NORTH PACIFIC UNIVERSITIES
MARINE MAMMAL
RESEARCH CONSORTIUM

MARINE MAMMALS IN THE LAB:
Tools for Conservation & Science

Workshop Proceedings

September 10-11, 2007

Editors: David A.S. Rosen
Andrew W. Trites

Hosted by:
UBC Marine Mammal Research Unit
Vancouver Aquarium
Alliance of Marine Mammal Parks and Aquariums

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ALLIANCE OF MARINE MAMMAL PARKS AND AQUARIUMS

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Executive Summary

Twenty-two participants from a variety of backgrounds and interests discussed how to improve the nature of research with marine mammals in the laboratory and ensure its continuation as a vital scientific resource in the future.

There was agreement that captive marine mammals represent a valuable scientific asset. Many of the pressing conservation and scientific research questions pertaining to marine mammals cannot be carried out with their wild counterparts. However, studying marine mammals in the laboratory incurs specific financial, scientific, and logistical challenges. The workshop generated potential solutions to many of these issues.

Participants expressed the need for greater cooperation and coordination between scientists to optimize the scientific value of research with captive marine mammals, and to minimize the costs of such research. This could be enhanced through scheduled in-person gatherings and web-based portals for listing active and proposed research. Better use must also be made of scientific resources and expertise, and novel sources of revenue have to be generated. There should also be greater sharing of documents relating to experimental design and research permitting. The effectiveness of research will benefit from greater communication between researchers and husbandry staff at institutions holding animals for research. Such efforts should raise the profile (and acceptance) of captive marine mammals science within the scientific community and for program administrators, leading to greater financial and research opportunities.

Nine specific recommendations were forwarded that could be immediately implemented to enhance communication and increase the value of captive marine mammal science:

1. Produce a list of research resources (animals, specialized skills and equipment);
2. Create a list of on-going captive marine mammal studies;
3. Produce a list of publications derived from research with captive marine mammals;
4. Develop a set of guidelines for communication, responsibilities, and intellectual ownership for collaborative projects;
5. Implement means for coordination of future studies (both web-based and scheduled workshop/meetings);
6. Design a means for sharing Standard Operating Procedures;
7. Hold a workshop to increase statistical rigor and standards in experimental design;
8. Introduce the use of Annual Survival Rates into institutions holding marine mammals; and
9. Heighten the awareness of the value and prevalence of captive studies to the US Marine Mammal Commission.

Foreword


Photo: David Rosen

Marine mammals have been studied outside of their natural environment for longer than there has been a recognized field of "marine mammal science". Scholander and Irving's seminal work on diving mammals in the 1930s and 1940s, and its identification of the physiological adaptations that make this group of animals so unique, was performed in the laboratory. Since that time there has been an expanding variety of marine mammals that are available to study in captivity, an increasing amount of time they can be held, a diversification of the types of studies that can be performed, and a resulting expanded wealth of knowledge (both "pure science" and husbandry-directed) that is obtained from these animals. There can be little doubt within the scientific community that such resources have greatly contributed to our knowledge of this unique group of animals.

However, keeping marine mammals in the laboratory is a difficult and expensive proposition. Their size and needs (environmental and social) impose logistical and scientific hurdles that can stretch most research budgets beyond the breaking point. Most of the scientific institutions that have specifically held marine mammals for research in the past have become victims of these difficulties. Even aquariums that hold animals for public display and education have to balance scientific desires with the demands of public access (which often ultimately pays for research).

Like many endeavours, there is an economy of scale realized through greater cooperation among scientists and institutions. However, although the community of marine mammal researchers is relatively small, the mechanisms for such coordination are – to date – limited. In 2005 the North Pacific Marine Science Foundation provided a grant to hold a workshop that would bring together members of the marine mammal community that worked with captive animals. The original proposal was for only six scientists. However, as word of the workshop spread, it became apparent that there was a great desire for others to participate in discussions about the future of research with captive marine mammals. Given the limited size of the original proposal, we were fortunate to have the Vancouver Aquarium and the Alliance of Marine Mammal Parks and Aquariums co-sponsor the event. The result was a two-day workshop held at the Vancouver Aquarium and the University of British Columbia's Fisheries Centre.

Our goal was to bring together researchers from a variety of aquatic facilities to brainstorm means to make laboratory studies of marine mammals more viable, scientifically valuable, and cost-effective. We hoped to increase the level of science through increased co-operation and synergy between institutions and researchers.

As you will read in the pages that follow, the end result of the workshop was a productive 48 hours of discussions and planning. The highlights of the workshop are contained in this proceeding, but the resulting planning and brainstorming is still evident months later. Our hope is that the tangible plans and goals generated through this workshop will be discussed and become embedded in the way we conduct laboratory science with marine mammals in the future. In other words, not just great ideas but concrete actions that increase the scientific value of marine mammals in the laboratory.

Numerous people contributed to the success of the workshop. Not least are the participants who managed to free up two days in their very hectic schedules and whose efforts directly resulted in the flurry of discussions. Several student volunteers helped in getting those thoughts on paper. We would like to also thank members of the Vancouver Aquarium and AMMPA who assisted in expanding the size of the workshop. Finally, we would like to thank the staff of the Marine Mammal Research Unit, particularly Pamela Rosenbaum and Morgan Davies, who made sure that the event operated seamlessly for everyone.

David Rosen, Ph.D.
February 2008

Captive Research: Challenges & Solutions

Moderator: Dr. Chris Harvey-Clark, DVM

1. Participant Presentations

Presentations were made by the workshop delegates about the types of laboratory marine mammal science that they and their institutions are undertaking (details of individual presentations in Appendix C). A survey of workshop participants identified a wealth of animal resources and a wide range of scientific studies that are underway. Most of these studies could only be conducted with marine mammals in the laboratory. They capitalize on the inherent controlled conditions, the broad range of possible behavioural and physiological manipulations, and the enhanced ability to conduct longitudinal studies. While the discussions emphasised the scientific need for captive marine mammals, it also stressed the immense expense in maintaining such a group of animals.

The financial burden imposed on keeping marine mammals in the lab highlighted the paradox inherent in current institution models: financial support versus accessibility. Facilities that primarily focus on research have to contend with extensive budget overheads for staff and maintenance. The costs must be paid for almost exclusively by research grants. This necessitates either acquiring a vast number of smaller research grants (with inherent time devoted to grant writing and administration) or securing a smaller number of substantial grants. Unfortunately, the latter typically restrict the research to within certain well-defined goals. Reliance on such grants also leaves the institutions exposed to drastic changes in funding stability. Given that maintenance costs are largely constant and must have the highest funding priority, any reduction in incoming research grants will have a disproportionate effect on the level of funding available for actual science.

A second model for studying captive marine mammals encompasses research on animals that are primarily kept for display and education. There has been an encouraging trend within the community of zoos and aquariums to support research projects, particularly in reference to explicit conservation goals. Some institutions directly fund research projects, and a few even have dedicated research departments (albeit often with a strong husbandry-centric research mandate). Most public aquariums report a certain proportion of gate receipts that are directed towards 'research', but it is often difficult to ascertain the exact nature of this support.

There is a growing acceptance of outside researchers working within a public institution, but there remain substantial hurdles. For example, the process of initiating a research project or obtaining institutional animal care approval is often unclear. Training and husbandry staffs are often inexperienced in dealing with the requirements of researchers or the manner of scientific investigation. Conversely, many researchers are inexperienced or insensitive to the limitations and needs of training and husbandry personnel. However, the greatest obstacle is probably the inherent limitation in animal access.

In a public facility, the requirements for display and education that generate the income that can support marine mammal research can also severely restrict access to those same animals. These limitations can take a number of forms, but primarily include limiting the times that animals are available and the types of experimental manipulations that can be performed. These difficulties can often be mitigated by directly incorporating research projects into the institutions display and education programs.

2. Difficulties and Solutions with Captive Marine Mammal Science

Working groups, comprising individuals with disparate perspectives, identified, discussed, and came up with possible solutions to the major difficulties specific to undertaking science with captive marine mammals. There were many common areas of concern, and many common solutions were also found (see Appendix D).

One over-riding difficulty with captive marine mammal studies is the immense expense that is required to maintain animals for research. There were obvious operational advantages to acquiring long-term funding rather than relying on a series of shorter-term grants. Most short-term funding operates on annual cycles and time-scales. Such funding sources use up a lot of the scientists' time in grant and report writing (rather than active research), are detrimental to graduate studies, and promote short-term research objectives.

Multi-year grants would be beneficial, as would new funding opportunities, as well as grants available more than just once per year throughout year. The inherent stability provided by long-term funding directly benefits the science program, by allowing scientists to concentrate on research and facilitating long-term planning of scientific programs. The latter will illicit greater cooperative research projects with other scientists and facilitate more complex, long-term studies.

The researchers all recognized the difficulty in acquiring long-term, stable funding. One potential solution is to increase linkages with aquaria or other public facilities. These institutions often possess valuable in-house expertise (e.g., animal husbandry, fund raising), as well as a pre-existing high local or even national profile. The aquariums benefit from associations with established research groups that help them fulfill their conservation, scientific, and education mandates. Additional means to reduce operational costs include 'piggybacking' studies (so that costs are shared among grants), and securing greater cooperation within the scientific community by promoting sharing of resources (e.g., specialty equipment) and facilities (including specialized laboratories or in-house analysis capabilities).

Beyond the cost of maintaining animals, there are concerns specific to working with a static group of captive marine mammals. Inevitably, the animals available for long-term research are aging. While specific studies may require different age classes, most studies are not focused on geriatric animals. There is also concern over the genetic makeup (example: mixing of Atlantic and Pacific subspecies) and genetic diversity of available animals. There is also the perception that research has a negative impact on the well being of these animals. Despite the best scientific designs there may be a cumulative effect of different studies on the behaviour, physiology, and anatomy of long-term laboratory animals. To a certain extent, study animals can be replaced by swapping between institutions, although this (finite) solution presents additional financial, logistical, and permitting issues. While short-term captivity has been successfully used in the past, this solution has its own set of drawbacks.

Acquiring new animals to expand scientific programs or act as replacement animals is also problematic. There may be growing public uneasiness regarding bringing wild marine mammals into a facility for either display (most animals are currently housed under display permits) or for scientific purposes. The continued successes of captive breeding programs of marine mammals bodes well for the future supply of animals for research, although the relatively small populations of some species will continue to be a challenge with respect to genetic relatedness. Both the number and genetic makeup of captive animals can be partly increased with advanced reproductive techniques such as artificial insemination. Whatever the ultimate source of study animals, greater effort must be placed on education and outreach to make the public and scientific community understand the need for research animal collections.

Inevitably, small sample size will always be an issue for studies with captive marine mammals. This can partly alleviated through good experimental designs and statistical justification. Proposals and grants should be proactively worded to justify anticipated sample sizes. Additionally, multiple institution access can be used to increase sample numbers – this can be aided by a comprehensive database of the number of animals (and research capacity) of each facility.

Even with adequate numbers of captive marine mammals, sufficient funding opportunities, and a desire to carry out cooperative research projects, there are further logistical issues that make it difficult to conduct research with marine mammals in a laboratory setting. Given the lack of formal channels of communication, it is often difficult to guarantee access to study animals, or to exchange ideas between researchers and support staff prior to initiation of experiments (at least one year, pending funding). Communication between researchers might be augmented through a joint web listing of potential projects, which

would also promote the possibility to piggyback studies (although there are issues regarding security of posting ideas to a public forum). The Alliance of Marine Mammal Parks and Aquariums releases a biennial research briefing book listing all member facilities, projects (both ongoing and completed), and PIs. Perhaps the most effective tool might be a formal yearly/biyearly meeting (such as at the Society for Marine Mammalogy conferences) specifically for lab coordination.

The research permitting process is also a common hurdle to the scientific process. Although there is unquestionably a need for regulatory, animal care, and scientific review, there is general agreement that the process is unduly lengthy and unnecessarily cumbersome. There is a need to coordinate institutional animal care assessments and streamline regulatory review processes. The process of regulatory reviews is often encumbered by duplication among researchers, which can collectively waste the time of individual researchers and can contribute to extending the permit review time. This can be decreased through sharing of materials/documentation, piggybacking multiple researchers and studies onto individual permits, and sharing copies of permits among researchers or institutions. It was also noted that the Alliance has permits for moving samples between member facilities.

The process of acquiring Institutional Animal Care and Use Committee (IACUC) permits can benefit from making reciprocity more acceptable, particularly between frequently interacting facilities. Greater use should be made of protocol precedents. For example, when one permit has been approved, it could be advertised in a fashion that can be referenced by other researchers and committees. Ultimately, the scientific community may wish to establish a library of Standard Operating Procedures that can be accessed internally and externally (which would also be beneficial for subsequent publications of research findings).

Public display facilities hold the greatest number of potential marine mammals for study. However, research conducted with such animals must address the potential conflicts with programming, such as time management of animals and staff. This can be partly alleviated by making sampling part of the facilities display/show. The researcher should be willing to discuss the value of their work through appropriate means of interpretation for the public. However, the most powerful tool to ease the process of planning and working within public facilities (and obtain institutional buy-in) is to ensure proper two-way communication between staff and researchers. Curatorial staff also need to be included in the early stages of the project planning, and the expectations of researchers need to be communicated up front as clearly and completely as possible (i.e., no surprises of 'extra' requirements).

On-site presentations and collaboration with facility staff and vets when designing experiments will yield better results. Similarly, pre-experimental dialogues with trainers, support staff, and vets on the value of technology, safety, and reasons why studies and specific procedures are necessary will ensure the cooperation of facilities/training staff/administration and help to convince them to try new techniques (e.g., fasting, biopsies). The Alliance could be used as a facilitator to determine costs and types of data that will be required in advance for proper coordination.

It is also important for institutions to maintain good, detailed, readily accessible records of all the marine mammals in their care, as is already a requirement of all Alliance facilities. This will make it easier for researchers to request information to supplement experimental data. Expansive animal husbandry records are also a valuable research resource in their own right.

Finally, there are issues with the public, the wider scientific community, and government agencies of accepting the applicability of captive animal studies to their wild counterparts. The fact is, while the behaviour and physiology of aquarium-born animals are intrinsically different, they can still act as a model for wild animals. It is important to emphasize captive work as a good model for answering fundamental questions, and to make sure studies are relevant to conservation goals. Scientists must focus on keeping research realistic (including asking appropriate questions) to the available number of animals. It is also important to publish basic studies using captive animals so they can be subsequently cited and to publish captive research in higher profile journals (i.e. *Science*, *Nature*) to raise the acceptance of such studies within the science community.

Relevance & Scientific Challenges

Moderators: Lance Barrett-Lennard and David Rosen

3. The Role of the Alliance of Marine Mammal Parks and Aquariums

A presentation was given by Dan Odell, the co-chair of the Alliance Research Committee, on the role of the Alliance and how it can assist in conducting studies with marine mammals in the laboratory.

The Alliance of Marine Mammal Parks and Aquariums is an international association representing marine life parks, aquariums, zoos, research facilities, and professional organizations. The Alliance was founded in 1987, and was known as the Marine Mammal Interest Group. It established an office near Washington, D.C. in 1992, when it was formally incorporated. One of its mandates is to promote conservation through public display, education, and research programs. The role of the Research Committee is to: advise/assist members, advise/assist the board, advise/assist other committees, and assist in the publication of the journal Aquatic Mammals.

The Alliance produces biennial summaries of research projects at member institutions. The 2004-05 Research Report is available for download from the AMMPA website (*www.ammpa.org/ResearchReport2005.pdf*). The Alliance reviews proposals but does not fund any projects. However, the Alliance often recommends to its members that they support important projects that have relevance to the marine mammal community. Also, the Alliance can facilitate cooperative interactions between researchers and its members in support of scientific studies.

Finally, the Alliance has Standards and Guidelines on which accreditation of member facilities are based. These specifically include standards for research.

4. Comparative Measures of Captive Animal Husbandry

Doug DeMaster made a presentation for recording and tracking Annual Survival Rates (ASRs) within captive populations of marine mammals. The aim was to accumulate data that could be used to compare/justify research demands on long-term captive animals. ASRs are a comparative measure of species-specific longevity using longitudinal data. The values are easily calculated in a spreadsheet (Doug provided an Excel example for demonstration purposes). More important from the perspective of institutional 'buy-in', it is also easily maintained due to a simple design (see Perry and DeMaster, 2001 for example). The ASRs can be used to judge the relative well-being of an institution's collection. Each institution can compare its individual ASR to an Industry average ASR. It has potential to help with public relations (health of specific captive populations), and to monitor/justify research loads on captive animals by monitoring long-term effects. The estimated cost per year to enter and maintain the database by a part-time grad student is approximately $20,000, which seems quite inexpensive for such an important piece of information.

Photo: Mystic Aquarium

5. Scientific Issues With Captive Marine Mammals

The participants broke into working groups to examine specific issues that arise from disseminating the results of studies with marine mammals in the laboratory (discussion leader Andrew Trites). The discussion highlighted the scientific value of laboratory studies with marine mammals. While there will always be limitations to the types of research that can be undertaken with laboratory animals, other branches of research actually benefit from the disconnect from their natural environment (in the form of increased experimental control and decreased external influences). The participants identified practical solutions to increase both the actual and perceived scientific value of such studies. Careful study aims and design, and greater cooperation among researchers and between science and non-science staff were stressed as solutions to a range of potential problems.

a. What research questions are best answered with captive marine mammals?

In general, the best types of studies with captive animals are those that require controlled variables or a detailed case history. There are differences between captive and wild individuals, and captive research should concentrate on phenomenons that are conserved between wild and captive populations, such as basic physiological or nutritional studies (hard-wired variables). This also includes studies that complement interpretations of free-ranging behaviour. Captive animals are also well-suited for ground-truthing techniques such as methods of tag attachment and design, measuring and describing capabilities and limitations, dose response studies, establishment of base line references, aging techniques, hearing thresholds, etc.

Another avenue of captive research encompasses husbandry related studies (birth control, disease prevention, supplementation, etc.). Captive animal populations also facilitate studies with endangered species that would be impossible to complete with their wild counterparts. Finally, captive studies are well-suited for facilities that emphasize public education.

b. What are the limitations of applying the results of captive studies to wild animals?

Although captive marine mammals are a valuable resource for studying their wild counterparts, there are several inherent differences between the two that must be taken into account when designing and interpreting experiments.

Essentially, it is impossible to accurately reproduce 'wild conditions', which is, conversely, one of the strengths of captive animal research. Captive animals may exhibit abnormal behavioural, social, and physiological patterns both known and unknown. Certain activities and behaviours (e.g., diving) are quite different in captive animals than in free-ranging animals. Therefore, researchers need to understand how such variables can affect their results (e.g., making judicious use of known covariates). Specific differences between wild and captive environments include the fact that captive animals usually have no predators, eat dead fish, are generally in a situation of greater anthropogenic activity, and lack extremes of environmental conditions and exposure to natural selection (including a limited gene pool). The absence of a need for migration and or extensive foraging activities may cause animals to be less physically fit than wild populations thereby influencing behaviour and physiology. Additionally, demographics of captive study groups are not always reflective of wild population (e.g., age, sex, weight).

Given the intensity of research schedules, it is important to understand the influence of previous experiments and medication versus knowledge of environmental and biological insults to wild animals. This is magnified by the fact that sample sizes are constantly limited (see *section c.* below). Finally, the perceptions of the scientific community may be negative even if the research is well designed and not over-interpreted (see *section d.* below).

c. How many are enough? How can sample sizes/statistical power be increased?

Sample size will always be an issue with captive marine mammal research. Descriptive studies usually require a smaller sample size than experimental studies. There is some practicality in the notion that 'enough' is a sample size sufficient to get the research published. Specific 'adequate' sample sizes depend on the nature of the study. In any case, each researcher should provide a specific rationale for the sample size chosen/used (including practical limitations), and use statistical power analyses and previous studies as precedents for sufficient sample sizes. There are various means that can be employed to increase effective sample sizes including meta studies, pooling multi-facility data, longitudinal studies/repeated measures, and use of temporarily captive "wild animals". Statistical power of available data can be increased by implementing better experimental design, application of Bayesian and other advanced statistical techniques, proper use of covariates, and by designing studies to utilize parameters with less inherent variability.

d. What are the misperceptions among the scientific community about captive marine mammal studies? How should they be addressed?

Despite years of successful research in many facilities and organizations such as the Alliance where members are on record as being "committed to funding research that benefits animals in our facilities and their counterparts in the wild", misperceptions can still be found.

A common misperception among some people is that research with captive marine mammals is a 'soft-science' or a 'poor second cousin' to wild studies. There is also a misconception that samples are easy to obtain and that marine mammal scientists are working on 'free time'. However inaccurate, the view may be prevalent enough to limit funding opportunities (via misinformed reviewers or granting agencies).

The generalized assumption that the results of captive studies are not applicable to wild animals is derived from a number of assertions including that captive animals are over- or under-fed (i.e., it is impossible to mimic wild consumption), that their behaviour is different from that in the wild, and that captive animals never die. There is also an inaccurate belief that the general public and sometimes the facilities themselves are negative towards science, and often husbandry concerns override science as a priority. The Alliance conducted a nationwide poll in the US in 2005 (conducted by Harris Interactive) that showed that 94% of the public believed that aquariums, zoos and marine life parks helped species in the wild by studying their biology and physiology.

Related misconceptions are that aquariums are not serious about science (just stuffed-animal sales), that the process of working within public institutions is plagued by red tape and lacks institutional buy-in, and that animals can not be trained to participate in science. In fact, the intense level of training accomplished by research programs is impressive and should not be underestimated as a selling point (through more behind-the-scenes tours and more public research sessions). It is also important to educate the scientists about public perceptions; being the target of negative perception prohibits a full understanding of the 'other' side.

Some of these misperception issues can be addressed through better communication. This includes communications with trainers, husbandry, and education sector prior to and post study completion, enhanced through careful design, interpretation, and public relations. The perception of the value of captive research within the scientific community can be enhanced through quality publications (as rated through an appropriate "citation index") preferably in journals with a high index score, and by sufficient citation of other published captive work in subsequent publications.

e. Synthesis of Working Group Discussions

A number of common themes were repeatedly mentioned during the working group discussions. Most notably, participants felt that:

i. Captive animals should be studied (a) as models for wild populations and (b) for purely scientific studies (cognition, echolocation).
ii. All institutions and facilities should implement and maintain computerized basic animal records (such as ASR) to have data readily available for public relations and collaborations.
iii. Multi-institutional web-based portals should be set up with lists of captive marine mammal publications/future work/on going work (yes – but who will set this up and fund it?). Must also address issues of security both within and outside captive marine mammal community.
iv. Standard operating procedures should be created for common procedures and to justify aspects of research that may be particularly sensitive for animals in a laboratory setting (e.g., wording to justify biopsy or small sample sizes).
v. Greater effort and organization should be made to promote collaborations or 'piggyback' studies.
vi. Establish contact well in advance of the start of project and include staff/husbandry.
vii. Consult with education staff for future interpretation after you have left.
viii. Share published paper with all involved. Tell husbandry/trainers/staff "Thank you" and share end product with them also.

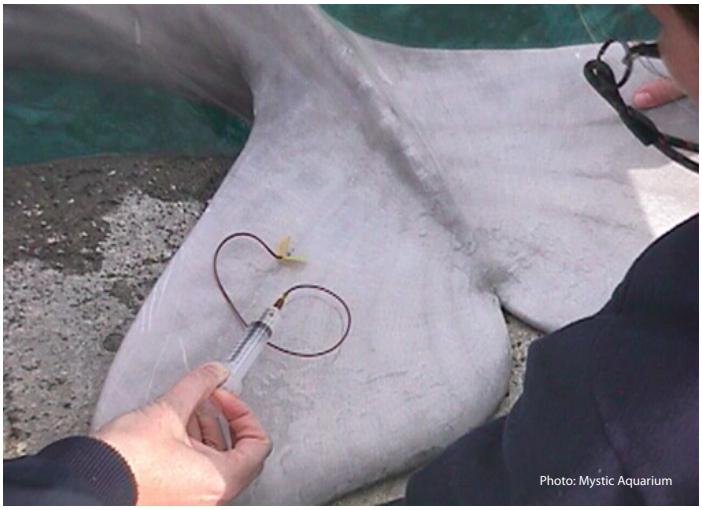


Photo: Mystic Aquarium


Photo: Vancouver Aquarium

6. Animal Protection Groups

Scientists and institutions using captive marine mammals for science often face a double challenge from groups concerned with both the concepts of holding animals for scientific research and holding marine mammals in general. A discussion was led by Jennifer Burns to address the role of the scientific community in dealing with these special interest groups.

It was generally recognized that different groups fall under the general categories of Animal Rights, Animal Welfare, and Animal Advocacy groups, spanning a range of interests and philosophies. Some Animal Welfare groups – Association of Zoos and Aquariums, Canadian Council on Animal Care, etc. – are already incorporated into the scientific process.

While it is important to avoid a negative relationship when possible, it is also recognized that the philosophies of certain groups make this impossible. It is important that scientists and institutions follow (and review) all of their own ethical guidelines, and not be afraid to raise their own concerns to other scientists and institutions (i.e., self-regulating to highest common standards). The marine mammal scientific community needs to be more pro-active (e.g., prior to a crisis) rather than reactive (e.g., after a fatal incident) and defensive towards animal welfare groups.

Researchers and institutions may sometimes deal with aggressive groups on an individual basis. Some approaches that could be used to reply or offset such interactions include:

- Formulate a united public relations message from the research community;
- Maintain credible working relationships between researchers and animal protection groups prior to conflicts (it is easier to attack/criticize someone you don't know personally);
- Establish common ground on collaborative conservation efforts to make sensitive issues easier to deal with;
- Identify and utilize institution's public speaking and advocacy strongholds on certain issues; and
- Provide less technical/jargon-based information.

7. Greater Use of Rehabilitation and Display Animals in Research: Unrealized Research Opportunities?

Martin Haulena gave a presentation on the potential use of display animals and those from rehabilitation facilities for research purposes. While these animals largely represent an 'untapped resource' there are a number of logistical and ethical factors regarding the practicality of such research.

There are several general types of research that can be conducted on these animals. Historical records should not be overlooked as an important source of longitudinal data. Clinical records can provide information on different environmental or medical factors that have affected the animals, as well as reveal novel pathogens and new diagnostic techniques. Therefore, the importance of institutions to keep detailed, easily accessible animal records must be emphasized. Even deceased animals can prove to be a valuable scientific resource. However, scientists must be pro-active and place formal sample requests (including storage and shipping details) before an animal is deceased, and institutions must have a system for honouring these requests. It would be beneficial to establish an industry standard of collection and recording of samples from deceased animals.

Rehab animals are particularly suitable to 'passive' or 'piggyback' studies, where information is collected as part of health analyses and recovery efforts. These types of studies are particularly beneficial to goals of population health monitoring, and can include obtaining samples for disease surveillance, endocrinology, immunology, and DNA.

'Active' research projects can be defined as those that involve manipulations outside of the normal husbandry requirements. In addition to various physiological manipulations, such projects can also include biopsies from animals with known histories and testing new technology, both on resident animals and those destined for release. Recently, the latter has included the development and deployment of implantable scientific equipment. The advantage of surgically-implanted instruments is that they remain attached and collected data for longer periods of time. However, implantations are limited by the necessity (and risk) of anaesthesia and possible surgical complications (requiring long-term observation and treatment).

Given the potential scientific value of the data, it is important to establish suitable techniques under controlled conditions. Specific examples of recent technologies include subcutaneous VHF tags (with internal or external antennas), Life History Transmitters (for more information, contact *markus.horning@oregonstate.edu*), and implantable electrocardiogram (ECG) loggers. While all three types of instruments have a large potential in free-ranging pinnipeds, there are still development issues to contend with. Initial public reaction to animals with such implants may be positive, but visual evidence of such research (tag attachment sites) can be used by interpreters for positive public education on why captive research is important.

There are often species-specific responses to implants, and different materials may result in different degrees of reaction. This highlights the need for adequate evaluation of both the instrument and the surgical procedure under controlled conditions.

8. Captive Research Challenges & Solutions

There are several common logistical problems involved with conducting studies with marine mammals in the lab. A discussion (led by Jo-Ann Mellish) identified two main obstacles – finances and communication – and came up with possible solutions.

a) Controlling costs and expanding funding opportunities:

It is obvious that the static challenges (core costs) of maintaining a captive research animal population are not going to change. One major solution is increased collaboration and communication among researchers (specific idea: a web-based portal for communication). This would make the most use of available research funds, rather than individual researchers or institutions competing for funds and attempting to finance research programs on their own. Effective cost sharing with a display institution's gate receipts will also help, although this is finite. This does not have to be limited to institutions that actually hold marine mammals for research; joint private/public ventures would see public institutions financially supporting research at private/academic research facilities. However, traditional research funding is limited. As a scientific community that requires these animals, we have to become more creative in harnessing alternate funding sources. Specific alternative fundraising examples include animal adoption programs, specialty license plates, and setting up fish tanks at airport/public places.

b) Working with trainers and staff, and public education

Thorough communication with all participating husbandry, veterinary, and training staff before a study begins is essential to promote eventual success and ensure future research studies. Trainers should be treated as a resource and be shown proper respect; these are dedicated professionals that have a huge influence on the success of a project and possess a wealth of information that can assist in designing and carrying out the research. Communication to trainers/public/staff should avoid technical jargon, but still be presented at a respectable level. It should emphasize the broader context and relevance of the work. Remember, non-scientists (e.g., board members, aquarium staff) often have a great influence on what research is conducted, and what funds are directed towards institutional science. Also, it is part of the scientific mandate to disseminate their findings to the general public. A specific suggestion was to set up an information booth at International Marine Animal Trainers Association meetings.

9. Improving Captive Research Programs

As a summary exercise, participants were asked to identify concrete solutions for improving the cooperation and synergy among researchers and institutions conducting studies of marine mammals. The aim was to delineate clear, actionable items that could be implemented by individuals, institutions, and scientific organizations (discussion leader: Lorrie Rea).

a) Increase communication and coordination of research

It is important to hold meetings between facilities or individual species groups 1-2 times per year to discuss inter-agency/inter-researcher collaborations. One possible solution is to hold these workshops/meetings in conjunction with Biennial Marine

Mammal Conferences, starting with the meeting scheduled for 2010 in Quebec City. However, this requires someone to organize it, and the gap between meetings also requires additional interim planning actions. There are other, more directed, means of increasing cooperation and coordination prior to start of research. Working examples include the annual Steller Sea Lion Coordination meeting, planned ASLC Transient workshop, and directed email solicitations from UBC Otariid Research program.

While there was general interest in a web-based information system (posted planned studies, contact info, request for collaborators), there were issues with security versus access and the question of who would take the lead in such a program. Aside from the direct scientific benefits to such planning and coordination, there is a need to convince permit offices of adequate communication among researchers to justify research programs.

b) Clarify up front the goals and benefits of the research

Researchers often undersell the benefits of captive animal research within their publications, resulting captive studies being viewed as a 'poor second cousin' to studies on animals in the wild. This contributes to a lack of acceptance of future research on several levels (i.e., permitting authorities, scientific community at large, public, media). The perceived value of captive marine mammal research can be increased by the quality of studies, number and quality of publications, and intensified education. There was also a suggestion that review papers on specific subjects (or even one on validity of captive marine mammal science) would be beneficial.

c) Expand utility of required agency reports

A great deal of time and effort is put into the reports prepared by scientists for their own funding agencies. These reports can also serve as an important resource for communication and cooperation. Scientists can expand the distribution of these required reports to other agencies en mass (e.g., ADFG Sea Lion program). There was also a suggestion to advocate a change in certain US federal guidelines so that six-month reporting is standard instead of a three-month period. It was felt that this would prove more useful to other researchers, and will encourage more detailed reporting. For those that do not regularly provide such reports, it was acknowledged that there was a large initial time investment (approximately a three-page document). However, following the first instalment, individual researchers can easily provide updates to their respective facilities research contributions.

d) Provide a list of publications specific to captive research

As part of a drive to increase the profile of captive marine mammal research, it was suggested that there should be a master list of relevant publications. The benefit would be multiple: researchers would get greater access to publications (particularly if pdfs or journal e-links were posted), authors would get broader exposure for their publications, and the heightened profile would ease permitting and funding for future research. Financial and technical support may be available through either the Marine Mammal Society or Alliance website.

e) Links for commonly cited publications to support captive research and its goals

In a similar vein, there is a wealth of publications that specifically address the general issues of the applicability and strengths of studying animals in the lab (whether for their intrinsic scientific interest, or in reference to their wild counterparts). On a more specific basis, there are a number of publications that address the issue of sample size that is frequently an issue with captive marine mammal studies. However, these resources are neither readily accessible nor widely known. There needs to be a concerted effort to summarize or centralize the relevant bodies of literature. This will assist researchers in designing, funding, and publishing laboratory studies.

f) Increase statistical rigor

One of the inevitable problems with working with captive marine mammals is low sample size. There are a number of

potential avenues to alleviate this problem. Actual sample size can be increased through cooperative research between institutions and even through building on previous studies (often unpublished specifically because of low sample size). Effective statistical rigor will make the most of available animals. One method is to improve experimental designs to maximize the statistical power from available samples. There are also a number of (not commonly used) statistical analyses that make the most out of such data.

It was felt that it would be beneficial to convene a workshop that specifically examined issues of experimental design and statistical methods in reference to low sample size. It was also noted that, for funding, animal care, and publication processes it was helpful to always cite publications containing validation of low sample sizes in similar studies.

g) Implement Annual Survival Rate summary

As previously described on page 9, this is not only provides a valuable data source, but also a metric for the cumulative effect of research programs on marine mammals.

h) Promote heightened recognition within U.S. Marine Mammal Commission

There was a clear concern that the U.S. Marine Mammal Commission currently pays little heed to captive marine mammal research. However, the Commission is a powerful group that can affect research funding within the U.S. system. It was agreed that raising the profile of captive marine mammal research could only be of benefit. It was suggested that there was a need for an Alliance or interagency committee to support relations with the Commission.

i) Establish better records of past, present, and future studies to establish captive research as current, valid field

There is a substantial time lag between research proposals, active experimentation, and publication; this limits opportunities for sufficient cooperation and coordination on an *ad hoc* basis, despite the relatively small marine mammal research community. There are also, inevitably, a number of studies that do not make it to publication, either because of personnel changes (e.g., grad students), time constraints, or insufficient sample sizes. Therefore, a database of any past, current, or proposed research (including grants pending, PI contacts) should be kept. This list can either be a compilation by a blanket agency (e.g., NOAA) or funded via a science committee (e.g., SMM, Alliance). Aside from the benefits of future cooperation, there are added benefits of avoiding undue replication or increasing effective sample size with previous studies.

j) Provide a species inventory and list of research resources for each facility

It is not always obvious to the scientific community what resources are available to researchers that want to work with marine mammals in the laboratory. A database of potential animal resources, including specialized capabilities (e.g., audiology, haematology, etc.) would greatly benefit the larger scientific community. This may also help convince institutions to actively make resources available to researchers. The more these resources are utilized, the greater the institutions' research profile and the more likely they are to support future research and provide more resources.

k) Develop tools to communicate and exchange information

It was emphasised that there was an increased need for both face-to-face meetings and internet communication between researchers. Additional ways to increase communication and cooperation was to facilitate reciprocity between research facilities and to create a multi-institutional web portal or webpage. There was also a need for keeping better basic animal records within institutions (including clinical records) – these not only provide important auxiliary data for ongoing research, but represent a wealth of data in itself. The use of standardized Dead Animal Request lists would ensure maximum scientific value of mortalities in captivity. While in the past such lists originated from individual researchers, the system would be most effective and reach a broader range of institutions if centrally managed (e.g., through AZA or CAZA).

l) Establish library of approved Standard Operating Procedures

Standard Operating Procedures (SOPs) for commonly used methods that have been accepted by Institutional Animal Care Committees should be available online through an electronic library. This would serve to ease permitting processes (by either referencing SOP# or cut-and-pasting relevant sections) and standardize samples among facilities (including between field and lab sampling). In addition to experimental protocols, details such as required blood volume collection, etc. would assist in evaluating efficacy of incorporating specific techniques into planning studies. Several organizations currently have a variety of SOPs available (e.g., CCAC), but there is no central protocol among marine mammal researchers.

m) Intellectual ownership

The theory of increased scientific cooperation and coordination was roundly endorsed. However, there are several issues that arise from such joint scientific ventures. Confusion over intellectual ownership and priorities and responsibilities of authorship can become significant concerns if not established beforehand. This is equally true for single studies among multiple scientists and also coordinated studies where certain sets of data may be used for multiple purposes by different investigators.

Communications that define in advance who is responsible for securing funding, collecting data, writing up, etc. will help avoid later misunderstandings. Confusion over authorship of resulting publications can be particularly difficult to resolve. While there are several existing institutional guidelines that assist in defining the role and responsibilities of authors, one of the common guiding principals is the concept of intellectual responsibility. There was discussion regarding composing a working template or a set of guidelines for collaborative research, but it was also acknowledged that there are some existing publications that already address these issues.

Appendix A: Workshop Agenda

DAY 1 Captive Research: Challenges & Solutions

Moderator: Dr. Chris Harvey-Clark, DVM

Monday, September 10, 2007
Ground Floor, AERL, The University of British Columbia

8:30	Registration
9:00	Welcome and Introductions
Session 1	Research Laboratory Presentations *(discussion leader: D. Rosen)* A general summary of established research programs describing animal resources, resource allocation, physical layout, support staff, scientific focus and study review, experiment schedules, detailed logistics, and research costs. *Presenters: Atkinson, ASLC; Mazzaro, Mystic; Rosen & Fahlman, UBC; Sheehan, Van Aquarium; Thompson, SMRU; VanBonn, Shedd; Xitco, US Navy.*
Session 2	Independent Researcher Presentations A general summary of work done by individual researchers and how it relates to broad research objectives. *Presenters: Hoopes, UCF; Thompson, SMRU; Zinn, UConn.*
12:00 – 13:00	Lunch
Session 3	Working Groups: Issues with Captive Marine Mammals *(discussion leader: D. Tollit)* Break into three working groups to discuss: 1) What are the major logistical problems with conducting research with captive marine mammals, and 2) How can they be resolved? Each group will generate a list of "top six problems" and potential solutions *Group 1: Thompson, Rosen, Atkinson, Fahlman, Trites, Mellish, Hoover-Miller, Xitco* *Group 2: VanBonn, McBain, Mazzaro, Barrett-Lennard Odell, Sheehan, Haulena* *Group 3: Hoopes, DeMaster, Zinn, Richmond, Rea, Burns, Tollit*
Session 4	Synthesis of Working Group Discussions Group leaders present their list of problems and solutions.
17:30	Dinner @ UBC (and ad hoc tour of UBC Facilities)

DAY 2 Relevance & Scientific Challenges

Moderators: Drs. Lance Barrett-Lennard and David Rosen

Tuesday, September 11, 2007
Ralph Shaw Room, Vancouver Aquarium

8:30	Coffee and Muffins
9:00	Welcome
Session 1	Discussion and Setting of Agenda
Session 2	The Role of the Alliance of Marine Mammal Parks and Aquariums *Presentation by D. Odell*
Session 3	Comparative Measures of Captive Animal Husbandry *Proposal by D. DeMaster*
Session 4	Working Groups: Issues with Captive Marine Mammals *(discussion leader A. Trites)* Break into four working groups to discuss: 1. What research questions are best answered with captive marine mammals? 2. What are the limitations of applying the results of captive studies to wild animals? 3. How many is enough? How can sample sizes/statistical power be increased? 4. What are the misperceptions among the scientific community about captive marine mammal studies? How should they be addressed?
Session 5	Synthesis of Working Group Discussions
12:00 – 13:00	Lunch followed by tour of Aquarium facilities
Session 6	Animal Welfare Groups *(discussion leader: Jennifer Burns)*
Session 7	Greater Use of Rehab and Display Animals in Research: Unrealized Research Opportunities? *(discussion leader: M. Haulena)*
Session 8	Captive Research Challenges & Solutions *(discussion leader: Jo-Ann Mellish)* 1. Controlling costs 2. Funding opportunities 3. Working with trainers and vet staff 4. Public education
Session 9	Improving Captive Research Programs – Concrete Solutions for Working Together *(discussion leader: Lorrie Rea)*
16:30	Adjournment

Appendix B: Workshop Participants

Shannon Atkinson	Alaska SeaLife Center	*Shannon.atkinson@alaskasealife.org*
Lance Barrett-Lennard	Vancouver Aquarium	*Lance.Barrett-Lennard@vanaqua.org*
Jennifer Burns	University of Alaska Anchorage	*afjmb4@uaa.alaska.edu*
Doug DeMaster	National Marine Mammal Lab	*Douglas.demaster@noaa.gov*
Andreas Fahlman	University of British Columbia	*fahlman@zoology.ubc.ca*
Chris Harvey-Clark	University of British Columbia	*chclark@interchange.ubc.ca*
Martin Haulena	Vancouver Aquarium	*Martin.Haulena@vanaqua.org*
Lisa Hoopes	University of Central Florida	*lhoopes@mail.ucf.edu*
Anne Hoover-Miller	Alaska SeaLife Center	*anneh@alaskasealife.org*
Lisa Mazzaro	Mystic Aquarium	*lmazzaro@MysticAquarium.org*
Jo-Ann Mellish	Alaska SeaLife Center	*joannm@alaskasealife.org*
Dan Odell	AMMPA	*dodell@cfl.rr.com*
Lorrie Rea	Alaska Department of Fish & Game	*lorrie_rea@fishgame.state.ak.us*
Julie Richmond	University of Connecticut	*Julie.richmond@uconn.edu*
David Rosen	University of British Columbia	*rosen@zoology.ubc.ca*
Brian Sheehan	Vancouver Aquarium	*Brian.sheehan@vanaqua.org*
Dave Thompson	Sea Mammal Research Unit	*dt2@st-and.ac.uk*
Dominic Tollit	University of British Columbia	*tollit@zoology.ubc.ca*
Andrew Trites	University of British Columbia	*trites@zoology.ubc.ca*
Bill VanBonn	John J. Shedd Aquarium	*bvanbonn@sheddaquarium.org*
Mark Xitco	U.S. Navy Marine Mammal Program	*mark.xitco@navy.mil*
Steven Zinn	University of Connecticut	*steven.zinn@uconn.edu*

Photo: Chad Nordstrom

Appendix C: Participant Presentations

Discussion Leader: D. Rosen, UBC

Presentations were made by each of the workshop delegates on a number of general and specific topics related to their interest in laboratory marine mammal science. The broad purpose was as a general introduction and to highlight common areas of interest for subsequent discussions.

First, presentations were given by a representative from each participating institution that has marine mammals available for research (both research institutions and Aquariums) to familiar attendees with available resources, general procedures for conducting research within the institution, and general scientific interests. These presentations included a summary of established research programs describing facilities, resources, and logistics within a loosely proscribed format: animal resources, resource allocation, physical layout, support staff, scientific focus and study review, experiment schedules, detailed logistics, research costs. Each presentation is briefly summarized below, with notes on any following discussions – for more details please contact the relevant facility directly.

This was followed by presentations from individual researchers that utilize marine mammals as visiting scientists at other institutions. These presentations gave a general summary of the types of studies they undertake with captive marine mammals, and how they relate to broader research objectives.

Research Laboratory Presentations

A. Shannon Atkinson – Alaska SeaLife Centre (www.alaskasealife.org)

- Animal resources: Steller sea lions (3 permanent residents, up to 30/year transients), Harbour seals (6 permanent residents, 3 display only), plus several species through rehab program
- Permanent residents are completely available for research (display is "incidental to research" as per MMPA permit)
- Rehabilitating animals may be available for limited research.
- Specialized Facilities: Steller sea lion lab (nutrition analyses), Harbor Seal Lab (some PCR work), Clinical Lab (blood chemistry and hematology), Endocrine Lab (UAF Recharge Center), Tissue Storage
- In addition to main research holding areas and pools, there is a high quarantine facility for Transient Juvenile Program (completely self-contained, including surgery), and rehabilitation facilities
- Scientific focus: High trophic levels, Declining/threatened/endangered species (Primarily GOA, Alaska waters, North Pacific)
- Funding Cycles – largely annual federal appropriations
- In-house directed research program
- Marine mammal subcommittee works with scientists to accommodate needs and maximize use of resources (animals, facilities, etc) while monitoring cumulative impacts
- Program Managers: Don Calkins, SSL and NFS, Anne Hoover-Miller, Harbor seal
- Contact for transient program: Dr. Jo-Anne Mellish
- Transient program: temporarily hold wild juvenile Steller sea lions for short-term research (up to 6 per group; 1-4 yrs old)

B. Lisa Mazzaro – Assist. Dir. Research & Animal Care, Mystic Aquarium (www.mysticaquarium.org)

- Aquarium dedicated to research and education since doors opened in 1973
- Formed a dedicated Research Department under direction of David St. Aubin in 1990
- Department has grown over the past 3 years under Dr. Tracy Romano
- Future goals: continue to increase scientific collaborations
- Facility has 7 northern fur seals, 6 Steller sea lions, and 3 each California sea lions, harbor seals, beluga whales (actual on-site numbers may be slightly different due to breeding programs/exchanges)
- Management plan to increase numbers through/for breeding
- Beluga voluntary husbandry behaviours: Blood collection, Ultrasound, Urine collection (females), Semen collection (in progress), Endoscopy, Gastric samples, Saliva collection, Cultures (blowhole, anal, vaginal), Morphometrics (girth), Match to sample (in progress)
- Pinniped voluntary husbandry behaviours: blood collection, cage training, shifting off exhibit, weights, injections, ultrasound, saliva collection, tooth brushing, semen collection, intraocular pressure measurement (in progress)
- Note: not every pinniped is trained for each behavior. All behavioral work is in progress
- Also ~35-40 animals brought into facility through stranding network
- All marine mammals primarily for public display, with opportunities for research (availability often seasonal)
- Vet support includes surgery, radiographs (semi-portable), and portable endoscope and ultrasound
- Other facilities: research labs, tissue storage, necropsy room
- Fee based lab diagnostic/research capabilities include aspects of neuromimmunology, Brucella, nutrition
- Research and Veterinary Science Mission: To conduct high quality research designed to broaden our understanding of the health challenges impacting aquatic species worldwide
- Integrative Research Program in Aquatic Animal Health: examples of current projects include Health & Risk Assessment of Bottlenose Dolphin Populations, Development of Fish Substitute (w Mazuri) including nutritional trials with belugas, marine Brucella project, Beluga artificial insemination,
- Other research activities include outreach and education,

incl "Researcher for a Day" program
- External Contact: Gayle Sirpenski - Animal Management Specialist
- 860-572-5955 ext. 108, *gsirpenski@mysticaquarium.org*
- Forms can be requested from Gayle and will soon be available on website
- Research Requests and Review Process: Internal Animal Care and Use Committee
  - o Meets twice per year (Jan/Feb & July/Aug)
  - o Can review requests via email at any time
  - o Led by Tracy Romano
- Future plans for a Research & Education Center

C. Dave Thompson, Sea Mammal Research Unit (www.smru.st-and.ac.uk)

- Resources: Grey and harbour seals; licensed to hold up to six seals at any one time.
- Animals are all wild caught and held temporarily captive; maximum captivity of 13 months.
- Species choice is result of the research program on which the SMRU's Home Office Project License (Animals (Scientific Procedures) Act 1986) is based
- The licence covers all animal experimentation carried out by SMRU staff and students.
- Future plans to maintain other species could easily be included as project modifications, but would require application to the Home Office for licence modifications
- The facility is housed in the Sea Mammal Research Unit, at the Gatty Marine Lab, University of St Andrews: main foraging/respirometry pool; small circular pool, isolation pool, feeding pool
- Main pool designed for 160m swims, respirometry dome, feeding devices
- Support staff: one full-time and two part-time animal technicians.
- SMRU has a single five-year licence for all animal work involving seals
- There are several layers to allocation of animal and pool time.
- Main focus is foraging and energetics of UK seals in support of our core/strategic research, funded by UK NERC;
- Includes: Energetics; Foraging behaviour; Diving physiology; Diet; Acoustic disturbance; toxicology; Telemetry
- Application procedure for researchers (internal and external)
  - o Internal - through PUG and consultation with licence holders and NACWO.
  - o External - usually through direct contact with research group members and then same as above.
- Follow-up discussion:
- Not sure if display animals can be used for research, but all animals caught for research can not be used for display
- Group discusses projects in October/November during facility shut down
- Also discussion on i) How strict is "not for public display" rule, and ii) cleaning schedule of pools

D. David Rosen – University of British Columbia (www.marinemammal.org)

- Animals: 11 female Steller sea lions from 3-9 yrs old, and one 13 yr old male
- Permits in place to acquire 6 northern fur seal pups
- All animals for research purposes, but also used for display & education as time allows; usually kept in back research area, with some in public display area
- General study areas: basic physiology, bioenergetics, nutrition, dietary validation, ground truthing techniques and technologies (see also Fahlman presentation on Open Water facility)
- Most research directed at species conservation and recovery
- Most research via Consortium-funded proposals, but also supplementary and solicited research projects
- Proposal process starts in November, initial research schedule set in spring, but requests for other studies (incl supplemental sampling) can be made any time
- Contacts are Dave Rosen (*rosen@zoology.ubc.ca*) and Andrew Trites (*trites@zoology.ubc.ca*)
- Several layers of review each for scientific, husbandry, training, and animal care input
- Basic husbandry costs covered – funds needed for any 'additional' costs
- Additional facilities include metabolic equipment and chambers, xray, ultrasound, swim flume w temperature control
- Research staff through UBC, training and vet staff contracted through Aquarium

E. Andreas Fahlman – University of British Columbia (www.marinemammal.org/research/openwater/index.php)

- Special project facility: Open Water Research Station
- Uses trained sea lions (3) in open water environment
- Main research focuses are cost of diving, foraging decisions, technology development – links between physiology and behaviour
- Facility at local marina consists of animal pen, animal transport boat, research boat, floating respirometry platform, and laboratory/office
- Recent research involves animals diving to set depth (up to 50m) to feeding tubes – measure oxygen consumption, dive patterns, effect of 'patch quality'

F. Brian Sheehan – Vancouver Aquarium (www.vanaqua.org)

- Animal resources: Belugas 1.3, Pacific White-Sided Dolphin 1.3, Steller Sea Lion 1.11, Northern Sea Otter 2.2, Harbour Seals 3.0
- A Not for profit facility; 16% of Aquariums' annual budget is dedicated to research
- Several display pools, as well as dedicated (off-display) research area (primarily UBC's Steller sea lion research)
- Study review: Aquarium falls under the auspices of the Canadian Council for Animal Care (CCAC)
- Aquarium has two committees that follow a process of

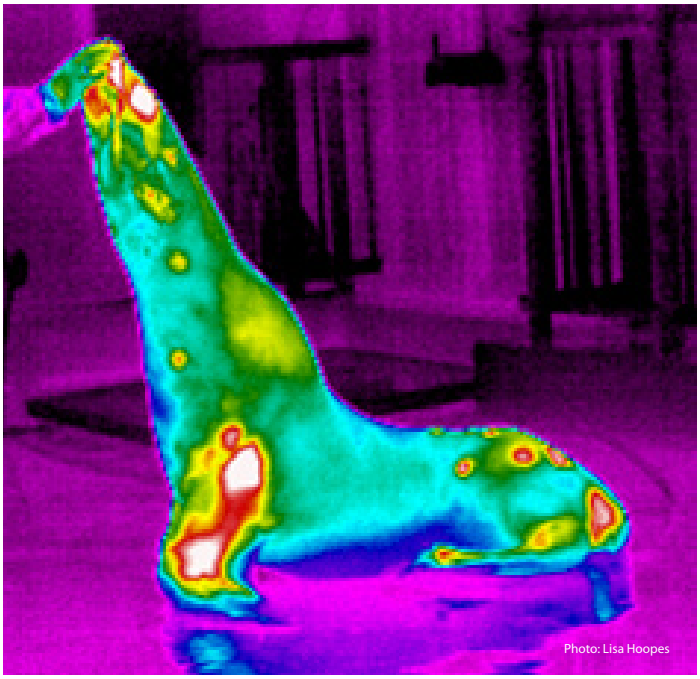
evaluation for each research project that is presented: Research Committee (RC) and the Animal Care Committee (ACC)
- One-off projects can often be worked around a flexible schedule
- Training shows in the off season facilitate the process of research
- Skillful interpretation can result in a positive reaction from our visitors- seeing research in action
- Other research can be successfully accomplished during regular training sessions
- Hard research costs are carried by the researcher
- Trainer time is not charged for nor (for the most part) are bench fees
- Hard materials/construction of any equipment is billed to the researcher
- Administrative costs are normally waived
- Research involving marine mammals has taken place at the Vancouver Aquarium since its beginning- from the arrival of the first killer whale to large scale projects such as the Steller project and it will continue
- Examples: Audiograms/Social interactions of belugas, beluga flipper bands/hearing studies/seal deterrents/ hormonal fecal studies/reproductive studies/beluga heart rate study/manatee deterrents from locks/tagged on husbandry- blood level/hormonal studies

G. Bill VanBonn, Senior Director, Animal Health Dept., John G. Shedd Aquarium (www.sheddaquarium.org)

- Animal Resources: White whales (7), Pacific white-side dolphins (4), California sea lions (3), Alaskan sea otters (5)
- Resource allocation: All animals are display animals
- Dolphins & sea lions participate in shows
- All other current learned behaviors are scheduled during sessions
- Several are on loan
- Interactive Oceanarium project focused on times other than scheduled sessions
- Other physical facilities: Fully equipped medical and surgical facilities on-site, environmental quality facilities on site, microbiology facilities on site, Gross dissection, histopathology, and molecular diagnostics via UIUC ZPP, R/V Coral Reef II, Miami
- Scientific focus
- Externally Engendered: Biosamples on request- immunology, toxicology, microbe surveillance; bioacoustics
- Internally Engendered: Advanced reproductive technologies; preventive medicine (erysipelas prevention); defining a healthy environment (hygiene hypothesis, molecular microbial ecology, Interactive Oceanarium)
- Hygiene hypothesis: refers to a human medical concept with growing support and that we are interested in understanding much more about the microbial ecology of managed aquarium systems; how they compare to natural systems, and how the differences may impact animal health. Managed aquaria place large selection pressures on aquatic microbes with oxidants to meet regulatory standards and strive for clarity in the water column. The resulting microbial community in the water column may be very, very different than that which these animals have evolved to live in, perhaps resulting in clinical conditions.
- A not-for-profit facility and Animal Health Department budget line restricted to Internally Engendered efforts to improve animal health and well-being
- Research includes opportunistic biosample collection and robust health surveillance program
- Follow-up discussion:
- Virtual tours and pictures at *www.sheddaquarium.org.*
- Remember other animals at aquariums besides marine mammals that are available for research
- University of Illinois at Urbana-Champaign Veterinary College provides board-certified veterinarians for necropsies, histologies, etc.
- R/V Coral Reef II, Miami – can be used as a research platform, and is available for use – schedule upon request. Currently used to perform undergraduate/graduate classes.
- Hygiene hypothesis – is cleaning the tank actually better for the animal?
- No longer have small granting program, but the possibility exists to initiate it again if there was funding available

H. Mark Xitco, US Navy Marine Mammal Program (www.spawar.navy.mil/sandiego/technology/mammals/)

- Space and Naval Warfare Systems Center, San Diego, Biosciences Division
- Lead laboratory for the U.S. Navy Marine Mammal Program
- 100+ marine mammals: Bottlenose dolphins, California sea lions, White whale
- All mammals are Fleet assets: No dedicated research animals; all animals may participate in research on a not-to-interfere basis
- Laboratories & Facilities: Veterinary Procedure / Surgical Lab; Clinical Pathology Laboratory; Open-ocean ranges; Open-ocean test facilities; Controlled Acoustic Animal Test Lab; Climate-Controlled Animal Test Lab
- Staff: Navy civilians & contractors (Engineers, Scientists, Technicians, Trainers, Vets), US Army Vet Corps, 4 post docs, 50 interns
- Navy Research Needs categorized into Marine Mammal Systems, Enabling Research, Marine Mammal Clinical Research, Effects of sonar/impulsive sound sources on marine mammals
- Research POC: *mark.xitco@navy.mil* or Veterinary research POC: *stephanie.wong@navy.mil*
- Not a funding agency; research must be aligned with Strategic Plan



Independent Researcher Presentations

A. Lisa Hoopes, University of Central Florida (http://biology.ucf.edu/~gworthy/PEBL/)

- Gave presentation on PEBL's (Physiological Ecology and Bioenergetics Lab) research
- Graham Worthy, Director of Lab also holds Chair for Hubbs-SeaWorld Research Institute
- Major research goals: Investigate the physiological ecology of marine vertebrates by studying their energetics, growth, reproduction, water balance, and feeding habits
- Integrate laboratory and field-based studies to better understand the capabilities of different species to withstand normal seasonal variation in their environment
- Work with a variety of wild and captive marine mammals, including California and Steller sea lions, manatees, and dolphins
- Specialized equipment includes thermal imager, portable ultrasound, and portable metabolic/thermal lab trailer

B. David Thompson, SMRU (www.smru.st-and.ac.uk)

- Gave presentation on results of studies testing accuracy of doubly labelled water vs respirometry methods to predict energy expenditure
- Also measured heart rate, activity and stomach temperature
- Also collected data on changes in metabolism associated with delays in digestion (separate from foraging)
- Tank setup at SMRU also ideal for measuring effect of foraging effort on dive characteristics
- Investigating uses of accelerometers to measure energy expenditure (flipper stroke) and intake (food capture)
- Another set of tanks are used for digestion studies (calibrations and validations of different techniques)

C. Julie Richmond, University of Connecticut (www.canr.uconn.edu/ansci/faculty/saz.htm)

- Main interaction with captive marine mammal science is in development of a model to assess nutritional status in free-ranging pinniped populations
- Specifically changes in somatotropic axis (growth hormones)
- Captive research with harbour seals and Steller sea lions looks at aspects of development and nutrition
- Utilized long-term residents and rehab animals in studies
- Discussion: Metabolic hormone levels – are they affected by stress/activity?

Appendix D: Difficulties and Solutions with Captive Marine Mammal Science

The participants broke into three working groups to identify, discuss, and come up with possible solutions to what they identify as the major difficulties in undertaking science with captive marine mammals (moderated by Dominic Tollit).

Each group was deliberately made up of people with a similar working perspective, and they were requested to address the exercise specifically with those specialized viewpoints. After each group presented and explained their list of issues, a general discussion took place. The specific questions put to the groups were:

1) What are the major logistical problems with conducting research with captive marine mammals, and
2) How can they be resolved?

Each group was directed to generate a list of the "top six problems" and potential solutions. Despite their disparate perspectives, there were several common areas of concern. These included (in)sufficient sample size, utility of captive animals as models for wild counterparts, and funding. There was also a common thread (from different perspectives) of appropriate communication between various components of researcher and husbandry/training staff.

Common solutions were also found. These included greater communication within the research community to maximize success of research projects. This should take the form of greater pre-experimental communication to maximize the data available from planned manipulations of study animals (layering projects), and more consultations to ensure that research is designed to maximize its credibility within the broader scientific community (specifically, applicability to wild animals). Appropriate experimental designs can also alleviate the concerns of small sample sizes.

There was also a recognized need for standardization of common procedures, which would facilitate data collection within a study (including easier review by appropriate Animal Care oversight) and for appropriate comparisons between studies. There was a need for regular organizational meetings (perhaps at biennial Biology of Marine Mammal conferences) that would permit greater cooperation between researchers (including maximizing data collection from planned manipulations) and promote the concept of marine mammals in the lab as a valuable, relevant scientific resource. These meetings would also be open to people associated with management and animal care sectors to foster a greater climate of cooperation with researchers.

The need for greater communication outside of the scientific community was also highlighted on several levels, including dialogue between scientists and facility support staff and the 'education of educators'.

Group Summaries – Difficulties and Solutions

Group 1: Researchers Without Direct Animal Resources

(Hoopes, DeMaster, Zinn, Richmond, Rea, Burns, Tollit)

1. Access to animals and giving/getting input prior to experiments (at least one year, pending funding)
   - Joint web listing to list potential projects – allows possibility to piggyback studies. Discussion regarding security of posting ideas in public forum
   - Alliance of Marine Mammal Parks and Aquariums – releases research briefing book listing all member facilities, projects (both ongoing and completed), and PIs
   - Formal yearly/biyearly meeting (such as at SMM) – specifically for lab coordination

2. Small Sample Size
   - Justification of using a low *n*
   - Need to have good experimental design and statistical justification
   - Proactively word proposals and grants to justify
   - Multiple institution access to increase sample numbers

3. Use of captive animals as good models for interpretation in the wild
   - Focus on keeping research realistic to available number of animals and proper questions for number of animals available
   - Publish basic studies using captive animals so they can be cited

4. Convincing facilities/training staff/administration to try new techniques (ie. fasting, biopsies)
   - Pre-experimental dialogues with trainers, support staff, and vets on value of technology, safety, and reasons why necessary
   - On-site presentation, collaborate with facility staff and vets when designing experiments
   - Two-way communication between staff and researchers

5. Funding cycles and their unpredictability
   - Annual funding detrimental to graduate studies
   - Create multi-year grants and projects
   - Also create more funding opportunities through year, instead of looking at grants only once yearly

6. Difficulties in relating applicability of captive research to public/recovery plans/agencies (Translating research goals to the public)
   - Emphasize captive work as a good model for answering fundamental questions
   - Publish captive research in higher profile journals (ie. *Science*, *Nature*)
   - Make sure studies relevant to conservation

Group 2: Researchers & Facilities with Research Animals

(Thompson, Rosen, Atkinson, Fahlman, Trites, Mellish, Hoover-Miller, Xitco)

1. Permits
   - Procedure is lengthy, cumbersome process
   - Coordinate IACUCs and streamline NMFS review
   - Alliance has permits for moving samples between facilities
2. Duplicate IACUCs
   - Make reciprocity more usual, particularly between frequently interacting facilities
   - Precedents – when one IACUC has been approved, advertise it
   - Idea of library of Standard Operating Procedures that can be accessed internally and externally (even for publications?)
3. Long-Term Funding
   - Get some – will give stability to program
   - Linkages with aquaria – difficult to 'go it alone'
4. Expense
5. Geriatric Animals
   - Aging – need to introduce new genetic makeup
   - Replacement of study animals
   - Short term captivity – idea has own set of drawbacks
6. Sample Size
   - Number of animals and capacity of facility
   - Bring in more animals from wild or other facilities
   - Short-term captivity
   - Co-ordination between institutions (including moving animals on temporary basis)

Group 3: Aquarium Personnel

(VanBonn, McBain, Mazzaro, Barrett-Lennard, Odell, Sheehan, Haulena)

1. Conflict with programming at public display facilities – time management of animals and staff
   - Make sampling part of display/show
   - Discuss value of work – have researcher front interpretation
   - Institutional buy-in – include curatorial staff in early stages of project
2. Communication
   - Expectations of researchers need to be communicated up front (no surprises on 'extra' requirements)
   - Use the Alliance as a window to determine costs and all data needed in advance for proper coordination
3. Permitting
   - Sharing materials, piggybacking on permits, shared permits
4. Costs
   - Piggybacking, sharing costs, resources, and facilities
5. Sustainability
   - Perception of negative impact of research on these animals
   - Most animals are housed under display permits – if breeding is unsuccessful, there will soon be none available due to public outcry regarding collections
   - Maintain populations with advanced reproductive techniques such as artificial insemination
   - Education and outreach to understand need for collections and use of collections for ultimate goal of research
6. Aquarium Born
   - Behaviour and physiology of aquarium-born animals are intrinsically different but can still act as a model for wild animals

Additional Comments from Working Group Discussions

Coordinating Research Programs

- Discussed necessity of good record-keeping of captive animals to make it easier for researchers to request information
- Possible resource for research – old records from aquaria
- Discussed library of Standard Operating Procedures for common procedures to standardize and make it easier to pass IACUCs

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