

EARTHWATCH INSTITUTE ANNUAL FIELD REPORT

Date completed: July 12th, 2009

Completed by: William Megill

Period covered by this report: May 2007 to June 2009

Project title: Whales of British Columbia

Dear volunteers,

As I write this, we are gearing up for our 16th season (11th with Earthwatch) studying grey whales off the coast of British Columbia. Our technicians Rob and Rianna are in Port Hardy with Krystal, cleaning the winter's 'memories' out of the Stardust, preparing her for the ride south to our new home in Ahousat, near Tofino, on the west coast of Vancouver Island. I'm off in a few days to Canada, arriving just in time to meet the first crew of new volunteers, for another summer of grey whales, mysids and mischief...

The document you are reading is a quick progress report on what we've been up to the last two years. Its intent is to 'close the loop' for you, to put the work you did (or may be thinking of doing with/for us in the field) into context. There's a lot going on at the field station, and on the boats, and I know it can sometimes be hard to imagine how your little contribution makes any real difference. Believe me though, it does. In the rest of this document, and others that will follow it over the years to come, I hope you will see how our research is coming together, and how your contribution to that research, whether it was spotting whales and taking notes for a photographer, hauling a kayak, hydrophone and camera through a kelp bed, or sifting invertebrates out of a net full of shells, is helping to inform and shape grey whale conservation plans throughout the Pacific Northwest and Baja California.

The last two years have been the tail end of a fairly adventurous roller-coaster ride for us at Cape Caution. After several years of bumper crops, as it were, suddenly in 05-06, we went through an emotional wringer, wondering whether the whales would ever come back. It was pretty clear why they'd left: the mysids were gone. Simple as that. Apparently they'd eaten them all. Then in 2007, the mysids started to reappear, and by the end of the season, the whales had started to figure it out. But it was in 2008 that things really came back to 'normal' – the mysids were back in force, with *Holmsimysis sculpta* taking its usual place as the most abundant mysid species, the whales were resident again for extended periods, and it all seemed quite normal again. That is, until the herd arrived, and demolished all the mysids...

We're moving now to a new area, to Clayoquot Sound on the south west coast of Vancouver Island, to join forces with the University of Victoria's Whale Lab, but we'll keep going back to Cape Caution every few weeks to keep an eye on what 'our' whales are up to.

Thank you everyone for all your help over the years. We simply couldn't have done it without you. And to those who are yet to join us, thanks for your interest, and we'll look forward to meeting you someday soon!

Yours,



William Megill, PhD

PI, Whales of British Columbia

Director, Ocean Technologies Lab, University of Bath

Reporting on research objectives

Objective 1: Map the various habitat types which are present in the study area

Preliminary data has been collected using diver observations and an underwater camera lowered off the bow of the research vessel while it drifted. Focus has initially been placed on kelp beds and their immediate surroundings, though we have made a few recordings in two areas outside kelp beds, one in Burnett Bay, and the other in Gwalgwalis. We have not yet begun to analyse these data nor to collate them into a map layer. The plan is to sample the environment more systematically during transects of the Cape Caution study area in 2009, and to develop a coordinated approach with the team from University of Victoria (UVic) to habitat mapping in the Clayoquot Sound study area.

Objective 2: Determine what use whales are making of the habitat

A sizeable database has now been collected of whale sightings throughout the Cape Caution study area, both during years of abundant mysid swarms and in years when mysids were scarce. In low abundance years, the whales tend to concentrate their activities in fewer, more spread out areas, while in high mysid abundance years, they seem to spread out over the whole of the study area. The important feeding areas were fairly constantly used throughout the study period, though there does seem to have been a shift away from North Bay in the latter years of the study. The geography is also only part of the story – the whales' use of the habitat in time is also important. In abundant mysid years, we see three distinct types of residence patterns: about a third of the animals seen during the summer are seen throughout, with residence times greater than four weeks, another third are more transient, remaining in the area for a week or so, and the final third show up only for a day and disappear. In mysid-sparse years, we don't see very many residents, and in the really bad years, all of the whales that did show, only stayed for a few hours. Analysis of the data is ongoing – our joining forces with the UVic group, who have extensive experience in GIS analysis, will be key to completing this objective.

Objective 3: Determine what grey whales eat

We have now conclusively demonstrated that grey whales in the Cape Caution area are feeding primarily, if not exclusively, on the extensive mysid swarms that collect in and around the kelp beds there. Occasional faecal samples have continued to contain parts of mysid carapaces, and whenever our divers have gone into areas where grey whales have been seen feeding (repeatedly surfacing in the same place, making tight circles and diving again in the same location as they surfaced, twisting & turning at the surface, etc.), they have inevitably found large swarms of mysids. Even in a deep water site, more than a mile from the nearest kelp bed, the divers found an extensive swarm of mysids in and among the rocks. What was interesting is that there were also apparent feeding pits in the sand between the rocks, suggesting that the whales are feeding on mysids in this environment in a manner identical to the way they feed on amphipods further north, namely by rolling on their sides, and vacuuming up the epibenthic mysids along with the sand and everything else.

The species composition of the mysids in the Cape Caution area was the focus in 2007 of an MSc thesis by Jacqueline Maud, and of follow-up research she did in the summer of 2008. This followed on from an initial study done by Lei Lani Stelle in 98-01. The species diversity was higher in 2008 than it had been in 2007, and the species composition was similar to the earlier 98-01 surveys. The dominant species in most years was *Holmesimysis sculpta*, but in

2007, during the 'mysid crisis', the dominant species was *Acanthomysis columbiae*. The species composition at Cape Caution is very different from Clayoquot Sound, where the dominant is *Neomysis rayi*, a species that is only occasionally encountered in the northern waters. Analysis is ongoing, particularly to try and understand the different habitat requirements of the different species, and why the dominance is different in the two areas.

Objective 4: Determine abundance of prey resources

This work was started in the 98-01 seasons, then put on hold for a few years, and restarted in 2005. Equipment failures and personnel changes dogged the project in 05 and 06, so it didn't really restart until 2007, when Jacqueline Maud took it on for MSc. Abundance was measured in the early years using a diver-operated still camera to measure the density, and swarm size was measured in diver body lengths. No attempt was made to measure the distribution of mysid swarms outside the focal kelp beds. In the later work, mysid distribution was measured using a video camera lowered from a drifting boat, and density was measured using a diver operated video camera, tethered to the boat in 2007, and cable-free in 2008. The results of the study so far are that mysids appear to be cycling in abundance in the Cape Caution area – they were obviously present in the years leading up to 2004, completely absent in 2005-6, concentrated in pockets in 2007, and generally present throughout the study area in 2008. During 2008, the highly abundant swarms were all but wiped out by intensive whale predation over the summer.

Objective 5: Determine how much time grey whales spend feeding

This objective has been achieved for 'normal' years. A paper (Stelle et al 2008) has been published which highlights the different amounts of time grey whales spend in feeding, foraging, and travelling modes, during years when both mysids and whales were reasonably abundant in the study area.

The amount of time whales were seen feeding rose quite significantly during the rich years of 2003-4 and dropped with a crash in the poor years of 2005-7, before beginning to rise again in 2008. Observations by divers seem to confirm that the change in feeding observations is closely linked to the presence or absence of extensive mysid swarms. When there are no mysids, it is no surprise that the whales keep moving, and that they stop to feed where there are dense swarms.

There appears to be some cycling happening – the period appears to be about 8 years. Analysis is still ongoing, but some initial results were presented in Maud & Megill (2009). One interesting observation made serendipitously in 2008 is that the whales are capable of locally extirpating their prey – the difference was stark on two scuba dives separated by three days on the same reef: on the first dive, (and on every prior dive), there were extensive, dense swarms of mysids; on the second, after a herd of about a dozen whales had been present for three days, there was nothing left – not one mysid to be found anywhere on the reef. Although obviously based on a very small sample size, the conclusion we draw is that the whales are not foraging optimally, but rather feeding until there's nothing left. Whether this is their natural behaviour, or a consequence of the disappearance of more traditional, higher caloric quality feeding areas further north, can not be said for certain, but if it continues, may have quite significant implications for the survival of mysids in many areas of the BC coast.

Objective 6: Determine what the energetic value is of prey to a grey whale

Work has not yet commenced on this objective. The bomb calorimeter we thought we had access to, has not materialised yet. It is also difficult to conserve the samples sufficiently well

to make measurement realistic. We are looking for a practical solution, and if one can be found, we will get started on this objective this summer.

Objective 7: Determine energetic cost of being a grey whale

This objective is in two parts. The first was to calculate the metabolic cost of being a grey whale from the blow rates observed at the surface. We have an extensive database of blow rates in several behaviour categories, which we will use as input data to models proposed in the literature to calculate the metabolic rate.

The second sub-objective was to develop a heart rate tag for deployment on wild grey whales. We had intended to build the tag early in this reporting period, but the student we had lined up to do the work decided on a different project, and the studentship dried up. We still intend to have a go, however, and are on the lookout for the right student to take on this project.

The first half of this objective is complete, except for the arithmetic. The second half has not commenced. Its start date will depend on an appropriate student and studentship becoming available, so probably not until October 2010.

Objective 8: Determine energetic cost of foraging

We now have data on the underwater behaviour of grey whales on their foraging grounds. This was collected as part of Becky Woodward's PhD thesis, which was completed in 2006. She published two articles based on the work, one in Marine Mammal Science in 2006, and the second in the Journal of Morphology, also in 2006.

We also have data on the underwater behaviour of greys on their wintering grounds. This was work conducted by Bernardo Garcia Carreras for his MPhil at the University of Bath, which he completed in 2008. He used a multibeam sonar to track the whales' movements underwater, finding that they swim complicated paths underwater, turning, twisting, and rolling, before surfacing to breathe – i.e. they do much more swimming than we would otherwise infer from the surface. He also found that they do a lot of sleeping on the bottom, again not something we were expecting to see.

Bernardo also dug through the literature, and made some observations on the scaling of cetacean morphology and performance with size. We will be revisiting his models, and his and Becky's data, to calculate a cost of foraging for our whales, which we will compare to the metabolic rates calculated from the breathing cycles. We plan to begin this work in the autumn.

Objective 9: Determine how grey whales find their prey

(This objective has been the focus of a PhD at the University of Bath by Jennifer Wladichuk. The fieldwork component of the research is now complete, and Jennifer is part way through the writing up. She hopes to submit sometime in the early autumn.)

It is obvious for any observer of grey whales on their feeding grounds that they 'know' where to find their prey. It is also obvious to any diver that they can not be using vision to find their way around. Visibility in the coastal North Pacific during the summer months is limited to 60' at most, and usually a lot less than that. It is often said that grey whales are 'visual' predators. This is potentially true for their small scale hunting, when they are tracking the extent of very large mysid swarms in and around a kelp bed or rock outcropping. However, the 'visual' predator explanation doesn't explain how they are able to find their way in a bee-

line from one kelp bed to the next, nor indeed, how they are able to hunt at night, or in the zero visibility which is often present after rainstorms.

All of that implies that there must be another sensory system involved, and the obvious candidate is acoustics. The conventional wisdom is that baleen whales do not echolocate, though there is some controversy around the subject. However, regardless of whether they do or not, there is plenty of information available to them in their acoustic environment. The sounds created by sources such as crashing waves, shifting substrate, currents, and many biological organisms, provide, thanks to their being scattered, absorbed and reflected by structures in the water column, a sort of 'acoustic daylight' akin to the scattered light we are used to in the visual world. Given that this sound field exists and that there is plenty of information in it, it stands to reason that the whales will have figured out how to make use of it.

The first step in working out how the animals might be doing this, is to map out the soundscape in the environment. The second step is to identify what features of the quality (frequency content) of the sound can be used to identify gross habitat type. Then the next step is to reduce the scale further and identify the local sources and sinks. And finally, the last step is to quantify the effect of absorption, scattering and reflection by structures in the water column, in our case, particularly kelp beds, which we know harbour mysid swarms, to see if there is some kind of signature that the whales might be using to navigate.

Recordings were made using a Cetacean Research hydrophone and a Zoom H2 MP3 recorder. Recordings were made at 44kHz (CD quality), usually by suspending the hydrophone from a sea kayak in reasonably calm weather. In areas further away from the research base at Skull Cove, the recordings were made either from the deck of the research vessel Stardust, or from her dinghy if the sea state was such that the slopping of surface waves on the hull dominated the recording). Toward the end of the summer of 2008, recordings were also made using a remote hydrophone anchored on the sea floor and left overnight.

Acoustic environments which were recorded included open water (defined as half a mile from the nearest shore, and >60' deep), a rocky bay, a sandy bay, a gravel bay, and deep water fjords. The frequency content of each of these environments is very obviously different. Surface generated noise such as waves and rain is also very obvious.

Kelp beds appear to structure the soundscape quite significantly. Initial results suggested that they might be acting as a band-block filter, creating an acoustic shadow in the 4kHz range. The excitement about this result died down a bit as more data came in, but the result remains that there is a real effect of the presence of a kelp bed on the sound quality (frequency content) which is transmitted through the kelp bed. Analysis and modeling continue, and should be completed by the end of the summer.

Objective 10: Determine how many whales there are

This is the longest running component of our research. Over the years we have photo-identified 126 individual grey whales in the waters near Cape Caution. About a third of these whales have been seen regularly, another third occasionally, and the final third only once. In any given year, the number of individuals sighted varies quite a bit, and appears to cycle with an approximately 8 year period. The largest number of whales identified in one summer was 91 in 2004, and the least was 5 in 2005. In the last few years, we have begun to see new calves, on average one a year. Our photographs have been integrated into the master catalogue maintained by the Cascadia Research Collective – most of our whales have been seen in other areas of the Pacific Northwest, including 5 which were photo-identified in 2005 off Kodiak Island, in Alaska, over a thousand miles away!

Project development

Our original objectives included much work at the Mexican end of the migration. Our focus there was on whether whales spend much time feeding there, and if so, on what they might be eating while they were there. Our hypothesis was that the grey whale migration is driven, as most other animal migrations are, by the seasonal variance in the availability of food. We spent several seasons recording whale behaviour in one of the so-called breeding lagoons, and observed obvious feeding behaviour on many occasions. Investigation of the potential prey in the areas where the whales had been seen feeding did not however turn up any dense assemblages of nutrient rich invertebrates. It may have been that our sampler was unable to penetrate the substrate to the same extent as a grey whale, or it may be that the whales were simply testing themselves to see if there was anything worth eating.

Either way, the relative paucity of observations of feeding behaviour, coupled with our inability to find dense food resources, convinced us that we were looking in the wrong place. If whales are indeed feeding in Mexico, they're more likely doing it out in the open ocean, where most of them spend most of their time (photo-identification results show that, other than mothers and calves, most animals do not spend extended periods in the lagoons). The logistics of working in open water are complicated (and expensive), so we switched tacks, and turned to a species which does rely on, and likely impacts, the benthic biodiversity of the lagoon, namely the black sea turtle, *Chelonia mydas*. Results of that study are reported elsewhere (Earthwatch project *Tracking Baja's Black Sea Turtles*).

As we move our primary area of operation to Clayoquot Sound, we don't envisage much change to the wording of the objectives, but the geography will now be completely different. We will also be working with a completely new sightings database, though many of the same individual whales use both areas. We will also be looking to continue our coverage of the old study area, though obviously in a less intense way.

What logistical or scientific challenges have you encountered in the past season and how will you address these during the next field season?

The biggest logistical and scientific challenge we're now going to face is the move to a new study area, and the merging of two established research teams, each with their own view on how to run the show. We're all planning to take this summer fairly easy – not to say we won't be focused on achieving research results, but there will be a season of flux while we all get a feel for the place and each other, and work out how best to work in the new circumstances.

Non-technical summary of results

It's taken a while, but I think we're finally getting there.

The last few years have been exciting ones for those of us studying the feeding ecology of grey whales on the coast of British Columbia. It's been a bit of a roller-coaster ride, as many of the volunteers who've lived through it with us can attest. For a while there, we were all left wondering whether the greys would ever return, and some volunteers in 05-06 must have wondered why we ever thought grey whales would make a good Earthwatch project at all.

After watching the numbers of whales at Cape Caution grow steadily year on year from 1998 to 2004, we were caught by surprise when in 2005 they disappeared altogether, and stayed pretty much gone through the summers of 2006 and 2007. It was a relief to see the numbers return in 2008 to levels which at least registered on the scale.

What we think is happening is that the whales and their prey are going through classical predator-prey cycling. This is a well-known phenomenon in terrestrial systems, but it's not often been seen in oceanic ones. Grey whales are voracious predators who vacuum up whole swarms of mysids, and are, as we discovered in 2008, capable of completely depleting a 2 square mile bay of its extensive so-dense-you-can't-see-through-them mysid swarms in the short space of three days. We still don't know much about the mysids, but we do know that they are not particularly good at recolonising, so it can take a while for them to recover.

The extraordinary number of whales that visited the Cape Caution area in 2004 (there were just shy of 100 in total, and on any given day, we might photograph 30-40 different individuals) seem to have essentially wiped out the mysid stock, and it's taken four years for it to come back abundant enough that the whales can once again make a living feeding on it.

We've seen this happen once before, or rather, we caught the tail-end of it. From 1994, when we first started our work at Cape Caution, until 1997, then numbers of whales we identified increased continuously. Then, in 1998, there was a sharp drop in sightings, and the average residence time also dropped significantly. Then, as now, there was a period of depressed whale abundance which lasted about three years, and then the whales started coming back.

It will be interesting to see how the numbers vary over the coming years. If it is truly predator-prey cycling, then we should expect to find ever increasing numbers of whales for another 3 or 4 years, and then another crash.

Alongside this feeding ecology research, we've also been looking at how whales find their way around. Jennifer Wladichuk is now writing up her PhD thesis on the whales' use of acoustic daylight, and specifically on how kelp beds modify the quality of the sound transmitted through them. She's found, by experiment and by numerical modelling, that the kelp beds absorb some frequencies more readily than others. She's still working on why that should be so, but it looks like the air-filled cores of the kelp stipes act as scatterers, and disperse some frequencies, much like a dense hedge masks the noise of a highway behind it. It stands to reason that if we can detect these frequency shifts, that the whales, who make a living out of hunting for mysids in kelp beds, would also be able to use them to navigate their way from food patch to food patch.

How do these data contribute to achieving conservation impacts? (e.g. actions based on results, management plans, site protection)

The grey whale is a conservation story in its own right. The Eastern North Pacific stock was hunted nearly to extinction in the early part of the 20th century. Thanks to a moratorium which came into force in the 1940s, the species has been able to make a recovery. They were declared recovered, and removed from the endangered species list, in 1993, when it was estimated that their numbers had returned to pre-whaling levels. The celebration was short-lived, however, and by the turn of the millenium, their numbers were dropping, and they were right back on the list of species of special concern. Nobody wants to relist them as endangered, but if the ecological changes keep happening the way they are in the North Pacific, then that might be inevitable.

Our observations are providing important information to the agencies responsible for developing the management plans for the grey whale, namely the US National Marine Fisheries Service (NMFS), and Fisheries and Oceans Canada. We are working particularly closely with NMFS, who have taken the lead on monitoring the size of the Southern Feeding

Aggregation (SFA), providing them with photo-identification data from the northern end of the SFA's range.

As grey whales continue to feel the pinch of dwindling resources in the arctic Bering Sea, where they have traditionally fed on benthic prey during the summer, they will necessarily need to spread out to other feeding areas, and apparently they are already exploiting mysids throughout the Gulf of Alaska. Given what we've seen of their ability to wipe out mysid aggregations, it becomes increasingly important to determine what resource is available to these animals as they increase the size of their foraging range.

On a smaller scale, our documentation of the presence of grey whales in the Cape Caution area is part of what led to the establishment of a Provincial Park which encompasses all of the shoreline upland of the whales' feeding area. There was originally also talk of including a marine component in the Park, but political negotiations between the provincial and federal governments are not yet complete.

What is/ are the significance/ benefits of your research at the following levels?

- **Local (to the area of the research site)**

The economy of the North Island was based on resource extraction – fishing, logging, mining – but with failure of each of those industries in turn, the focus is now turning to tourism. The business aspects of our research activities fit right into that focus, and we are well known in the local community. At one time, we were even one of the largest employers in Port Hardy!

From a research point of view, the local area benefits from our efforts as information flows out about the existing biodiversity, and the impact of the threats, well-known to biologists, but still largely unknown to the general public, on that biodiversity, and even on the resources (e.g. fish) which support the ecotourism economy itself.

- **National / Regional**

Our work on grey whales in British Columbia has been incorporated into a province-wide consultation on the marine ecosystem in advance of the provincial government's lifting of the moratorium on oil & gas exploration in Queen Charlotte Sound. Furthermore, our data has been used by the US government (NMFS) to establish management plans in response to the renewed demand by the Makah tribe of Washington State to renew whaling.

- **International**

We have been working closely with colleagues in Canada, the US, Mexico, and the UK on various aspects of our research. The whales are very much an international species – cross border work between groups in Canada and the US is essential to developing an effective management strategy. We have been a big part of that international effort. Furthermore, our research on the grey whale migration, and particularly on the benthic ecology of San Ignacio Lagoon, has fed into conservation efforts in Mexico. Finally, our work on nearshore acoustics has been done in collaboration with UK scientists, and we hope is leading to further work on anthropogenic noise in UK waters.

Communication of results

The period covered by this report is May 2007 to July 2009.

Earthwatch support for our research has been acknowledged in all of our research publications, reports, theses and conference presentations. The Earthwatch logo appears on the side of our boats, vehicles, and submersibles. It is usually acknowledged in media reports.

Printed: peer reviewed scientific publications; books / book sections; reports, management plans or policies; fact sheets, brochures, leaflets, pamphlets, posters, academic dissertations, annual reports, proceedings of conferences or workshops; letters; newsletters.

Research publication

Stelle, L. L., Megill, W. M., Kinzel, M. R., 2008. Activity budgets and diving behaviour of gray whales (*Eschrichtius robustus*) in feeding grounds off coastal British Columbia. *Marine Mammal Science*, 24 (3), pp. 462-478.

Conference abstracts & proceedings

Kinzel, M. R., Megill, W. M., 2008. Chlorophyll distribution and whale occupancy patterns: Using SeaWiFS ocean color data to monitor coastal ecosystems dynamics. In: Proceedings of the 2008 ASPRS conference, Apr 2008, Portland, OR.

Wladichuk, J. L., Megill, W. M., Maud, J. L., Stelle, L. L., 2008. Grey whales - population trends, prey and acoustics. Presentation to the annual British Columbia Marine Mammal Symposium, UBC, Vancouver, November 2008.

Maud, J. L., Megill, W. M., 2008. Grey whales as switching predators in a tertiary feeding area. Annual meeting of the European Cetacean Society, Amsterdam.

Wladichuk, J. L., Megill, W. M., Blondel, P., 2008. Passive echolocation techniques of eastern Pacific grey whales and biomimetic applications. Proceedings of the 2nd joint ASA-EAA conference Acoustics 08, Paris

Stelle, L. L., Megill, W. M., Kinzel, M. R., 2008. Activity budget, diving behavior and foraging ecology of gray whales (*Eschrichtius robustus*) off coastal British Columbia. Poster presented to the 2008 meeting of the American Cetacean Society, Monterrey CA, November 2008.

Calambokidis, J., Laake, J., Goshu, M., Gearin, P., Szaniszlo, W., Newell, C., Tombach, C., Megill, W. M., Deecke, V. B., 2008. Seasonal resident gray whales in the Pacific Northwest: Results from collaborative research from 1999 to 2007. Presentation to the 2008 meeting of the American Cetacean Society, Monterrey CA, November 2008.

Maud, J. L., Stelle, L. L., Megill, W. M., 2008. A "switching" predator in a changing ocean: Is predator-prey cycling in grey whales feeding near Cape Caution, BC, sustainable? Poster presented to the 2008 annual meeting of the American Cetacean Society, Monterrey CA, November 2008.

Wladichuk, J. L., Megill, W. M., Blondel, P., 2007. A bioinspired approach to sound localization in the underwater coastal environment. Pacific Rim Underwater Acoustics Conference, Vancouver, October 2007.

Wladichuk, J., Megill, W., Blondel, P., 2007. A Bioinspired Approach to Sound Localization in the Underwater Coastal Environment. In: Underwater Acoustic Measurements 2007, Jun 2007, Heraklion, Crete.

Wladichuk, J.L., Megill, W. M., Blondel, P., 2007. A bioinspired approach to sound localization in the underwater coastal environment. In: Proceedings of the 2nd international conference & exhibition on Underwater Acoustic Measurements: Technologies & Results.

Theses & Dissertations

Maud, J. L., 2008. Distribution and abundance of mysid shrimp related to grey whale abundance, British Columbia, Canada. MSc thesis. Dept of Marine Biology. University of Wales - Bangor.

Garcia Carreras, B., 2007. Swimming biomechanics of grey whales. MPhil thesis, University of Bath.

Laskin, D. N., 2007. A marine GIS case study of micro-scale gray whale (*Eschrichtius robustus*) habitat-use off Vancouver Island, British Columbia. MGIS thesis, Dept of Geography, University of Calgary.

Lewis, A. J., 2007. Grey whale abundance near Cape Caution. Honours thesis. University of Bangor.

Contract reports

Megill, W. M., Maud, J. M., (2009). Return of grey whales, *Eschrichtius robustus*, to the Central Coast of British Columbia and North Coast of Vancouver Island, summer 2008. Report being prepared for National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, WA.

Megill, W. M., Maud, J. M., (2009). An anomolous near absence of grey whales on the Central Coast of British Columbia and North Coast of Vancouver Island, summer 2007. Report being prepared for National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, WA.

Megill, W. M., Lewis, A. J., 2007. Surveys for Grey Whales, *Eschrichtius robustus*, on the Central Coast of British Columbia and North Coast of Vancouver Island. Report prepared for National Marine Mammal Laboratory, National Marine Fisheries Service, Seattle, WA.

Visual: artwork; visitor centre, poster or display, slides, photographs

Digital: database; internet - websites, email group/ blog/forum; CD Rom, e-newsletter

Cape Caution grey whale sightings database. <http://www.bath.ac.uk/mech-eng/research/projects/Xusela>

Photo-identification by Internet – an online matching system for grey whale research. <http://cerf.bc.ca/catalogs.asp>

Mass media: broadcast production; film; TV, radio, print (newspaper/ magazine coverage); Press releases; press conference; interview, article creation; press trip

E-Magazine. Jan/Feb 2008. Trail of the Whale. by Roddy Sheer. <http://www.emagazine.com/view/?4019>

The Independent on Sunday. May 2007. Shrinking giants: the grey whales under threat from starvation. <http://news.independent.co.uk/environment/wildlife/article2508688.ece>

There was a lot of coverage throughout 2006, 2007 and 2008, including BBC, YouTube, and many copycat websites & blogs.

Meetings and conferences: presentations/ lectures; conferences; workshops; training sessions; discussions; local community meetings and events.

Megill, W. M., Garcia Carreras, B., 2008. Using a SeaBat 8128 to study the underwater behaviour of grey whales in a Mexican breeding lagoon. Reson Users' Conference, Oceanology International, London.

Educational resources: lesson plans; resource packs

Other (specify):

The project's robot submersible, the *Hawthorne*, took part the international competition, the **Student Autonomous Underwater Challenge – Europe**, held in Gosport, England, in 2007, and in Brest, France, in 2008. After a series of last-minute setbacks, it finished a disappointing last in the 2007 competition, but redeemed itself in the 2008 competition, coming joint second behind the dominant Heriot-Watt entry.

The project's new robot submersible, the *Seabiscuit*, took part in the 2009 competition, and finished first in its division. The robot is, at the time of writing, being prepared for a new season at sea off British Columbia.

Educational Opportunities

Does your project directly or indirectly involve the following groups in your research topic?

- **Local communities**

We make a point of working with local young people in all of the areas we operate in. Over the past few years, we have been working very closely with Rob & Nola Bachen, who operate the Dawson's Landing Marina & General Store in Rivers Inlet, BC. Their daughter Krystal has been working for us every summer since 2005. Her parents are very supportive of her interest in marine biology, and we're doing what we can to encourage and assist her to go on to further education.

In Mexico, we've worked closely with the local community, involving local high school children directly in our work, and we've made good contacts with the local primary school teachers as well.

- **Students**

Almost all of our work is led by university students, from senior undergraduates through to PhDs. As reported elsewhere in this document, our Earthwatch project has provided the field support for 4 PhDs, 2 MScs, 3 Diplomas, and many undergraduate honours theses. We have run teen and family teams to involve the younger generation, and some of those students are still in touch, heading for degrees in biology. All of the students, regardless of level, have got a lot out of the programme, acquiring not only a knowledge of ecology, but also of how a team works together to achieve a common goal.

- **Early career scientists**

We have not had any postdoctoral researchers during this reporting period.

- **Other groups**

How does your research help these groups better understand and act towards the conservation of a sustainable environment?

The students' increased understanding is obvious. Those that have done theses with us have picked up a familiarity not only of the literature, but also of the realities of collecting field data and interpreting it, in all of its glory and ugliness. They have also acquired a knowledge base and skill set which they can draw upon as they follow their interests in field ecology or conservation. I have written recommendations for several of my former students and even for student volunteers, who have now moved into careers in ecology. Almost more importantly, though, is that the memories, contacts and awareness that are still with the students who've gone off into other fields.

Our local community work is likewise important. In Rivers Inlet, we're mostly preaching to the choir, but in Mexico, our interaction with the locals has brought home some of the messages that researchers have been trying to get across for years. There have been many studies done in Laguna San Ignacio, but they have failed over the years to connect with the locals, mostly because the scientists just keep to themselves, often don't speak the language, and don't otherwise have much reason to interact with the locals. Our way of operating is completely different – we interact with the local community directly, at several different levels. My efforts to learn and speak Spanish, right from the first day I arrived in the camps back in 2001, have endeared me to the local community, and my/our involvement in everything from the local women's arts cooperative, to the ecotourism business that feeds the community, to the conservation easement efforts being undertaken in conjunction with the big NGOs, to little things like hiring local kids and buying lunches in the local cantina, has meant that our work is known, accepted and appreciated in the community, as evidenced by the warm welcome we receive every year.

Has your project contributed to the completion of Masters' or PhD theses or degrees, or other educational research findings?

MSc – Maud JL (2008) – predator-prey interaction of grey whales and mysid shrimp

MPhil – Garcia Carreras B (2008) – grey whale biomechanics

PhD (ongoing) – Wladichuk JL (expected submission Autumn 2009) – grey whale bioacoustics

PhD (ongoing) – Williamson BJ (expected submission Autumn 2010) – robot submersible

MSc/PhD (just starting) – Burnham R – title still TBD

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