ABSTRACTS

Gray Whales and Climate Change: Sentinels of the North Pacific / Arctic Ecosystems

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Reception and Social – all are welcome

Gray Whales and Climate Change: Sentinels of the North Pacific/Arctic Ecosystems

Introduction – Steven Swartz and Sue Moore

This workshop brings together a group of marine scientists with broad research interests and experience to review and discuss gray whale population dynamics and behavior change in the context of environmental changes that are being observed throughout the gray whales' North Pacific and Arctic range. Specific topics discussed include observed changes in physical, chemical, and biological oceanography of the North Pacific and Arctic and the time scales of those changes, and the history and current status of the gray whale population including shifts in distribution, phenology, population dynamics, and behavior throughout their range. All of this information is discussed in the context of how well gray whales serve as indicators of changing environments, and how they serve as "sentinels of the North Pacific/Arctic ecosystems." This workshop will contribute to the development of a qualitative framework for integrating gray whales and other marine mammals into ecosystem and climate change studies.

A post-workshop publication of these presentations is contemplated.

The workshop organizers gratefully acknowledge the support of the Pacific Life Foundation and the American Cetacean Society which made this workshop possible.

Abstract

A Brief Look at Cenozoic Climate Swings, with an emphasis on the Late Pleistocene and Holocene Conditions in which Gray Whales Lived

Pieter Arend Folkens

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This planet has endured dramatic changes through the course of cetacean history — from super-greenhouse conditions with ice-free poles to protracted ice ages defined by 4km-thick sheets of ice extending into the lower latitudes. A relatively brief moment in the Early Eocene marked the emergence of the first four-legged terrestrial whales and was followed by key switching points (climate reversals) that punctuated the subsequent evolution of cetacea. Paleooceanographic events such as the onset of the Indian subcontinent colliding with Asia and the completion of the Isthmus of Panama contributed to these changes in profound ways. Following the Pliocene appearance of the earliest Eschrichtiids, gray whales endured dramatic Pleistocene oscillations between very cold glacial states and relatively brief warm interglacials. For much of this time, the Beringia land bridge blocked the Arctic, but when the interglacials set in, Northern Hemisphere inter-ocean travel became possible. During the Eemian Interglacial, the Arctic was ice-free for thousands of years followed by an ice age lasting 100,000 years. The Holocene Interglacial (a.k.a. the "period of human civilization") provides insights into conditions during the Eemian Interglacial based on present understandings of temperature and ice extent. It also puts the climate state of today into a recent historical context for questions like: "How did gray whales survive a dynamic Arctic climate that hinges between frozen and thawed."

Abstract

Evolutionary Biogeography and Paleontology of Eschrichtiid Mysticete Whales

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The living gray whale, *Eschrichtius robustus*, is morphologically and behaviorally distinct from other extant mysticetes. Molecular and morphological evidence suggests a close phylogenetic relationship with rorquals (Family Balaenopteridae). Although currently restricted to the North Pacific, gray whales formerly inhabited the North Atlantic until their expiration in the 17th Century. Fossil remains of *Eschrichtius* are known from the middle Pleistocene of southern California, USA (probably *E. robustus*; ~220 ka) and the latest Pliocene or earliest Pleistocene of Hokkaido, Japan (*Eschrichtius* sp.; ~2.5-1.5 Ma). Fossil eschrichtiids assignable to genera other than *Eschrichtius* are now known from the middle to late Pliocene of southern California, USA (Eschrichtiidae n. gen. et sp.; ~4.5-2.5 Ma) and the early Pliocene of northern Italy (*Eschrichtioides gastaldi*; ~5.3-3.5 Ma). A fossil dentary from the early Pliocene of Belgium (*Megapteropsis robusta*; ~4.5 Ma) may represent another species of Eschrichtiidae from the North Atlantic. A purported fossil eschrichtiid from the late Miocene of southern Italy (*Archaeschrictius ruggieroi*; ~10-7.5 Ma) is based on a dentary with very unusual morphology that is probably the result of postdepositional bone. and is probably not a member of this family.

Preliminary biogeographic analysis of the much improved eschrichtiid fossil record suggests that the family evolved in the Mediterranean or North Atlantic during the latest Miocene or earliest Pliocene, with stem eschrichtiids dispersing westward (possibly via the North Equatorial Current) into the Pacific through the open Central American Seaway. Speciation in the North Pacific produced at least two lineages, one of which is represented by the modern genus. It is hypothesized that *E. robustus* evolved in the North Pacific and dispersed back into the North Atlantic during the Pleistocene via the Arctic Ocean. Although the role played by Plio-Pleistocene glacial-interglacial oscillations and related changes in global sea level in driving eschrichtiid evolution cannot be accurately assessed at this time, it is likely that these were important factors.

Abstract

North Pacific – Arctic Ocean Climate Oscillations

Nicholas A. Bond

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Gray whales range over a vast and diverse area, and the variability of the climate across this range is composed of a number of separate parts. Primary contributions to this “symphony” include the well-known Pacific Decadal Oscillation (PDO) and Arctic Oscillation (AO), but other, and less-known modes of climate variability probably play important roles in particular locations and seasons. An example of the latter is the North Pacific Gyre Oscillation (NPGO), which has been demonstrated to relate to the marine ecosystem of the California Current System. Another one is the East Pacific-North Pacific (EP-NP) mode, which projects on the atmospheric forcing, and multiple aspects of the biology, in the Gulf of Alaska during spring and summer. There exist other aspects the climate forcing that are important to the marine ecosystem but are not necessarily related to basin-scale patterns of variability. Notable examples here are upwelling along the U.S. west coast, cross-shelf transports in the coastal Gulf of Alaska, wind mixing in the Bering Sea, and cloudiness/solar irradiance (and ultimately primary production) in the Chukchi Sea. The combined effects of these different contributions should be considered in terms of understanding the effects of past climate fluctuations, and future climate changes, on the habitats of the gray whale.

Abstract

ENSO and longer-term variability of productivity in the North Pacific

Paul C. Fiedler

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The El Niño-Southern Oscillation dominates interannual variability of winds, surface temperature, thermocline/nutricline depth, and primary productivity in the tropical Pacific Ocean. However, ENSO is known to contribute to interannual variability throughout the Indo-Pacific and even in the Atlantic Ocean and globally at higher latitudes. An analysis of 11 years of SeaWiFS monthly chlorophyll estimates shows patterns of the relative magnitude of interannual and seasonal variability throughout the North Pacific, and of the correlation between chlorophyll interannual variability and ENSO indices. Potentially impacting gray whale breeding, migration and feeding, ENSO variability is significant in the California Current, Gulf of Alaska, and Bering Sea, although there are severe limitations on satellite ocean color data at high latitudes. Longer-term changes in productivity on gray whale feeding grounds are likely to result from changes in ice cover and water temperature related to global warming.

Abstract

Marine Mammals as Ecosystem Sentinels

Sue E. Moore

NOAA Fisheries Service, National Marine Mammal Laboratory, Alaska Fisheries Science Center, and Applied Physics Laboratory, University of Washington, Seattle, WA

The earth's climate is changing, possibly at an unprecedented rate. Overall, the planet is warming, sea ice and glaciers are in retreat, sea level is rising, and pollutants are accumulating in the environment and within organisms. These clear physical changes undoubtedly affect marine ecosystems. Species dependent on sea ice, such as the polar bear (*Ursus maritimus*) and the ringed seal (*Phoca hispida*), provide the clearest examples of sensitivity to climate change. Responses of cetaceans to climate change are more difficult to discern, but in the eastern North Pacific evidence is emerging that gray whales (*Eschrichtius robustus*) are delaying their southbound migration, expanding their feeding range along the migration route and northward to Arctic waters, and even remaining in polar waters over winter – all indications that North Pacific and Arctic ecosystems are in transition. To use marine mammals a sentinels of ecosystem change, we must expand our existing research strategies to encompass the decadal and ocean-basin temporal and spatial scales consistent with their natural histories.

Abstract

Eastern North Pacific Gray Whale Population History and Migration Timing Shifts

Dave Rugh

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Alaska Fisheries Science Center, Seattle, WA

The Eastern North Pacific stock of gray whales has demonstrated a remarkable recovery following heavy exploitation, especially from 1855-1874 when abundance may have been in the low thousands. Between 1968 and 1998, there was a 2.5% per annum increase, rising to a high of nearly 30,000 whales. However, since then, abundance has dropped to about 20,000, possibly representing a response to environmental limitations, albeit temporarily exaggerated by unusually warm seas in Alaska in 1998 and 1999. It is anticipated that in the future, abundance estimates will rise and fall as the population finds a balance with the carrying capacity of its environment, although some of the inter-year variance may be attributed to inconsistent proportions of the population migrating as far south as Granite Canyon, near Carmel, where the routine, shore-based counts have been conducted most seasons since 1967.

These counts allow for inter-year comparisons of median migration dates. Prior to 1980, median dates ranged from 4-13 January (overall median = 8 January; SE = 0.6), but from 1985-2000, there was a one-week (6.8 day) delay, with median dates ranging from 12-18 January (overall median = 15 January; SE = 0.9). This change occurred shortly after a major oceanographic regime shift in the North Pacific. Since 2000, median dates seem to be delayed even further (ranging 17-26 January; median = 22 January; SE = 2.5). Migratory timing may be related to how far these whales have gone to forage for food in the Arctic.

Abstract

Examination of the Links between Climate and Calf Production in the Eastern Pacific Population of Gray Whales.

Wayne Perryman*, George Watters, and Lisa Schwarz

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Each fall seasonal ice begins to form in the Arctic and eventually extends southward covering all of the primary feeding grounds for the majority of the eastern Pacific population of gray whales. In the spring this processes is reversed and ice recedes north through the Bering Straits. We have found that there is a link between the timing of the retreat of seasonal ice and estimates of northbound gray whale calves the following season. We propose that, in early Spring, seasonal ice can block access to feeding grounds for pregnant females and thus impact the probability that existing pregnancies will be carried to term. We constructed a model to examine alternative hypotheses linking ice during the year of ovulation or late in the feeding season of pregnancy to gray whale reproduction and found that these factors explained only a small proportion of the observed inter-annual variability in calf estimates.

We looked at the historical distribution of seasonal ice to consider the estimates of northbound calves from 1980 and 1981 and found no evidence to support a link between ice and calf production during those years. Although there has been a decline in seasonal ice cover over the 30 years considered in this study, the impacts of ice on recruitment to this population appear tightly linked now that ice cover has been significantly reduced. While this result may seem surprising, the main feeding grounds of gray whales have shifted to the north, from locations south of the Bering Straits to locations in the Chukchi Sea. The long term trend in reduction of ice did not keep pace with this shift, thus increasing the sensitivity of this population to the timing of the retreat of ice in the Spring.

Abstract

Gray Whale Feeding Offshore Kodiak, Alaska

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A vessel-based survey was conducted July 10 through 17th 2008 in Ugak Bay on the east side of Kodiak Island, Alaska as one component of a study designed to assess year-round foraging by Eastern North Pacific gray whales. Specific survey objectives were to a) photo-identify individual gray whales foraging in the study area, b) sample encountered mud plumes and fecal clouds and c) identify prey available as forage through benthic sampling. Survey effort was concentrated at the mouth of Ugak Bay where previous gray whale studies had occurred. Photographs of individual gray whales were obtained when possible. At least one photograph (left dorsal, right dorsal or fluke) was collected from 46 gray whales. Identification photographs are currently being matched to the North Pacific gray whale catalog at Cascadia Research Collective. A total of 14 benthic samples were collected using a van Veen grab from eight predetermined sites, with one additional sample collection occurring in the vicinity of a large number of foraging whales. All but two of the predetermined sites were sampled on both an incoming and outgoing tide. Samples of mud plumes and fecal clouds were also collected on eight occasions. By count of individuals, benthic samples were dominated in decreasing order by cumaceans, bivalves, amphipods and polychaete worms. Only remains of the cumacean *Diastylopisis dawsoni* were found in the mud plume and fecal samples. Initial results suggest gray whales were foraging on high concentrations of cumaceans, which is in strong agreement with the previous study on gray whales foraging near Ugak Bay, Alaska.

Abstract
Seasonal Resident Gray Whales in the Pacific Northwest: Results from Collaborative Research Between 1999 to 2007

Calambokidis, J.*, A. Klimik, L. Schlender, J. Laake, M. Gosho, P. Gearin, B. Gisborne, W. MeGill, V. Deeke, C. Tombach, C. Newell, J. Darling, W. Szaniszlo, D. Goley, and B. Witteveen.

*** Cascadia Research, Olympia, WA**

Gray whales have been documented feeding through the spring, summer, and fall in a number of areas well south of their primary feeding grounds in Alaska waters. These animals have been called Summer or Seasonal Resident whales as well as the Pacific Coast Feeding Aggregation (PCFA). Some of the pioneering work on these animals was conducted by Jim Darling off the west coast of Vancouver Island who first demonstrated with photo-ID that some of these animals returned to the same areas year after year. Here we describe the results of a collaborative effort conducted since 1998 to look at the movements, interchange, and abundance of these animals between northern California and SE Alaska. Abundance estimates from closed and open population models have consistently yielded estimates of about 250 animals. This includes a core group that returns annually although there also are animals seen for only short periods that may be stragglers from the larger migration. While there is considerable movement and interchange among areas from northern California to SE Alaska, individuals show clear preferences for some areas that they are most likely to return to, although there is some annual and seasonal variations in these patterns. There were also whales that fed in some areas that showed a different patterns including one area of northern Puget Sound where a consistent small group of gray whales returned to feed each spring for several months but then apparently continued to Alaskan feeding areas and were not part of the PCFA whales. The abundance estimates did not show a significant change as a result of the major mortality event of 1999 and 2000 suggesting this event primarily affected the animals that feed in Alaska waters. The variable locations and prey of these whales is a demonstration of the surprising versatility of gray whales, a species that was previously thought to be a highly specialized feeder with a very regimented migration.

Abstract

The Beggar's Banquet: Gray Whale Predator-Prey Dynamics on the Outskirts

Laura Joan Feyrer*, Dave Duffus and Christina Tombach-Wright

***Whale Research Lab, Dept. of Geography, University of Victoria**

Against the backdrop of mixed and veiled signals from our 20 year research programme, we pose the question, do summering gray whales provide a useful indicator of environmental change, and if so, at what scale are they reliable? We propose four required themes for an indicator species, and then compare our localized knowledge of gray whale ecology and habitat to criteria derived from those themes.

Gray whales forage through the summer months in restricted neighborhoods along the British Columbia coast. While small in area, these sites can at times produce high biomass of a variety of different prey items. Due to the restrictions of prey habitat, which limit the extent of many of the sites, these areas can also suffer high depletion rates, and quite likely local extinction of certain prey items. In our study area, predator and prey have been under constant and increasing surveillance for over 12 years, including detailed studies of community ecology, spatial patterning and more recently the study of broader environmental conditions that create the seasonal zooplankton trove.

With this foundation, we will endeavor to sort the signal from the noise in this highly dynamic setting, and create a general model of ecology in these localized neighborhoods. In order to capture the signal of changing ocean climate and ensuing habitat alterations for gray whales, we advocate a multi-scale research framework, focusing on monitoring peripheral sites, like ours, coupled with similarly detailed studies in core areas, and increasing effort in surveying throughout the various spatio-ecological domains of their migratory range.

Abstract

Measuring chemical tracers in the tissues of Eastern North Pacific gray whales (*Eschrichtius robustus*)

Gina Ylitalo

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Chemical tracers have been measured in the tissues of marine mammals to help provide information on the quality of a sampled tissue, animal body condition or their primary prey. For example, measuring organochlorine contaminants (OCs) in North Pacific killer whales has provided information on the potential health effects associated with exposure to these compounds. In addition, these data together with information on other chemical tracers (e.g., ratios of carbon and nitrogen stable isotopes, fatty acids) have been used to help describe the geographical feeding ranges and potential prey of these predators. Over the past 20 years, we have analyzed tissues of more than 150 eastern North Pacific gray whales (*Eschrichtius robustus*) for a number of chemical tracers, including PCBs, DDTs, toxic metals, as well as lipid profile and percent lipid, to determine baseline levels of these compounds in presumably "healthy" and stranded animals. We found that stranded juvenile gray whales had higher concentrations of OCs than juvenile subsistence whales, most likely a result of retention of these chemicals in blubber of the stranded animals as lipid stores are depleted for energy use rather than from a difference in diet or feeding areas. We also examined differences in blubber lipid class profiles and percent lipid among healthy and stranded whales and found that significantly higher lipid levels were measured in blubber of subsistence animals that were sampled following summer feeding in the Bering and Chukchi Seas compared to the blubber percent lipid values in biopsied and stranded animals. Blubber samples of presumably healthy gray whales (i.e., from subsistence and biopsy sampling) contained primarily triglycerides whereas the blubber of stranded animals that showed lipid decomposition had reduced triglycerides and increased proportions of free fatty acids, cholesterol and phospholipids. Profiles of OC classes were assessed among "seasonal resident" gray whales sampled from 1996 – 2001 off the Washington Coast, with animals sampled in 1998 containing elevated proportions of the OC contaminant hexachlorobenzene (HCB) compared to whales sampled in other years, indicating a potential change in diet in animals sampled in 1998. OC and lipid analyses of different blubber depths of gray whales collected during a Russian subsistence harvest in 2001 demonstrated that these compounds are stratified in the blubber of these animals. Future studies should include analyses of OCs, lipids and lipid classes as well as fatty acids and ratios of stable isotope in tissues of Eastern North Pacific gray whales to help determine potential changes (e.g., dietary changes) associated with environmental variability.

Abstract

Health and Nutrition in Gray Whales

***Frances Gulland, Teri Rowles, Jonna Mazet, Lorenzo Rojas-Bracho,**

and Rei Rasmussen

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Gray whale stranding data for the last 10 years show an increase in 1999 and 2000 with a decrease to pre-“event” numbers in 2001-2006. During the die-off period, stranded whales appeared severely emaciated, but use of blubber lipid analysis was not useful in determing health status due decomposition. Analysis of volatile lipid metabolites in exhaled breath has been used to evaluate metabolic status in humans, elephants, dolphins, and orca. We have collected 38 breath samples from free-ranging gray whales in San Ignacio Lagoon, Baja California Sur, Mexico: 18 calves, 18 accompanying adult females, and 2 single adults. Preliminary analyses indicate that adult females with calves are in a state of ketosis consistent with fasting with 155 identified GC-MS peaks containing elevated ketones, aldehydes and alkenes. In contrast, samples from a lone adult engaged in feeding-like behavior and from suckling calves had metabolite profiles with about one half of the number of compounds identified in nursing females. The total ketone levels in these latter breath samples were much lower and simple; consisting almost entirely of acetone as would be expected from healthy, well nourished whales.

Abstract

Seasonal and Annual Variation in Body Condition of Western Gray Whales Off Northeastern Sakhalin Island, Russia

Amanda L. Bradford*, David W. Weller, Yulia V. Ivashchenko,

Alexander M. Burdin, and Robert L. Brownell, Jr.

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The western gray whale population (*Eschrichtius robustus*) is critically endangered and its potential for recovery is uncertain. Along with other natural and anthropogenic threats, western gray whales are susceptible to nutritional stress, known from regular observations of individual whales in compromised body condition. Thus, the ability to visually quantify the relative body condition of free-ranging western gray whales and evaluate how this condition varies seasonally and annually is needed. A photo-identification study of western gray whales on their feeding ground off the northeastern coast of Sakhalin Island, Russia, produced a large dataset of digital, film, and video images of 150 identified individuals from 1994 to 2005. These images were utilized to visually assess the body condition (i.e., good, fair, poor) of western gray whales by evaluating the relative amount of subcutaneous fat in three body regions presumed to reflect reductions in body condition. Multinomial logistic regression for ordinal responses was used to evaluate the effects of year, month, whale class, and sex on the body condition of western gray whales. Significant findings of the analysis indicate that: 1) the body condition of whales varied annually and seasonally; 2) the body condition of whales improved as each feeding season progressed; and 3) lactating females were in relatively poorer body condition nursing calves in comparatively better body condition. Future work aimed at investigating the causes and consequences of compromised body condition in western gray whales is necessary for understanding the health and viability of this population. The visual assessment protocol and analysis framework presented here offer a tool for monitoring the body condition of gray whales as a species, which is of importance in the face of ongoing climate change.

ABSTRACT

Observations of Gray Whales in the Baja Breeding Lagoons: Indications of Response to Environmental Changes

Jorge Urban R. and Steven L. Swartz*

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Large cetaceans have long been thought of as the mighty monarchs of the world's oceans. These long-lived species have been around for millions of years and have survived significant periods of geologic changes that have affected the ocean environment and its marine ecosystems. Large cetaceans have evolved specific life histories that afford them the opportunity to adjust to changes in their environments that affect their prey, migrations, breeding and survivorship. The scientific study of living whales allows the examination of how large cetacean species deal with changes in their environment and habitats they rely on for feeding, breeding and migrations. Some of the better studied species are exhibiting apparent responses to climate related changes in their habitats and the resources on which they depend. Thus, observations of these species can inform us about their health and status, and the health and status of their ocean habitats. Species such as the gray whale have been called by Sue Moore "Sentinels of the Seas." Observations of gray whales in the breeding lagoons of Baja California will be discussed in the context of how well these large cetaceans serve as indicators of environmental change , and how this species is adjusting to such changes.