's overall success. It will be much easier to achieve those goals if the Director does not go to the field annually during the first several years of his tenure. His time would be best spent at his AERD office guiding the AMLR team in data analysis and the production of publications, as well as focusing on his own modeling research (perhaps aided by a post-doctoral colleague) Additionally, increased interaction and collaboration with NOAA Fisheries headquarters staff will enhance the Program's effectiveness. A reduction in the Director's field time will also facilitate increased interaction with the Department of State and the National Science Foundation to result in a strengthened U.S. position at CCAMLR.

Invest in Analyzing AMLR Data. There is much that can be learned from further analysis of existing data. A National Research Council (NRC) post-doctoral position would be an ideal vehicle for training a young scientist and for analyzing existing AMLR data. Similarly the NSF provides post-doctoral opportunities that could be used to provide opportunities for young scientists to bring new ideas and approaches to such analyses.

Undertake a Strategic Determination of AMLR Needs. The identification of potential AMLR needs is an urgent priority and should include an assessment of which monitoring activities can be undertaken less frequently than on an annual basis. It is indeed possible that after sustained evaluation of current activities, AMLR scientists will conclude that all monitoring should be undertaken annually. However, this should be a well thought-through conclusion, rather than a continuation of business as usual. It is also essential that any determination of both current and future AMLR needs should be developed within a strategic framework (as above) that accounts for assigned priorities, designates deployment of personnel and outlines a timetable for the delivery of

results/outcomes. Other key aspects to be addressed should include analyses of the adequacy of logistical support (both ship and shore-based), staffing levels (including training requirements and student involvement) and the utilization of external (other than NOAA-based) funding opportunities. Formal consideration should also be given to potential future expansion of the AMLR Program in the next 3 to 5 years to account for non-krill based studies and to anticipate the potential demands of climate change or other research needs. This strategic framework should identify the appropriate level of AMLR-based leadership input into the CCAMLR scientific realm as well as the building of scientific ties with other relevant research institutions, or individuals, at a national and international level. It should also be flexible enough to anticipate priority needs as these emerge.

Initiate the Integrated Assessment for Providing Management Advice for the Antarctic Krill Fishery. Increasing national and international logistic and resource constraints mean that stock assessments for Antarctic krill such as provided by the CCAMLR 2000 Synoptic Survey will be increasingly difficult to generate. However, AMLR is well poised to lead future stock assessments that make better use of the mesoscale monitoring surveys undertaken by AMLR, the British Antarctic Survey (BAS) and the Palmer Station Long Term Ecological Research (PAL LTER) Programs. Incorporating information from krill predators, the fishery, and environmental data will be essential if these mesoscale surveys are to provide useful demographic information about krill. Therefore, AMLR should enhance its collaborative links with other groups, in particular BAS and PAL LTER but also colleagues from krill harvesting nations, to develop an integrated krill stock assessment. An integrated assessment would have the added advantage of facilitating estimation of both absolute and proportional krill recruitment, which will be an enormous step forward for SC-CAMLR and CCAMLR's management of the krill resource.

Work with NSF Polar Programs, the Palmer Long-term Ecological Research Program, British Antarctic Survey & AMLR Monitoring Programs to Plan a Joint Workshop . By integrating the work done by the PAL LTER, BAS, and AMLR along the Antarctic Peninsula, each group will develop a much more comprehensive understanding of this extremely important part of the Antarctic and will help integrate AMLR into the broader Antarctic scientific community.

Continue the Development of Marine Spatial Planning. Marine spatial planning is a high priority for CCAMLR, the overall Antarctic Treaty System and the broader marine management community. The extensive, high-quality AMLR datasets and models form an important resource for developments in this area. The most effective contributions within the CCAMLR forum will be through partnerships between the AMLR and other researchers, particularly with scientists supported by the BAS and the NSF conducting long-term research programs in the Antarctic Peninsula region. Additionally, collaboration with the NSF Office of Polar Programs, with respect to its activities directed to environmental stewardship in Antarctica, would enhance success in this area of activity.

Provide a Program of Professional Development for the AERD Director. The new Director of the AERD, Dr. George Watters, has taken on a range of new and challenging responsibilities. Formal professional development in scientific and research management will allow him to function more efficiently, both in AMLR and the wider NMFS community.

Achieving the Vision: Action over the Next 3-5 Years

On a slightly longer time scale and with a moderate amount of additional funding, we believe the following actions are critical:

Undertake Analysis of Core Data Holdings to Develop a Regional Study for the Intergovernmental Panel on Climate Change Assessment Report 5. The Program's integrated data holdings range from oceanography, phytoplankton, krill, and fish to air breathing predators. They are likely to provide an opportunity for high profile, time-integrated analyses with high citation potential and which will contribute significantly to raising the AMLR Program's profile. Key analyses should be completed in time for March 2011, and published before August 2012 in order to fit with the IPCC timetable.

Expand Beyond Krill-based Studies. The current species-centric approach within AMLR is based on the original goals and objectives of CCAMLR. However, with the recognition of the importance of climate change effects on Antarctic ecosystems, it is important that AMLR begin discussions of how to be more inclusive of such effects in sampling marine ecosystem components. Some effort has been made to collect data on ancillary species such as flighted seabirds and other zooplankton taxa. These types of measurements should be expanded so that AMLR will be in a position to benchmark and detect changes in the ecosystem as well as to interface with programs that are focused on climate change.

Sustain a Graduate Student and Postdoctoral Program. The NRC and/or NSF postdoctoral positions described above should be viewed as the first in a continuous series of postdoctoral colleagues and graduate students working with AMLR staff. In addition to training the next generation of Antarctic scientists, post-doctoral colleagues and graduate students will help the Program attain the visibility it deserves.

Add a Staff Position for the Organization and Training of Observers. All indications are that the need for observers on fishing, commercial, support and tourist vessels in the Southern Ocean is poised to increase greatly. An AERD staff member dedicated to such training and logistics will also be able to support other logistical aspects of the AMLR Program.

Add a Staff Position for a Physical Oceanographer. The AMLR Program has collected extensive hydrographic data sets, most of which remain unanalyzed, in part because of the workload of the single oceanographer on staff. Another staff member trained in modern physical oceanography (including use of circulation models) will help

move the AMLR program's hydrographic data collection activities to science-based interpretations integrating oceanographic data into ecological studies.

Achieving the Vision: Action Beyond 5 Years

On the longest time scale, and with the greatest possibility of increased funding, we consider these actions to be critical:

Add a Staff Member to Work on Abundance and Diet of Pelagic Fish. This work will feed into a more precise formulation of the Integrated Assessment Framework for krill, as well as other species. For example, AMLR has contributed to the dataset on myctophid fish that resides with CCAMLR but which has not been fully analyzed.

Sustain Increased Engagement with Broader Southern Ocean Scientific Community. A number of ongoing initiatives involve planning activities and programs with time frames of ten to fifty years. These will provide the basis for much of the scientific direction for future Southern Ocean research. Such initiatives include the Southern Ocean Observing System (SOOS), the Integrating Climate and Ecosystem Dynamics (ICED) program, and the Southern Ocean Sentinel (SOS), all now currently under development. All three international programs have scientific goals and objectives that are directly relevant to those of AMLR.

Participation in the SOOS will enhance the AMLR science program. For example, the SOOS has an objective of developing automated sensor systems for the Southern Ocean. Involvement in designing the SOOS might allow some of AMLR's monitoring measurements to be moved to other groups and/or to automated sensor systems (e.g. for chlorophyll). Involvement in how the SOOS is designed is critical to ensuring that coverage occurs in areas of interest to AMLR.

Furthermore, contribution of the AMLR measurements to the larger SOOS data management system will allow access to these data by a wider community. In this way, the AMLR data will become critical to the wider scientific community (beyond CCAMLR), which will provide international support for funding long-term acquisition of relevant data.

The initial focus of the ICED program (next 3-5 years) is on developing models to be used to understand the effects of climate and exploitation on Southern Ocean food webs. The development of a community that will use such models is an ICED priority. The AMLR Program possesses data sets and scientific insights that could be integral to model development. The AMLR Program would in turn benefit from working with the ICED modeling community as this will provide a framework for broader synthesis and integration of AMLR data and ideas.

The focus of the SOS in the next 3-5 years is on developing assessments of the state of understanding of climate impacts on Southern Ocean ecosystems. The AMLR program should aim to provide information that can be used in the IPCC AR5. The AMLR

Program is in a unique position to provide major input into the SOS assessments. Its long-term data sets are globally unique and could provide the basis for much of the assessment developed by SOS. The SOS is designed as a 30-50 year program and as such could provide a framework for integrating AMLR data into a larger, long-term circumpolar program.

Involvement in the scientific programs beyond those that are focused on the Southern Ocean is important for AMLR as scientific focus shifts to Earth-system issues. The Integrated Marine Biogeochemistry and Ecosystem Research (IMBER) Program of the International Geosphere-Biosphere Program (IGBP) is focused on understanding the sensitivity of marine biogeochemical cycles and ecosystems to global change at long time scales. Participation by AMLR scientists in IMBER-related working groups, focus groups, and workshops would raise the visibility of AMLR and also allow AMLR data and results to be placed in a larger context. Involvement in IMBER follow-on programs will also ensure an AMLR international science legacy outside CCAMLR.

The AMLR program therefore can have an important role in SOOS, ICED, SOS, IMBER and other programs to be developed in the future. To ensure this role, AMLR scientists will need to be involved in the workshops, science steering committees, and working groups tasked with developing and coordinating such programs. This will require that AMLR scientists (i) produce primary publications that result in the wider global community recognizing the value of the Program; (ii) be given the time, support and flexibility to participate at influential levels in international programs (other than, but still including CCAMLR), and (iii) expand AMLR to include the expertise and personnel (e.g. climate and food webs analyses, sensor systems) to effectively interact with these programs. To avoid over-commitment of already busy staff, careful consideration needs to be given to an evolving, strategic approach to involvement in such programs as well as to the priority to be attached to such involvement.

Conclusion

Science is the focus of U.S. activity in the Antarctic and the AMLR Program is a crown jewel of Antarctic science. The research conducted by AMLR is a unique integration of an interdisciplinary approach that serves as a model for NMFS colleagues working in other ecosystems. Indeed, the AMLR program is a model of how to conduct scientific research in support of Ecosystem Based Fishery Management. It therefore should be made more widely known both within and outside the NMFS.

AMLR has considerable potential to take new, innovative and important steps forward. Now is therefore the time to consolidate gains and to begin developing approaches and strategies so that AMLR scientists will be poised to assume leadership roles in programs defining the future of Southern Ocean research.