The First Barkley *Sound Knowledge* Symposium

Programme and Extended Abstracts

9-11 February 2010
Bamfield Marine Sciences Centre

edited by Thomas A. Okey and Kathryn L. Wallace

West Coast Aquatic

Tsawalk
the power of one

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West Coast Aquatic

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Bamfield Marine Sciences Centre, Bamfield, BC, Canada

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Notes:

Welcome

The First Barkley Sound Knowledge Symposium was conceived and developed with the vision of assembling and sharing existing knowledge about Barkley Sound ecosystems, human uses, and values in a *living* and *open* knowledge-base for the support of sustainability planning initiatives.

The goal of the Symposium is to assemble ecological knowledge of Barkley Sound from scientific, indigenous, and other local realms into formats that may be used to support marine planning initiatives, and to inform the general public. The Symposium Advisory Committee chose three Symposium themes:

1. Understanding historical changes in the Barkley Sound coastal marine ecosystem, expectations for future changes, and visions for desired social-ecological states;
2. Distributions of natural resources, human uses, and related values in space and time;
3. Indicators of the integrity and health of Barkley Sound marine ecosystems (and social-ecological systems) in the context of planning goals, objectives, and targets.

The eleven sessions highlighted in the Table of Contents and the Symposium Schedule emerged from an original list of session topics chosen by the Advisory Committee. Being the inaugural effort to develop a knowledge symposium of this kind focused on a region of the West Coast of Vancouver Island (WCVI), the supporting network and organization had to be discovered and invented in real time by the Organizing Committee with guidance from the Advisory Committee. Despite some minor challenges, the response to this initiative was very positive, as evidenced by the present Program and Extended Abstracts. This product alone represents a valuable contribution to the growing knowledge base and knowledge network of Barkley Sound. This Barkley Sound effort is an example of how knowledge can be collated for broader areas such as the West Coast of Vancouver Island. However, the broader planning initiatives that are informed by such knowledge require more specific and strategic guidance from knowledge communities than mere knowledge collation.

Fortunately, the Barkley Sound Knowledge Symposium has attracted numerous experts in natural resources stewardship and management from different cultures and realms of knowledge. The great challenge is in agreeing on goals, objectives, strategies, actions, as well as in developing an indicator-based system of evaluation that allows us to learn how different strategies and actions affect the various values that we are attempting to maximize, be they social, cultural, economic, ecological, or some combination. So beyond a representative sampling of background knowledge and perspectives, this ecological symposium approaches this strategic need by exploring ecological baselines; ecological indicators and knowledge for planning and decision-making; community approaches to goals, objectives, and targets, and approaches to gather spatial information and conduct spatial analyses for optimizing values.

There are a variety of potential reasons for organizing and holding the First Barkley Sound Knowledge Symposium, and each participant and contributor has their own set. The knowledge network that emerges or expands through this effort should indeed embrace these diverse motivations, making it a true network that uses partnership and collaboration find solutions through a discourse that combines perspectives.

There are several ongoing planning initiatives on the West Coast of Vancouver Island that will benefit from such efforts and partnerships, and which we will learn about at the Symposium, but the original impetus behind the inception of this symposium was the process that is now underway through West Coast Aquatic (formerly the West Coast Vancouver Island Aquatic Management Board) with goal of developing a Coastal and Ocean Plan for all the marine and littoral areas along the West Coast of Vancouver Island including the adjacent Exclusive Economic Zone. This plan will be ecosystem-based, integrated, and spatially nested such that issues can be addressed at appropriate scales. This plan may recommend the development of Ocean Zoning plans for particular WCVI areas such as Barkley and Clayoquot Sounds. The current symposium will help us to develop all the elements of the *knowledge base* that will support this planning process (Figure 1).

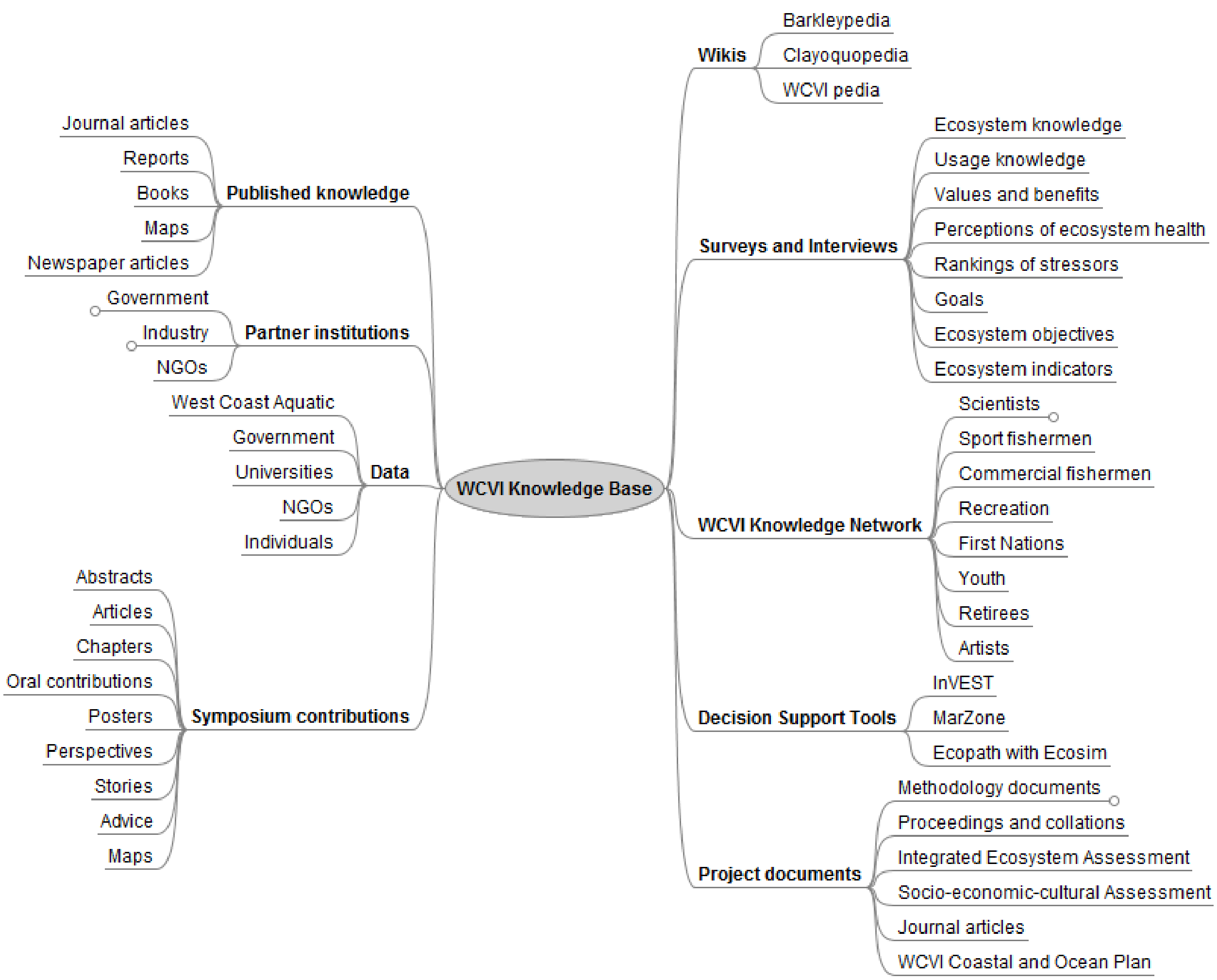

Figure 1. Example elements of the knowledge base for the West Coast of Vancouver Island, which is a necessary underpinning for the support and development of an integrated and ecosystem-based Coastal and Ocean Plan for the West Coast of Vancouver Island.

Contributed knowledge will be documented in Barkleypedia and in an edited proceedings volume to be published as part of an Integrated Ecosystem Assessment (IEA). This IEA, which will include socio-economic and cultural assessment, will form the basis of a comprehensive coastal marine plan for Barkley Sound and an integrated coastal and ocean management plan for the broader West Coast of Vancouver Island area. The ultimate vision is integrated, collaborative, and truly participatory coastal and ocean planning and management that will ensure the restoration and sustainability of the region's unique ecological, social, cultural, and economic values.

Bamfield is situated just inside the southernmost corner of Barkley Sound adjacent to the exposed outer coast and within easy reach of some of the most wonderful and spectacular habitats and ecosystems in the world, and which people have interacted with for millennia. I am deeply grateful to have had the opportunity to call it home with my wife and daughter for a whole year as the Scientist in Residence at Bamfield Marine Sciences Centre. On behalf of the Symposium Organizing Committee, I am pleased to welcome you to this premier scientific institution, and I hope you will join me in appreciating the hospitality of our territorial host, the Huu-ay-aht First Nation, and the other First Nations of the Barkley Sound ecosystem as we embark on our journey.

Tom Okey
Organizing Committee, Barkley Sound Knowledge Symposium
Director of Ecosystem Science, West Coast Aquatic
Pew Fellow in Marine Conservation

Symposium Organizing Committee

- W. Tom Joe, Huu-ay-aht First Nation supported through West Coast Aquatic
- Jake Martens, West Coast Aquatic
- Tom Okey, West Coast Aquatic
- Kelly Poirier, West Coast Aquatic
- Kathryn Wallace, West Coast Aquatic (Symposium Coordinator)

Symposium Advisory Committee

- Mairi Best, NEPTUNE Canada, University of Victoria
- Audrey Dallimore, School of Environment and Sustainability, Royal Roads University
- Edward J. Gregr, Scitech Environmental Consulting, IRES, University of British Columbia
- Kim Hyatt, Regional Ecosystems Program, Fisheries and Oceans Canada, Pacific Biological Station
- Chief Anne Mack, Toquaht First Nation
- Stefan Ochman, Fisheries Manager, Huu-ay-aht First Nation
- Rich Pawlowicz, Ocean Dynamics Laboratory, Dept. of Earth and Ocean Sciences, University of British Columbia
- Derek Peters, Naasiismis, Tyee Ha'wilth, Huu-ay-aht First Nation
- Denis St. Claire (on behalf of Chief Councilor Les Sam)
- Anne Stewart, Public Education Coordinator, Bamfield Marine Sciences Centre
- Sharon Styan, Uchucklesaht First Nation (on behalf of Chief Councilor Charlie Cootes)
- Ron Tanasichuk, Fisheries and Oceans Canada, Pacific Biological Station
- Sarah Tyne, Information and Communications Officer, Bamfield Marine Sciences Centre
- Yuri Zharikov, Monitoring Ecologist, Pacific Rim National Park Reserve, Parks Canada

ACKNOWLEDGEMENTS

The Organizing Committee would like to express our sincere gratitude to the Huu-ay-aht First Nation for hosting this event on their traditional territory. Chief Robert Dennis Sr., Tyee Ha'wiih Naasiismis Derek Peters, Councilor Irene Williams, Councilor Rob Dennis Jr., Tom Happynook, W. Tom Joe, Molly Clappis, and Jessica Burns all deserve recognition for their support, encouragement, and efforts.

We are also indebted to the other Barkley Sound First Nations, including, Tseshaht, Uchucklesaht, Toquaht, Ucluelet and Hupacasath for their generous support and participation.

Sincere thanks to Symposium Advisory Committee: Mairi Best, Audrey Dallimore, Edward J. Gregr, Kim Hyatt, Stefan Ochman, Rich Pawlowicz, Naasiismis Derek Peters, Anne Stewart, Ron Tanasichuk, Sarah Tyne, Yuri Zharikov, Chief Anne Mack, Denis St. Claire, and Sharon Styan whose patience, knowledge and expertise were invaluable.

The Symposium was made possible through various types of support and partnership of the following sponsors: The Gordon and Better Moore Foundation, Royal Roads University, The Bamfield Marine Sciences Centre, West Coast Aquatic, Fisheries and Oceans Canada, The Pew Fellows Program in Marine Conservation and Parks Canada.

Grateful acknowledgements are also extended to the keynote speakers, Dr. Mairi M.R. Best, Dr. Terrie Klinger, Dr. Jane Watson, Dr. Louis D. Druehl, and special guests in the facilitated conversation on *Long-term perspectives on ecosystem change* including Dr. Gordon Hartman, Mr. Steve Rush, Councilor Rob Dennis Jr., Councilor Willard Gallic Sr., Chief Anne Mack, and Mr. Ladner Touchie, and the conversation on *Resource users perspectives on ecosystem change* including Mr. Peter Mieres, Mr. Odd Grydeland, Mr. Rick Nookemus , Mr. Geoff Lindsay, Councilor Stella Peters, Mr. Bob Bowker, and Mr. Ian Macdonald, and facilitators Anne Stewart and Tom Joe. We thank additional special speakers Barbara Touchie, Marylin Touchie, Tom Tatoosh, and others.

Special thanks to everyone at the Bamfield Marine Science Centre, especially Sarah Tyne and other members of the staff for hosting this event at a truly world class venue.

Finally, the Organizing Committee would also like to thank West Coast Aquatic staff members Pam Keel, Andrew Day, Denise Dalmer, Ken Watts, Kevin Head, Jennifer Spencer, Laura Loucks, the Na-a-qu-us liaisons from the various Barkley Sound and WCVI First Nations, and the entire West Coast Aquatic Board for their various types of support in the preparation this event.

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SYMPOSIUM SCHEDULE

TUESDAY, 9 February 2009	
7:30	Board the MV Francis Barkley at Harbour Quay in Port Alberni
8:00	*MV Frances Barkley* launches for Barkley Sound and Bamfield
Session 1. Understanding Place and People	
8:15	Introduction to presentations enroute to Bamfield aboard the MV Frances Barkley
8:30	Presentation 1 (Hupacasath) - Mr. Tom Tatoosh
8:45	
9:00	Presentation 2 (Uchucklesaht) - Mr. Steve Rush
9:15	
9:30	Presentation 4 (Toquaht) - Mr. David Johnsen
9:45	
10:00	Presentation 5 (Ucluelet) - Ms. Marylin Touchie
10:15	
10:30	Presentation 3 (Tseshaht) - Councilor Willard Gallic Sr.
10:45	
11:00	Presentation 6 (Huu-ay-aht) - Councilor Rob Dennis Jr
11:15	
11:30	Arrive in Bamfield. Disembark and unload to accommodations.
11:45	Registration desk in Rix Atrium
12:00	
12:15	Opening Prayer and Welcome to Traditional Territories
12:30	Lunch is served
12:45	
13:00	
13:15	Brad Anholt, Welcome to Bamfield Marine Sciences Centre [during lunch]
13:30	Okey, Symposium Introduction
13:45	**Keynote Address**: Mr. Denis St. Claire: "The Last Forty Years and the Next Two Decades"
14:00	
Session 2. Climate, Geology, and Oceanography	
14:15	Dallimore - A 10,000 year history of the climate, sea level, oceanography, marine ecosystems and earthquake activity in Barkley Sound
14:30	Palowicz - Seasonal variations in Barkley Sound water mass characteristics and deep renewal 2004-2009
14:45	Greengrove - Physical Oceanographic Conditions in Barkley & Clayoquot Sounds, BC, Canada - 2000-2009 - Focus on Effingham Inlet
15:00	Wellness Break

15:15	**Interactive Keynote Address**: Dr. Mairi Best: "Live Data from the Coast to the Deep Sea: NEPTUNE Canada"
15:30	
15:45	
16:00	
Session 3. Ecological Baselines: from Forests to Fisheries to People	
16:15	Mackinnon - Terrestrial ecosystems of Barkley Sound
16:30	Rutherford - Overview of surveys conducted by Fisheries and Oceans Canada on invertebrate stocks in Barkley Sound
16:45	Mckechnie - An Archaeological Perspective on the Hake Fishery in Barkley Sound
17:00	Tanasichuk -- Short lived fish and the question of baselines in Barkley Sound
17:15	Morgan - Huu-ay-aht First Nation Marine Resource Inventory
17:30	
17:45	
18:00	Blessing - Dinner is served
18:15	
18:30	
18:45	
19:00	
19:15	Session 4. Poster Session
Poster	Beach - Ucluelet Harbour: a safe landing, but does it provide safe food?
Poster	Beaugrand - Monitoring Coastal Erosion and Climate Change/Variability Impacts in Pacific Rim National Park Reserve
Poster	Chan - Exploring the feasibility of Wizard Islet as an indicator of rocky intertidal communities in Barkley Sound
Poster	de Graaf - Monitoring critical fish habitat: Eelgrass and forage fish spawning beaches in Barkley Sound
Poster	Earle - The significance of oral histories of the 1700 Cascadia Earthquake
Poster	Fu - Fish/shellfish community structure in Barkley Sound
Poster	Hay - Fossil diatoms as indicators of past hydrological and climate variability in Barkley Sound, British Columbia
Poster	Head - Mapping features, values, and uses in Barkley Sound and the WCVI
Poster	Heim - A new species of the genus Tethya (Porifera, Demospongiae) from Barkley Sound, Vancouver Island, Canada*
Poster	Leys - Glass sponges take advantage of current-induced flow
Poster	Leys - Observing suspension feeders graze: a NEPTUNE observatory in 3D
Poster	Mak - Social-Ecological History for Nearshore Ecosystems of WCVI
Poster	Mckechnie - Archaeological Evidence of a Possible Paleo-tsunami at the Tl'aadiiwa Village, West Coast Trail, Pacific Rim National Park Reserve
Poster	Murray - Protected Areas and Poverty Reduction: A Canada-Africa Research and Learning Alliance
Poster	Ramshaw - The distribution and abundance of kelp-derived detritus off the west coast of Vancouver Island
Poster	Szaniszlo - Seasonal Abundance and Distribution of Steller Sea Lions in BC's Coastal National Park Reserves

Poster	Tam - Decision-Making for Ecosystem Services: Values, Process and Structure
Poster	Tanasichuk - Factors affecting the productivity of Pacific herring (Clupea pallasi) from the West Coast of Vancouver Island
Poster	Tanasichuk - Factors affecting the returns of coho (Oncohrynchus kisutch), sockeye (O. nerka) and chum (O. keta) salmon from the WCVI
WEDNESDAY, 10 February 2009	
7:30	Blessing - Breakfast
7:45	
8:00	
8:15	
8:30	To Lecture Hall
Session 5. Indicators for planning and decision making	
8:45	Clarkson - Black Oystercatchers – Shoreline Sentinel of Barkley Sound
9:00	Zharikov - Population trends and drivers of annual variability in seabirds in Barkley Sound
9:15	Burger - The importance of Barkley Sound and adjacent seas to the global seabird community
9:30	Tanasichuk - Interannual variation in euphausiids (krill) in Barkley Sound, 1991-2009
9:45	Yakimishyn - Spatial variability in eelgrass fish diversity in the Broken Group Islands, Barkley Sound
10:00	de Graaf - Measuring the Connectivity of Eelgrass Habitats in Barkley Sound: Fine-Scale Population Genetic Structure of the Bay Pipefish.
10:15	Hyatt - Annual to centennial scale variations in returns of Barkley Sound sockeye salmon as an indicator of ecosystem and human health
10:30	*Wellness Break*
Session 6. Ecosystem knowledge for planning and decision making	
10:45	Okey - How ecosystem knowledge will inform sustainability planning in Barkley Sound and the West Coast of Vancouver Island
11:00	**Keynote Address:** Dr. Terrie Klinger: The San Juan Islands and Puget Sound planning experiences
11:15	
Session 7. Habitat and spatial characterization	
11:30	Markel - Spatially consistent rockfish recruitment across kelp and eelgrass habitats in Barkley Sound: implications for RCA effectiveness
12:00	Gregr - Building a comprehensive substrate map for ecosystem analysis
12:15	Bodtker - British Columbia Marine Conservation Analysis project: Generating information to support integrated marine planning
12:30	Blessing - Lunch is served
12:45	
13:00	
13:15	
13:30	Toft - Coastal and marine planning informed by mapping and valuation of ecosystem services of the West Coast of Vancouver Island

Session 8. Community approaches to goals, objectives, and targets	
13:45	Burnett - A Web-Based, Federated, Marine Use Management System for Small Communities
14:00	Insley - Community Based Ecological Monitoring: Lessons from the Bering Sea
14:15	Murdock - Historical and future climate impacts for a community-based resilience analysis
14:30	Liston - Building Resilient coastal communities in the face of climate change impacts on coastal and marine resources and ecosystems in British Columbia
14:45	Wallace - Public and expert survey of ecosystem knowledge, uses, values and perceptions of health, stressors, and solutions for the WCVI
15:00	Wellness Break
15:15	Longo - Enlisting Digital Fishers to Assess Data from the Deep and Elicit Judgment from the Crowd
15:30	
15:45	
16:00	Schmitt - Freshwater Hatchery Management Practices that Could be Incorporated to Rebuild Wild Stocks of Chinook Salmon
16:15	Wellness break (and moving chairs)
Session 9. Perspectives on ecological change	
16:30	**Resource Users Perspectives on Ecosystem Change**: a facilitated conversation with invited guests
16:45	
17:00	
17:15	
17:30	Free time
17:45	
18:00	Blessing - Dinner is served
18:15	
18:30	
18:45	
19:00	Assemble in Rix Atrium
19:15	**Longterm perspectives on ecological change**: a facilitated conversation with special guests
19:30	
19:45	
20:00	
20:15	Continue conversation if desired
THURSDAY, 11 February 2009	
7:30	Blessing - Breakfast
7:45	
8:00	
8:15	

Session 10. Ecological Baselines: Shallow subtidal	
8:30	
8:45	**Keynote Address**: Dr. Jane Watson: "Sea otters, history and natural variation; the importance of having a baseline"
9:00	
9:15	Martone - Effects of sea otter predation on subtidal rocky reef food web structure and productivity on the west coast of Vancouver Island
9:30	Singh - Impacts of sea otter foraging on intertidal communities: implications of sea otter re-establishment in Barkley Sound
9:45	Dick - Are sea otters good for fish?
10:00	Espinosa-Romero - Using ecosystem models to predict effects of sea otters return to the west coast of Vancouver Island
10:15	**Keynote Address:** Dr. Louis Druehl: "The Kelp of Barkley Sound: Ecology, History, Economics, and Leisure"
10:30	
10:45	**Symposium wrap up, thank you, and prayer**
11:00	
11:15	Collect bag lunch/ Thank you and closing of symposium during lunch?
11:30	Free time
11:45	
12:00	
12:15	Board MV Francis Barkley for Port Alberni
12:30	
12:45	
13:00	
Session 11. Looking to the Future	
13:15	Presentation 1 (Huu-ay-aht) - Undecided
13:30	Presentation 2 (Ucluelet) - Marylin Touchie
13:45	Presentation 3 (Toquaht) - Chief Anne Mack
14:00	Presentation 4 (Tseshaht) - Undecided
14:15	Presentation 5 (Uchucklesaht) - Mr. Steve Rush
14:30	Presentation 6 (Hupacasath) - Tom Tatoosh
14:45	
15:00	
15:15	
15:30	
15:45	Arrival in Port Alberni in time to get to the Olympics!

KEYNOTE SPEAKERS

MR. DENIS ST. CLAIRE

Archaeologist, ethnographer, educator, owner of Coast Heritage Consulting

Keynote Address: The Last Forty Years and the Next Two Decades

Mr. St. Claire has immersed himself in the archaeology and ethnography of the Barkley Sound and surrounding areas for more than three decades in capacities that have blended scholarly, professional, and personal realms. Mr. St. Claire has worked with elders of the Huu-ay-aht, Tseshaht, Hupacasath, Uchucklesaht, Toquaht, Ucluelet, Ahousaht, Keltsemath, and Tla-o-qui-aht, collecting place names and site usage data throughout the 1970's, 80's and 90's. These were critical decades for understanding the interacting human and natural histories of the region. His extensive work with elders, hereditary chiefs and elected First Nation councils has given him a favorable reputation among Nuu-chah-nulth First Nations, as well as valuable insights into appropriate cultural/procedural protocols and interview techniques. Mr. St. Claire was adopted into Tseshaht's Tyee Ha'wiilth Adam Shewish's family and continues to be a friend, family member and asset to the Tseshaht community.

DR. MAIRI M.R. BEST

Associate Director (Science), NEPTUNE Canada.

Interactive Keynote Address: "Live Data from the Coast to the Deep Sea: NEPTUNE Canada"

Dr. Mairi Best is a marine scientist interested in biological, physical, and chemical factors that control the preservation of calcium carbonate skeletons: our primary source of paleo-biological information and the primary way carbon is transferred from the atmosphere-ocean to the crust in the carbon cycle. Production and preservation of calcium carbonate is affected by ocean "acidification". After her B.Sc. honours in Geology from Laurentian University, including scuba-based research on reefs of St Lucia, Mairi worked on fossil and modern reefs in Papua New Guinea through the Australian Institute of Marine Science. From there she did a PhD at the University of Chicago with fellowships at the Smithsonian Tropical Research Institute. As assistant professor at McGill University, she continued to expand her NSERC-funded research program, including experiments deployed on the VENUS cabled observatory. She continues this research as an Adjunct Professor in the University of Victoria's School of Earth and Ocean Sciences. Mairi fosters and facilitates the efforts of a growing community of NEPTUNE Canada scientists – those designing the pioneer suite of instruments and experiments deployed in 2009, and developing approaches to data analysis and integration. She also manages the integration between the vision of the scientific community and the engineering and information technology infrastructure.

Dr. Terrie Klinger

Associate Professor, School of Marine Affairs and Adjunct Associate Professor, School of Aquatic and Fisheries Sciences, University of Washington

Keynote Address: "The San Juan Islands and Puget Sound planning experiences"

Dr. Terrie Klinger is Associate Professor of Marine Affairs at the University of Washington where she studies marine ecology and marine policy. Klinger holds a Ph.D. in Biological Oceanography from the Scripps Institution of Oceanography. Her research has included investigations of nearshore intertidal and subtidal communities and their response to disturbance, biological invasion, and climate change. She serves as Chair of the Olympic Coast National Marine Sanctuary Advisory Council, Governor's Appointee to the Northwest Straits Commission, and as a lead author of the Puget Sound Science Update.

Dr. Jane Watson

Professor, Vancouver Island University, Nanaimo, BC, Canada

Keynote Address: "Sea otters, history and natural variation: the importance of having a baseline"

Jane Watson has been observing, measuring, and studying the underwater ecosystems of Barkley Sound for nearly 30 years. She is interested in how marine vertebrates affect and interact with coastal ecosystems. Her current research is on sea otter community ecology, and she is particularly interested in how sea otter predation affects the biological communities of underwater rocky reefs including the life history strategies of sea otter prey species.

Dr. Louis D. Druehl

Professor Emeritus, Simon Fraser University and Bamfield Marine Sciences Centre

Keynote Address: "Marine algae and ecological change in Barkley Sound and west coast of Vancouver Island"

Dr. Louis Druehl has taught marine botany at Simon Fraser University and various marine stations for over thirty years. His ongoing research advances understanding of kelp ecology, evolution and cultivation, and his doggerel amuses. Louis and his partner, Rae Hopkins, have operated Canadian Kelp Resources (www.canadiankelp.com) out of Bamfield for over twenty-five years. CKR has a line of sea vegetables (Barkley Sound Kelp), provides kelp for pharmaceutical and cosmetic companies, and champions kelp farming and the development of kelp-based cottage industries locally and abroad.

SESSION 1. UNDERSTANDING PLACE AND PEOPLE

First Nations interpretations of place, origins, histories, and interactions with marine and coastal ecosystems, with a focus on ecosystem knowledge of the Nation. Onboard the RV Francis Barkley during the journey from Port Alberni to Bamfield.

HUPACASATH FIRST NATION PERSPECTIVES – MR. TOM TATOOSH

UCHUCKLESAHT FIRST NATION PERSPECTIVES – MR. STEVE RUSH

TOQUAHT FIRST NATION PERSPECTIVES – CHIEF ANNE MACK

UCLUELET FIRST NATION PERSPECTIVES – MS. MARYLIN TOUCHIE

TSESHAHT FIRST NATION PERSPECTIVES – COUNCILOR WILLARD GALLIC SR.

HUU-AY-AHT FIRST NATION PERSPECTIVES – COUNCILOR ROB DENNIS JR.

KEYNOTE ADDRESS 1: THE LAST FORTY YEARS AND THE NEXT TWO DECADES

MR. DENIS ST. CLAIRE

Archaeologist, ethnographer, educator, owner of Coast Heritage Consulting

This keynote address traces the development of our knowledge about the archaeology and ethnography of Barkley Sound and the West Coast of Vancouver Island from the early 70's to the present. During that time, tremendous progress has been made in understanding the archaeology of the Barkley Sound area, its sequence and chronology, as well as its ethnography / ethnohistory. The presentation touches on some hopes for the future of research in the area and the cross-over benefits that other sciences can derive from the results of the regional archaeological work of the past 30 plus years. The address concludes with a plea for joint, multidisciplinary projects in the coming years.

SESSION 2. CLIMATE, GEOLOGY, AND OCEANOGRAPHY

A 10,000 YEAR HISTORY OF THE CLIMATE, SEA LEVEL, OCEANOGRAPHY, MARINE ECOSYSTEMS AND EARTHQUAKE ACTIVITY IN BARKLEY SOUND.

AUDREY DALLIMORE [1,2], RANDOLPH, J. ENKIN [2] , MURAY B. HAY [3], CYNTHIA A. WRIGHT [4], AND RICHARD E. THOMSON [5]

[1 *]School of Environment and Sustainability, Royal Roads University, Victoria, BC,V9B 5Y2, Canada,Audrey.Dallimore@royalroads.ca:[2] Geological Survey of Canada-Pacific, Natural Resources Canada, Institute of Ocean Sciences, Sidney, BC, V8L 4B2, Canada,renkin@nrcan.gc.ca:[3]Programme de géographie

Département des Sciences humaines, Université du Québec à Chicoutimi(Québec), G7H 2B1 Canada, **Murray_Hay@uqac.ca**: [4] Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, V8L 4B2, Canada.

Summary
The sedimentary record in a 40.9 meter piston core raised from the inner basin within Effingham Inlet, Barkley Sound British Columbia, Canada, during the 2002 MONA (Marges Ouest Nord Américaines) campaign, spans from14,360 ^{14}C yr BP (17,300 cal yr BP). This important marine sediment core, widely regarded as the best high resolution (annual) record of paleoenvironmental conditions in the Pacific northeast, archives changes in sedimentation and sea-level immediately following deglaciation of the Late Wisconsin Fraser Glaciation, which peaked about 15,000 ^{14}C yr BP. Our interpretations include details about natural cyclical and abrupt climate, oceanographic and ecosystem changes, a 40 m change in sea level in Barkley Sound and major earthquake events, as glaciers receded from the west coast of Canada.

Methods or mode of knowledge
A 40.9 m long sediment core (MD02-2494) was raised using the Calypso piston core system on board the French ship the *RV Marion Dufresne*, in the inner basin of Effingham Inlet in June, 2002. Subsequently detailed analyses of the lithology, physical properties, diatom and fish scale assemblages were carried out in the laboratories of the Geological Survey of Canada-Pacific . Fifty-nine samples of wood, plant and shell material were recovered for Accelerator Mass Spectrometry (AMS) radiocarbon dating. Multibeam bathymetric data were collected in April, 2005 aboard the *CCGS Vector* using Kongsberg-Simrad's EM-3000 multibeam echo sounder. Oceanographic water property transects of the inlet have been performed from the *CCGS Tully* since 1995.

Results or observations
Both abrupt and cyclical changes in the natural environment in Barkley Sound are recorded in the core sediments, most noteably a profound change in oceanographic and ecological conditions which occurred about 4,000 years ago. Some indications indicate that we are now experiencing another abrupt change in climate and ocean conditions, which may be analogous to the abrupt changes of 4,000 years ago [4]. Detailed results of this research can be found in the publications listed below.

Discussion and conclusion

The research from Effingham Inlet gives us a quantitative analyses of the present and past environment in Barkley Sound, and what we may expect in the future under global climate change. Our general understanding of the climate system is based on data recorded in about the past 100 years. However, this short duration has not witnessed the full range of Earth's climatic variability and it includes human-caused disturbances to the natural climate system. Therefore interpretation of the geologic record is vital to accurately placing 20th and 21st century climate in historical context, evaluating the significance of future changes in climate, and analyzing uncertainties in the projection of climate change [8]. The dramatic changes in sea level recorded in this core also have implications for the possibility of early human migration routes and glacial refugia.

Key words

Paleoenvironment, sea level change, climate change, fish scales, earthquakes.

Literature cited

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SEASONAL VARIATIONS IN BARKLEY SOUND WATER MASS CHARACTERISTICS AND DEEP RENEWAL 2004-2009.

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Summary

A regular time series of water column properties in Barkley Sound has been collected on a monthly basis since Feb 2004. Results show a regular seasonal cycle, superimposed on a longer-term cooling. Waters below 60m are regularly hypoxic in late summer.

Methods
Regular hydrographic surveys of Barkley Sound water column properties at locations near the Sarita River in Trevor Channel, and near Swale Rock in Imperial Eagle Channel, have been carried out on an annual basis since Feb 2001, and on a monthly basis since Feb 2004. Parameters measured include temperature, salinity, dissolved oxygen (since 2004) and chlorophyll fluorescence (since summer 2005). Plots of the results are available at the **Barkley Sound Time Series webpage**

Results or observations
There is a pronounced seasonal cycle in water column properties at all depths. At depths of 0 to 40m flow is generally unrestricted, andmeasured values are similar over the whole sound at any one time. Between 40m and 100m Trevor Channel water is renewed only by the restricted flow from the open ocean via Imperial Eagle channel and through Junction Passage. Trevor Channel properties track, but are not identical to, properties in Eagle Channel. Below about 120m water in Trevor Channel and Alberni Inlet is isolated from the open ocean and stagnant for much of the year. These deep waters are renewed in summer every year, but the time period during which renewal occurs varies from year to year. Renewal occurred over 5 consecutive months in 2006, but only over 3 consecutive months in other years. In 2007 renewal occured only during May and November.

Oxygen levels in the deep water are low because the upwelled Pacific Intermediate water that enters during the summer has low oxygen levels. However, oxygen levels during the stagnant period sometimes decrease and sometimes increase, probably reflecting a changing balance between the downward diffusion of oxygenated water from above and the utilization of oxygen by organic decomposition. Water in Barkley Sound is hypoxic (< 2 ml/l of Oxygen) below about 60m in the late summer and early fall, but the depth of this boundary increases to about 120m over the late fall and winter. The entire water column is generally above hypoxic levels during May through June, during the initial stages of deep water renewal.

Chlorophyll concentrations are elevated during the summer, and greatest in a relatively thin layer at depths of around 10m. No pronounced spring bloom has been observed. However, this may be an artifact of the sparse monthly sampling, with the bloom occuring between sampling times.

Discussion
Long-term seasonal trends in Barkley Sound water properties probably reflect climatological changes in the coastal winds and offshore water properties, and may be useful as a proxy for inlet properties all along the west coast of Vancouver Island.

Key words
Hydrographic, water column properties, seasonal cycle, climate

PHYSICAL OCEANOGRAPHIC CONDITIONS IN BARKLEY & CLAYOQUOT SOUNDS, BC, CANADA - 2000-2009 - FOCUS ON EFFINGHAM INLET

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The physical oceanographic conditions in the inlets and fjords of Barkley and Clayoquot Sounds along the outer coast of Vancouver Island in British Columbia, Canada have been explored for the past ten years as part of an ongoing multidisciplinary project that involves faculty and students from multiple institutions. The hydrographic conditions in these deep glacially formed fjords are heavily influenced by complex bathymetry, strong tidal currents, topographically steered winds and coastal oceanographic upwelling and downwelling. Many of the deep inner bays of these inlets are anoxic with renewal times on the order of months to years, with only aperiodic flushing. The interannual distribution and variability of summer temperature, salinity, density, oxygen and fluorescence are examined and related to possible local forcing conditions for inlets in both Barkley and Clayoquot Sounds over the period from 2000-2009 with a particular focus on Effingham Inlet.

KEYNOTE ADDRESS 2: LIVE DATA FROM THE COAST TO THE DEEP SEA: NEPTUNE CANADA

DR MAIRI M.R. BEST, ASSOCIATE DIRECTOR (SCIENCE), NEPTUNE CANADA, ON BEHALF OF BARNES, C, BEST, M, BORNHOLD, B, JOHNSON, F, PHIBBS, P, PIRENNE, B

NEPTUNE Canada, P.O. Box 1700, Stn CSC, Victoria, BC V8W 2Y2, Canada, mmrbest@uvic.ca

Data are streaming live from the Northeast Pacific, and these data are freely and openly available to the world through the Internet. They are provided by the NEPTUNE Canada regional cabled ocean observatory which spans the northern Juan de Fuca Plate. A zone of immense ocean richness, this is an ideal site for studying the dynamic interactions at the land/sea interface that drive oceanic cycles. The key factors in capturing the driving forces in this dynamic zone are temporal resolution and integrated linkages among disparate data types. NEPTUNE Canada provides the continuous power and bandwidth capacity to permit sampling of physical, chemical, geological, and biological gradients at temporal resolutions relevant to the volatility of the coastal system.

Most of the initial experiments, planned through workshops and international competitions, were installed at 4 out of the 5 network nodes during the summer of 2009. At inshore Folger Passage (Barkley Sound, west Vancouver Island), controls on biological productivity are used to evaluate the effects of marine processes on invertebrates, fish and marine mammals. Experiments around Barkley Canyon quantify changes in biological and chemical activity associated with nutrients and cross-shelf sediment transport at the shelf/slope break and through the canyon. Along the mid-continental slope, exposed and shallowly buried hydrates allow monitoring of changes in their distribution, structure, and venting, and relationships to earthquakes, slope failures and plate motions. Circulation Obviation Retrofit Kits (CORKs) at mid-plate ODP 1026-7 boreholes will monitor real-time changes in crustal temperature and pressure, in response to earthquakes, hydrothermal convection or plate strain. At Endeavour Ridge (instruments installed summer 2010), complex interactions among volcanic, tectonic, hydrothermal and biological processes will be quantified at western edge of Juan de Fuca plate. Across the network, high resolution seismic information elucidates tectonic processes and earthquakes, and a tsunami system determines open ocean tsunami amplitude, propagation direction, and speed. The infrastructure has capacity to expand and we invite participation in experiments, data analysis, and technology development; for information and opportunities: **http://www.neptunecanada.ca**.

Building this $100M facility over the past decade required integration of hardware, software, and people networks. Hardware developed and installed includes: 800km powered fibre-optic Backbone cable; Nodes and Junction Boxes; mobile platforms including a Vertical Profiler and a seabed Crawler, and scores of Instruments. The vast majority of this complex hardware network is operating successfully following installation, a coup in these extreme environments. A significant part of this success is due to the logistical support of the ROPOS ROV. In parallel, software and hardware systems are acquiring, archiving, and delivering continuous real-time data. A web environment to combine this data access with analysis and visualization, collaborative tools, interoperability, and instrument control is in place and expanding. A network of scientists, engineers and technicians is contributing to the process in every phase.

NEPTUNE Canada will transform our understanding of biological, chemical, physical, and geological processes across an entire tectonic plate from the shelf to the deep sea (17-2700m). Real-time continuous monitoring, archiving, and long time series allows us to capture the temporal nature, characteristics, and linkages of these natural processes in ways never before possible.

SESSION 3. ECOLOGICAL BASELINES: FROM FORESTS TO FISHERIES TO PEOPLE

TERRESTRIAL ECOSYSTEMS OF BARKLEY SOUND

ANDY MACKINNON

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Summary
Barkley Sound is a body of water. But Barkley Sound, considered broadly, includes all of the lands that drain into Barkley Sound. This is analogous to the adjacent Clayoquot Sound (to the northwest) which is generally perceived as including both terrestrial and marine components.

The terrestrial components of these West Coast Vancouver Island systems range elevationally from low elevation and montane Coastal Western Hemlock to subalpine Mountain Hemlock, and climatically from the west coast's very wet hypermaritime to the very dry maritime ecosystems of eastern Vancouver Island on the northern end of Barkley Sound (1). Total annual precipitation within Barkley Sound ranges from about 1 meter to more than 3 meters. Its terrestrial ecosystems are predominantly coniferous forest, with smaller areas of deciduous or mixed forests (riparian or otherwise disturbed) and non-forested areas such as wetlands.

Barkley Sound's terrestrial ecosystems are part of the coastal temperate rainforest biome (2). These ecosystems support many species of plants, animals, fungi and lichens, including species that are listed as threatened and endangered by BC's Conservation Data Centre. These temperate rainforests are distinctive globally in that fire is not an important disturbance agent. Because of this, a century ago, most of Barkley Sound's forests were old-growth forests. Today, the vast majority have been logged and converted to second-growth forests.

And in a wet, west coast environment, these terrestrial ecosystems are all upstream from the coastal and marine ecosystems that are the focus of this Symposium. That means that anything that affects these terrestrial ecosystems will be felt in the freshwater and marine realms.

Integrated ecosystem management must consider management of the entire (terrestrial, freshwater and marine) ecosystem if it is to be effective. This principle should be included in Integrated Ecosystem Assessments and related reports. This Symposium is focused on marine ecosystems; future Symposia should include consideration of terrestrial ecosystems in their deliberations.

Methods or mode of knowledge

The ecosystem maps (biogeoclimatic subzones and variants) are from BECWeb (3). The ecosystems described are from the Vancouver Region field guide (1). Forest cover maps are compiled from several different government and forest company sources and updated with SPOT imagery. Satellite images 1973 and 2009 are from LANDSAT.

Results or observations

To be determined (analyses underway).

Discussion and conclusion

Integrated ecosystem management must consider management of the entire (terrestrial, freshwater and marine) ecosystem if it is to be effective. This principle should be included in Integrated Ecosystem Assessments and related reports. Future Symposia should include consideration of terrestrial ecosystems in their deliberations.

Key words

terrestrial ecosystems, temperate rainforest, old-growth forest, ecosystem management

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OVERVIEW OF SURVEYS CONDUCTED BY FISHERIES AND OCEANS CANADA ON INVERTEBRATE STOCKS IN BARKLEY SOUND

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Summary

The Shellfish Section of the Department of Fisheries and Oceans (DFO), Science Branch, Marine Ecosystems and Aquaculture Division conducts a variety of surveys on invertebrate stocks in Barkley Sound. These surveys are designed to address a wide range of objectives, ranging from estimating abundance and monitoring trends in biomass for the management of commercial fisheries and species at risk, and monitoring trends in biomass and dispersion of non-indigenous and invertebrates. Species that are targetted for surveys include sub-tidal (geoduck, sea urchin, sea cucumber, abalone and shrimp) and intertidal (Manila, littleneck, and butter clams and Olympia oyster) species. Surveys of

non-indigenous and potentially invasive species focus on intertidal bivalves, gastropods and crustaceans.

Methods or mode of knowledge
Dive/transect survey methodolgy is employed to estimate geoduck, red sea urchin, sea cucumber, and abalone density. For shrimp, a fishery-independent trawl survey, using an excluder device with 78 mm spacing, is conducted annually from the Coast Guard Research Vessel Neocaligus. This survey is primarily directed at monitoring annual trends in shrimp populations, however all catch is identified and weighed to provide ecosystem information on co-occuring species. Beach transect, quadrat, and trapping surveys are conducted in the intertidal region, from which the majority of non-indigenous species present in Barkley Sound have been identified. All survey data are georeferenced and reside in databases maintained by the Shellfish Data Unit, Pacific Biological Station, Nanaimo B.C.

Results or observations
The surveys for geoduck, sea urchin, sea cucumber and shrimp have been primarily in support of fisheries management to ensure sustainable harvest. Abalone surveys are conducted to evalute the efficacy of rebuilding initiatives as well as to provide advice on broodstock collection. Surveys of non-indigenous and potentially invasive species commenced in 2006 and have focused on intertidal bivalves, gastropods and crustaceans. Several species (Japanese oyster drill, European mouse-ear snail, New Zealand mudsnail, European flat oyster, Japanese green mussel) were reported from Barkley Sound for the first time as a result of these surveys. In concert with these surveys, a trapping program to examine abundance and distribution of European green crab was carried out. This led to a long-term population monitoring program in Pipestem Inlet.

Discussion and conclusion
The intent of this paper is to inform those involved in Barkley Sound sustainability planning of the various studies that DFO is conducting on invertebrate stocks in the area. Although the overview of surveys presented in this report is primarily species specific, they are an important component of the data required as input into ecosystem management and sustainability planning.

Key words
Invertebrates, stock assessment, invasive species, surveys,

An Archaeological Perspective on the Hake Fishery in Barkley Sound

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Summary
Today, Hake (*Merluccius productus*) are an ecologically and commercially important fish species in Barkley Sound. A number of studies demonstrate that hake populations fluctuate in relation to recent climatic and ecosystem changes[1,2,3] but few studies have examined the long term abundance of hake in Barkley Sound[4]. This preliminary study investigates the prehistoric hake fishery using

zooarchaeological analyses of archaeofauna recovered from two archaeological sites in Barkley Sound.

Methods

I participated in the archaeological excavation and subsequent laboratory analysis of fish remains recovered from Tseshaht First Nation and Huu-ay-aht First Nation village sites in the Broken Group Islands and the Deer Group Islands respectively[5,6]. I examined fish remains using the comparative osteological collection at the University of Victoria and identified fish specimens from a variety of spatial and temporal contexts dating to within the past 5,000 years. I created a regression-based equation for estimating hake total length (quadrate widths from 8 known-length specimens, R squared value =0.98) and applied it to a sample of archaeological hake specimens (n=202).

Results

Hake are present in all three sites in deposits which date to between 5000 yr BP and 250 yr BP. Hake abundance differs considerably between the examined sites which appear to reflect a combination of local ecological factors and distinct cultural preferences. Regression-based length estimates indicate archaeological specimens have a size range of 33-58 cm which is larger than the mean adult spawning age of 30cm[1]. Hake abundance rises considerably between approximately 700-1500 yr BP and drops after approximately 700 yr BP.

Discussion and conclusions

This preliminary and ongoing study suggests that hake contributed significantly to aboriginal fishing activities in Barkley Sound and yet hake abundance fluctuated considerably over broad time scales. This presenter seeks input and perspective on these results from audience members.

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Huu-ay-aht First Nation Marine Resources Inventory

Dennis Morgan

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Summary
In 1998 a series of Marine Resource Maps were prepared for the Huu-ay-aht First Nation as an important pre-treaty exercise. Nine maps were prepared ranging in subject from the biophysical layout of the HFN Traditional Territory to distribution of kelp and shellfish, to anadromous salmon distribution, to location of offshore fishing and marine mammal harvesting sites. This presentation will discuss the preparation of these maps including data sources (extensive Traditional Use Study sources were consulted) and GIS techniques for map preparation.

Session 4. Posters

Ucluelet Harbour: A Safe Landing, But Does It Provide Safe Food?

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Summary
The name "Ucluelet" comes from the Nuu-chah-nulth word meaning "safe landing place". The associated harbour has a long history of providing safety and food for coastal communities, such as the Ucluelet First Nations, and more recently, the District of Ucluelet. Industrial activity in Ucluelet Harbour ranged from a mill in the late 1800s, through canneries, fish buying stations, reduction plants, and processing facilities in the mid-1990s, through to today's bustling ecotourism industry and commercial fleet. Although the protectiveness of the harbour hasn't been compromised by these activities, the safety of the food has. For instance, clam harvesting, a main food source for early harbour dwellers, has been closed within Ucluelet Inlet since 1972. And although crabbing is still open, many Ucluelet First Nations members have expressed concern over the health of the meat due to industrial contamination. Although Ucluelet membership acknowledges a growing dependence on purchased foods, many people continue to use traditional foods because they are more economical, have greater nutrient value, and provide a connection with cultural values. Over the past decade, the Ucluelet First Nations has been working with area groups to clean up the harbour and to begin to quantify the toxicological integrity of important seafood resources, such as clams and crabs. This

presentation will focus on describing the crab community in Ucluelet Harbour and the toxicological safety of the food source. This will describe the integrity of an import indicator of the health of Ucluelet Harbour.

Methods

Regular crab monitoring was conducted in Ucluelet Harbour between June and October 2008. Traps were left in the harbour for a 24-hour soak, and when collected, the crew measured the crabs for size and shell hardness and noted sex and injuries. Twice during the sampling period samples were collected for heavy metal toxicological analysis by Bodycote Testing Group in Surrey.

Results

The abundance survey of crabs noted healthy populations in early summer. August and September was more soft-shell and female crabs captured, thus potentially indicating a less desirable time to fish. In late October, the number of "keepers" increased again. Further work will increase understanding about optimal crabbing periods and about the overall health of the crab population. The toxicological portion of the research looked for the presence or mercury and 32 other metals in the crab meat. The fall samples came back with very low levels of all metals tested, but the summer samples showed very high levels of arsenic. The meat was within safe levels for all other metals at that time.

Discussion

Although the concentration of arsenic was high in Ucluelet Harbour crabs in the summer, this is not necessarily a reason for concern. One must consider the concentration of contaminants in the food and the rate of consumption of that food in order to determine the level of exposure for a given period of time , and thus the risk. The benefits of eating local foods tend to outweigh any potential contamination concerns. Ucluelet Harbour crabs contain extremely high levels of calcium, as well as high levels of zinc and iron. These alone may play a protective role against the contaminant toxicity.

Key words

Food safey, toxicology, crab abundance, ecological indicators

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Monitoring Coastal Erosion and Climate Change/Variability Impacts in Pacific Rim National Park Reserve

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Summary

In 2008-2009 a geoindicators monitoring program for coastal erosion and climate variability impacts was developed for Pacific Rim National Park Reserve (PRNPR) to provide timely information on the state of the park and to inform parks management actions. This presentation draws specific focus to Wickaninnish Beach, which supports one of the largest beach-dune systems on Vancouver Island.

Methods of monitoring include repeat cross-sectional and full topographic surveys, repeat vantage photographs, airphoto analysis, and analysis of the wind, wave, and water level regime.

Results, to date, are informative only of seasonal changes. Longer-term monitoring will better reveal contemporary erosional/depositional trends of the beach-dune system. Airphoto analyses show that Wickaninnish Beach has prograded at a rate of 0.2 m a^{-1} from 1973-2007 and over this period dune sand surface extent was reduced by 27.8%[1]. Progradation can be attributed to a fall in relative sea level caused by regional tectonic uplift[2] anda high dune rebuilding potential (aeolian sand transport potential = 59871.22 m^3m^{-1}, resultant aeolian sand transport = 19383.31 m^3m^{-1}, over 9434 hours). Loss of the dune sand surface is indicative of dune stabilization by native and invasive vegetation (e.g., *Ammophila arenaria* or European beach grass) likely due to recent increasing air temperatures and precipitation trends associated with climate change[3].

Erosive water levels are reached 4.3 a^{-1}, as determined via superimposing calculated water levels on cross-sectional profiles. Statistical relations show that average monthly observed water levels are significantly correlated to the Pacific Decadal Oscillation (PDO), the Northern Oscillation Index (NOI), and the Multivariate El Niño Southern Oscillation (ENSO) Index (MEI), and the monthly maximum observed water levels are also significantly correlated to NOI and MEI. The strongest correlation ($r = -0.346$) is between the mean monthly observed water levels and NOI. This suggests that climate variability signals are manifest in regional erosional water level regimes.

Methods

Four cross-sectional profiles in the Wickaninnish beach-dune system are surveyed annually to provide insight to annual trends in erosion/deposition of beach and backshore sediments. Airphoto analyses yield insight to longer-term historical changes in shoreline position, open dune sand surface, and large woody debris cover. As of September 2009, monthly full topographic surveys have been conducted to monitor 3D morphological responses to a dune restoration initiative. Control for these surveys (GRS1980) was established on Wickaninnish Beach using Real Time Kinetic (RTK) methods. Repeat vantage photographs provide a qualitative record of changes.

Profiles were corrected to Chart Datum (CD) by adding 2.095 m to the GRS 1980 elevations[4] and wave runup (a defining measure for dune erosion) was also calculated[5]. Total water levels (TWL) were superimposed on the cross-sectional profiles to determine the frequency of erosive water levels that exceeded the beach-dune junction. A bivariate correlation was also performed between monthly observed water levels and available climate variability indices (MEI, NOI, PDO) to examine the strength of shared variance using Pearson's Product Moment Coefficient (r). Rebuilding potential was estimated through analysis of the wind regime competent to transport beach sands using WRPLOT View and calculation of sediment transport potential[6].

Results

To date, repeat topographic profiles have shown general seasonal changes (e.g., build up of the beach summer profile). Longer-term monitoring should be more revealing of contemporary trends. Monthly full topographic surveys will reveal quantitative data on volumetric changes and morphological responses within the beach-dune complex and derived values (e.g., sand flux) may also be correlated to climatic variability indices. Airphoto analysis shows that Wickaninnish Beach is prograding at a rate of 0.2 m yr^{-1} over the period of 1973-2007 and, during this time, open dune sand surface extent declined by 27.8% indicating stabilization by vegetation. The NOI showed the strongest significant relationship with both regional monthly mean (r = -0.346) and maximum observed water levels (r=-0.185). Erosive water levels are reached 4.3 a^{-1}. Analysis of the wind record revealed a bimodal wind regime, with WNW winds predominant in the summer months and SE winds predominant in the winter months. Sand transport potential was 59871.22 m^3m^{-1} and resultant aeolian sand transport potential was 19383.31 m^3m^{-1} over a period of 9434 hours.

Discussion and conclusion

The Wickaninnish dunes are aligned with predominant WNW summer winds. This alignment is likely due to both the shoreline orientation at Wickaninnish and a higher winter aeolian transport threshold resulting from increased precipitation. While the beach is eroded annually in response to high water level events, the historical airphoto record has shown a trend of shoreline progradation. This can be attributed to regional tectonic uplift. In addition, the calculated aeolian sediment transport potential is high (59871.22 m^3m^{-1}) and could support rapid dune rebuilding and possible progradation over time. This suggests that the risk of beach-dune ecosystem loss due to erosion is low, provided onshore sand supply does not decrease appreciably. However, stabilization trends and invasion by *Ammophila arenaria* threaten the beach-dune morphodynamics and ecosystem integrity. In addition, erosive events will continue to pose challenges for managing park infrastructure, particularly with increasing climatic variability trends and identified linkages to regional mean and maximum observed water levels.

Through correlations between water levels and NOI, ENSO was shown to have the strongest relationship (negative) with both mean and maximum monthly observed water levels. This suggests that the extra-tropical effects of ENSO are received in the region. In particular, negative NOI values (El Niño conditions) may force high water events and, therefore, in strong El Niño years, PRNPR can expect more extreme water level events. Whether this relates to regionally amplified water levels due to thermal expansion effects, or changes in the wave climate, remains to be explored.

Key words

beach, dune, erosion, climate variability, geoindicators

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Exploring the feasibility of Wizard Islet as an indicator of rocky intertidal communities in Barkley Sound

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Summary

Time series data such as those collected on Wizard Islet, in the Deer Group Islands in Barkley Sound, can be useful for monitoring large, long-term impacts and intertidal community responses to anthropogenic effects, and may also be valuable in the establishment of reserves and marine protected areas (Gillman, 2006). By investigating the intertidal communities in comparable locations within Barkley Sound, we evaluated the island's potential use as an indicator representing the habitats in this area. After sampling Dixon Island, Aguilar Point, and one of the Ross Islets using protocol consistent with that used on Wizard Islet, our results revealed significant differences in species composition among sites. In light of these differences, we cannot conclude that the intertidal community of Wizard Islet is sufficiently representative of Barkley Sound as a whole to serve as a general indicator of the biological communities in the region, though observed long term changes at Wizard Islet may have value by itself. We recommend more detailed characterization of individual locations to obtain accurate information about the variability of responses to climate and oceanographic variability in Barkley Sound and the broader region.

Methods or mode of knowledge

Time series data has been collected for Wizard Islet's intertidal system since 1997 (Cowan et al., 1997). For comparison purposes, three other locations, Dixon Island, Aguilar Point, and one of the Ross Islets, were sampled in a manner consistent with the time-series protocol used on Wizard Islet. Small (0.25mx0.25m) and large (0.5mx0.5m) quadrats were used to sample five transects per site. We recorded percent cover of algae and sessile invertebrates and enumerated four species of motile invertebrates. Relative wave exposure information was collected using a LifeSaversTM candy test. Multidimensional scaling (MDS) and analysis of similarity (ANOSIM) tests were run in Primer to assess similarities between tidal heights and sites.

Results or observations

Species composition of both sessile and motile biota differed significantly among all sites. Several major trends in the greatest species contributors to dissimilarity were consistent with literature findings on exposure trends (Bell, 1997; Ackerman & Nishizaki, 2004; Helmuth & Denny, 2003; Gilman, 2006; Jonsson et al., 2006; Paine 1987; Lubchenco, 1983). No significant differences between exposure at Ross, Aguilar, and Wizard were found, although Dixon was significantly higher than Ross and Agulair.

Discussion and conclusion

Our results indicate significant differences in species composition among the sites at Wizard Islet, Ross Islet, Aguilar Point, and Dixon Island. Due to these differences, we cannot conclude that the intertidal community of Wizard Islet is sufficiently representative of Barkley Sound to be used as a general indicator for the community composition, responses to stressors and variability in the region. However, it should be noted that the keystone species *Pisaster ochraceus* (the Ochre Seastar)did not differ in abundance among sites; it is possible the ANOSIM overestimated functional dissimilarities among sites. We suggest that future research efforts focus on more detailed characterization of the area and analyze the species data obtained from different perspectives, for example, adjusting for keystoneness.

Key words
wave exposure, LifeSaversTM test, Ross Islets, Dixon Island, Aguilar Point

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MONITORING CRITICAL FISH HABITAT: EELGRASS AND FORAGE FISH SPAWNING BEACHES IN BARKLEY SOUND.

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Summary
Eelgrass, *Zostera marina*, is at the base of an extremely productive nearshore ecosystem[2]. Eelgrass provides a critical habitat for fish, invertebrates, birds, and mammals[2]. Seagrass habitats worldwide are monitored as indicators of marine ecosystem health. Eelgrass provides an essential spawning habitat for herring. Many species found within eelgrass meadows factor significantly in our local economies as well as the social and spiritual well-being of coastal communities.

Certain intertidal sandy/gravel beaches are critical spawning habitat for beach spawning forage fish species Pacific sand lance, surf smelt and capelin[1]. Forage fish species are critical to ecosystem

function[1]. Successfully rebuilding endangered populations and local salmon stocks may rely, in part, to protecting local forage fish stocks and their critical spawning habitats[1].

The Huu-ay-aht/Bamfield Eelgrass Stewardship program (HBESP) was initiated in 2002. The HBESP maps and monitors eelgrass beds in Barkley Sound. The program has expanded to include monitoring and mapping intertidal forage fish spawning habitats.

Methods or mode of knowledge

Eelgrass beds are mapped by using divers and an underwater camera. Eelgrass plant density, length and width measurements are also taken. Data are housed on the BC Eelgrass Atlas housed on the Community Mapping Network. Fish diversity data, collected in the summer and fall, are obtained using a beach seine. A total of eight eelgrass beds are monitored in a 2-year rotation. Recently, the program has expanded to include monitoring for the eelgrass wasting disease.

Results

Eelgrass beds were initially mapped within a four-kilometer radius of the Bamfield Marine Sciences Centre. The program has been expanded and eelgrass beds have been mapped along the coastline of the Sarita watershed and the Deer Group Islands.

Through the Bamfield Marine Sciences Centre university program, several undergradate university students have contributed projects to the program to assist with understanding eelgrass health and fish communities.

Discussion and conclusion

Major commercial fish stocks have declined throughout the Barkley Sound region. These fisheries have historically been important to the cultural and economic stability of both the Huu-ay-aht First Nation and the fishing community of Bamfield. As a major component of the nearshore ecosystem, impairment of eelgrass systems has far reaching effects on the health and productivity of marine environments.

Since 2002, The Huu-ay-aht Bamfield Eelgrass Stewardship Program has collected valuable baseline data. With the expansion of the program to include additional forage fish species spawning habitats (surf smelt and Pacific sand lance), the monitoring program will continue to contribute valuable biological data needed for ocean zone planning.

Key words

Eelgrass, Barkley Sound, Huu-ay-aht, forage fish, surf smelt, Pacific sand lance, herring, salmon, community mapping network.

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THE SIGNIFICANCE OF ORAL HISTORIES OF THE 1700 CASCADIA EARTHQUAKE

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Summary
The January 26 1700 Cascadia Earthquake (M~8.5) was only directly witnessed by First Nations people and although there are no first-hand written accounts of its physical or human impact, we have transcripts of two important oral histories from Vancouver Island, one from the Qu'wut'sun (Coast Salish) of the Cowichan Valley area[1], and one from the Huu ay aht (Nuu Chah Nuulth) of the Barkley Sound area[2]. These oral histories are described and interpreted in the context of our modern knowledge of this major earthquake—based on physical evidence obtained from various sites along the coast from Vancouver Island to Oregon—and they prove to be remarkably accurate accounts of the events of 310 years ago. The potential impacts of future subduction-related earthquakes on the Barkley Sound region are discussed in light of this indigenous knowledge.

Methods or mode of knowledge
First Nations oral histories have been interpreted in light of our existing knowledge of the 1700 Cascadia Earthquake, knowledge that has been derived from sedimentological, dendrochronological, seismological, geophysical and oceanographical evidence gathered along the western coast of North America and in Japan, and from an understanding of the plates and plate motions of this region.

Results or observations
First Nations accounts—stories that passed through almost 300 years of generation to generation oral transmission—provide useful information about the 1700 Cascadia Earthquake. Based on our current understanding of this earthquake, these accounts appear to be highly credible in respect of the timing of the earthquake and duration of its aftershocks, the time lapse between the initial shock and the arrival of the first tsunami wave and the destructiveness of the tsunami waves. They provide a perspective that we have no other way to acquire.

Discussion and conclusion
The west coast of North America, from Oregon to southern British Columbia, is subject to large subduction-related earthquakes, and although we cannot predict the timing of the next one, the likelihood of its occurrence increases with each passing year. Scientific knowledge of earthquakes and tsunamis helps us to prepare for the next one, but only first-hand accounts can bring home the reality of their destructiveness. Not only do the two oral histories described here provide a unique perspective on the 1700 earthquake, their credibility demonstrates that such accounts can be a useful adjunct to direct observations in many fields.

Key words
1700 Cascadia Earthquake, tsunami, oral histories, Coast Salish, Nuu-Chah-Nulth

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FISH/SHELLFISH COMMUNITY STRUCTURE IN BARKLEY SOUND

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Summary

The understanding of fish community structure is an essential component of ecosystem based fisheries management [1, 2]. For the purposes of ecosystem modeling, fisheries management, and stock assessment, fishery independent trawl surveys are often conducted, which usually result in complex bodies of biotic and environmental data. These complex multi-dimensional data require effective analytical approaches in order for the distributional patterns and inter-species / species-environment relationships to be extracted. In this study, we applied a practical multivariate analysis strategy [3] to the data from shrimp research trawl surveys conducted in the Barkley Sound from 1998-2008 so as to understand how the fish/shellfish community differed spatially and temporally, how these changes were linked to certain environmental variables, as well as species co-occurrence and potential interspecies interactions.

Methods or mode of knowledge

The shrimp research surveys have carried out 427 tows over all the years and have resulted in 66 species/groups that have been recorded at least once. The starting point for the multivariate analyses is the concept of similarity between any pair of tows in terms of the fish/shellfish community. Bray-Curtis Similarities on the square-root transformed biomass data of the 66 species were calculated between every pair of tows, and two tows were considered perfectly similar only if they contain the same species in exactly the same biomass. The similarities were displayed on two -dimensional plots through non-metric Multi-dimensional Scaling (MDS) provided in PRIMER v. 6 [4]. The two-way nested Analysis of similarities (ANOSIM) was used to test for the degree of dissimilarity between years and depth strata, and RELATE for testing spatial and temporal seriation. The BEST routine was applied to narrow down the complete species list to a fewer species that would “best explain” the pattern of the full assemblages for aiding to explain causality between biota and environment. MDS on 41 species with frequency of occurrence being greater than 4% was conducted for inferring species co-occurrence and interspecies interactions.

Results or observations

Multivariate analyses showed that biotic differences between adjacent depth strata (< 75, 75-125, > 125 m) were much greater than differences between adjacent years. Biota showed significant spatial seriation, i.e., adjacent tow stations tended to have more similar community structure. There was also strong temporal seriation with the community structure differing from that of 1998 gradually further as the time progressed to 2004, however, there appeared to be a turn-around in 2005. The smallest possible subset of eight species/groups (Eelpouts, Eulachon, Flathead sole, Pacific hake, Sidestripe shrimp, Slender sole, Smelts, and Smooth pink shrimp) were identified to be the influential ones whose Bray-Curtis similarity matrix correlated at with the similarity matrix for the full set of 66 species. These species tended to dominate in different areas.

Discussion and conclusion

These multivariate analyses helped us to understand how the fish/shellfish community differed spatially and over time, how these changes were linked to certain environmental variables, and how species co-occurred and potentially interacted. Such knowledge is invaluable for ecosystem-based integrated management of the Barkley Sound.

Key words

Fish/shellfish community, multivariate analyses, spatial/temporal seriation, species co-occurrence.

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Fossil diatoms as indicators of past hydrological and climate variability in Barkley Sound, British Columbia

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Summary

Diatoms are single-celled siliceous algae forming the base of the marine food chain along temperate coasts.[1] Sensitive to environmental conditions, the abundance and composition of the fossil diatom assemblages preserved in the coastal sediment record allows us to reconstruct past environmental conditions. Coastal inlets represent an interface between marine and terrestrial systems and act as excellent sites for the analysis of past environments, via a paleoenvironmental approach.[2] In Effingham Inlet, a small fjord within Barkley Sound, fossil diatom assemblages analyzed from the sediment record suggest highly variable ocean-climate conditions over the last millennia.[3] Our results suggest that spring hydrologic conditions since 1950 AD differ from the previous 1500 years, with the earlier records suggesting a mixed spring discharge regime of rain and snowmelt sources as opposed to the rainfall dominant regime of the last 60 years.[3] Furthermore, the sudden appearance of "new" diatom species in the sediment record within the last 500 years hints at a regional shift in environmental conditions.[4]

Methods or mode of knowledge

A box and Kasten core were collected from the inner basin of Effingham Inlet and sediment subsamples were analyzed for diatom assemblages. Chronological control was constrained by a dozen radiocarbon dates, varve counts, as well as lead-210 and cesium-137 dating methods.

Results or observations

Abrupt shifts in diatom abundance and composition were noted along the 1500 year record. Assemblages reflecting typical marine spring bloom conditions were occasionally replaced by brackish water diatoms. Multiple lines of evidence suggest these brackish conditions reflect a greater freshwater input into Effingham Inlet at the time, likely related to greater snowmelt in the watershed. Three diatom taxa emerged as major components of the microflora in the inlet over the last 500 years. These species had only a very sporadic occurrence and minimal abundance over the previous 4500 years.

Discussion and conclusion

Effingham Inlet represents an excellent archive of changes in regional oceanographic and climatic conditions.[2,5,6,] Diatom analyses reveal that late 20th century freshwater input into Effingham Inlet was reduced relative to the previous 1500 years, likely related to a reduced snowpack within the watershed. This reduced spring discharge favoured greater spring diatom production and fewer bottom-water renewal events. The past millennium was marked by abrupt shifts in hydrological conditions and marine conditions. Superimposed on this variability was the appearance of three diatom species that became major components of the modern diatom flora. Although appearing as a sudden bloom of introduced "exotic" species, analysis of 5000 years of sediment record shows that these species were sporadically present in Effingham Inlet in the past although conditions apparently favoured neither their establishment nor dominance. Their recent establishment would suggest a change in the regional marine conditions, however, there are no clear patterns emerging from the sediment record. Future studies will explore the regional spatial and temporal scale of these species appearances and pursue regional reconstructions of past changes in marine conditions over the last millennium.

Key words

diatoms, hydrology, paleoenvironments, sediments, climate

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A NEW SPECIES OF THE GENUS TETHYA (PORIFERA, DEMOSPONGIAE) FROM BARKLEY SOUND, VANCOUVER ISLAND, CANADA*

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Summary

Sponges of the genus ***Tethya*** (Porifera, Demospongiae, Hadromerida) are represented in all seas, with a strong species record from tropical waters. For the Pacific coast of North America only one species is presently described: ***Tethya californiana*** de Laubenfels 1932 [1], which is common in the shallow waters of Southern Californian. Originally described as ***Tethya aurantia*** var. ***californiana***, it was redescribed in 1993 by Sarà and Correiro as a valid species [2]. Here we report the finding of a new species from the North-American Pacific area: ***Tethya*** sp. nov.* from Barkley Sound near Bamfield, British Columbia, Canada. To our knowledge it is the first new sponge species described from a type locality within Barkley Sound.

This abstract/poster is not issued for any purpose of zoological nomenclature. A detailed species description is presently in revision in Zootaxa.

Methods

Specimens of ***Tethya*** sp. were collected by Sally P. Leys (Edmonton, BC) in the shallow infralittoral (10 - 25 m depth) near Ohiat Islet (48°51'3.00'' N, 125°11'60.00'' W). Cytochrome Oxidase Subunit I mtDNA gene (COI) was amplified, sequenced and compared to ***T. californiana*** COI (AY561978) and other species in a phylogenetic analysis (PAUP, MrBayes, RAxML) [3, 4]. The morphology of both species was qualitatively and morphometrically analyzed using light/scanning electron microscopy [4] as well as x-ray-microtomography and virtual 3D reconstruction [5-7].

Results

COI analysis shows that ***Tethya*** sp. nov from Barkley Sound is closely related to ***T. californiana***. Nucleotide and translated aa sequences differ by 4bp, respectively 2 aa (0.93%). Morphologically both species are similar in external morphology (globular shape, red to orange color, size up to 12 cm, occasionally larger). ***Tethya*** sp. nov differs from ***T. californiana*** in the following characters: surface conulose; non-alveolar massive cortex dominated by an extremely dense megaster accumulation; the morphometric values of the megasters differ between the two species and the oxyspherasters rarely display bent rays.

Discussion and conclusion

The genetic distance of the CO1 sequences of ***Tethya*** sp. nov. and ***T. californiana*** equals the distance among other species of the genus. The morphological similarities are only superficial, with the body shape representing a plesiomorphic character and color as well as size. Many morphological

characters (SEM and x-ray microtomography of spicules/skeleton structures) also suggest that it is a valid new species.
At present the manuscript formally describing and naming the species is under final editorial revision. It will be named after the collector, who is a renowned Canadian sponge scientist. To our knowledge, it is the first sponge species described from Barkley Sound.

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Key words
Tethya sp. nov., COI, x-ray microtomography, skeleton, spicules

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GLASS SPONGES TAKE ADVANTAGE OF CURRENT-INDUCED FLOW

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Summary
Flow through sponges (Porifera) is thought to be enhanced by ambient current due to Bernoulli's principal, pressure differential, viscosity entrainments, or a combination of the three mechanisms. Vogel's test of this phenomenon suggested that current augmented by fanning live and inactivated (killed in freshwater) sponges increased the flow through the sponge. Glass sponges are an ideal subject with which to re-examine the hypothesis. Individuals are large (up to 1m tall), chalice-shaped animals, with a cavernous atrial cavity and a body wall less than 1cm thick that houses the flagellated chambers. Hexactinellids, alone among sponges, can instantly arrest their feeding current; such exact control over the feeding current seems counter-intuitive to a system based on passive flow.

We found that while glass sponges do pump and can control their flow by arresting the pump, they can also take advantage of passive flow.

Methods

We used Accoustic Doppler Velocimeters (ADVs) to measure flow velocities from glass sponges and ambient waterat 165m depth at the Fraser Ridge sponge reef in the Strait of Georgia, and carried out in tank experiments using ADVs in a flow flume, located at Bamfield Marine Sciences Centre, using specimens collected from Barkley Sound. Estimated flow through the sponge filtration system was calculated from measurements made from scanning electron micrographs.

Results

Week-long in situ ADV records illustrated that excurrent flow corresponded to local tidal rhythms (measured with a nearby current profiler). Ambient velocities above 25cm/s corresponded to excurrent velocity of approximately 5cm/s. Flow tank measurements with live and killed sponges confirmed that *Aphrocallistes vastus* pumps at 1-5cm/s and that an increase in ambient flow to 20cm/s generated a small increase in flow out of the sponge. In both experiments, the sponge pumping pattern occasionally deviated from the ambient flow suggesting it is able to control pumping irrespective of ambient flow. The effective velocity of water across the collar microvilli was estimated to be 0.6μm/s at an axial velocity of 1cm/s, and 2.8μm/s at an axial excurrent velocity of 5cm/s suggesting that a small increase in excurrent velocity translates into substantial increase in water processed by the sponge.

Discussion

Our results suggest that while glass sponges can control their excurrent flow velocities, they can and do also take advantage of induced current. We are presently modeling the flow through the aquiferous system of the glass and other sponges.

Observing suspension feeders graze: a NEPTUNE observatory in 3D

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Summary

Grazing by suspension feeding animals has been shown to have a massive impact on the overlying bodies of water, both by depleting it of micro and picoplankton, but in also recycling carbon and nitrogen either as larger sized fecal pellets that other animals can consume, or as CO_2 and ammonium which are re-circulated to surface waters providing nutrients for plankton. In Barkley Sound, glass sponges and tunicates are abundant on fjord walls and contribute substantially to the carbon turnover (Yahel et al, 2007). Despite targeting similar food sources, sponges and tunicates have very different

morphologies and physiologies and have had to develop distinct mechanisms for extracting food and for coping with the large amount of lithic material (clays) in coastal water.

There is evidence that both sponges and tunicates can quickly detect and respond to minute changes in pressure by arresting their feeding current. Pressure changes may signal turbulence bringing in unclean water. In tunicates small hair-cell structures (coronal organs) are implicated as mechanosensory receptors. Primary cilia on epithelial cells of demosponges may have the same function, and although similar structures are not yet known in glass sponges, they too respond to vibration passed through the water.

We took advantage of the opportunity presented by NEPTUNE to develop a 3D camera for observing the time-lapsed behavior of tunicates and sponges in situ. With NEPTUNE and Highland Technologies we have made a 3D camera that will allow calculation of minute changes in volume of animals as a proxy for behavioural responses to changes in the environment. Volume data will be correlated with real-time recordings of current, pressure, temperature, light and turbidity data provided by instruments at the NEPTUNE Folger Node.

Methods

The 3D camera consists of 8, 5 megapixel 'Grasshopper'Ô digital cameras mounted in watertight housings and controlled by a dedicated solid state computer. The cameras are mounted in a semi-circle such that each sees a different side of the organism. In house software developed at the U of Alberta calculates even more views not seen by any of the cameras and produces a single 3 dimensional image. The 3D images will allow us to estimate an approximate volume of the animal in every image and correlate minute behavioural changes with ambient pressure, turbidity and current recorded by adjacent instruments. The turbid environment of Barkley Sound adds challenge to the computing aspects of this project. The above system will be permanently deployed at the Folger Node of the NEPTUNE observatory at the entrance to Barkley Sound and be accessible online.

Discussion

Underwater imaging in 3D has recently been used to monitor corals on the Great Barrier Reef. This is the first experiment in 3D imaging in temperate turbid waters and is expected to provide valuable data for software development for imaging underwater.

Key words

Imaging; 3D; NEPTUNE; suspension feeding; tunicates; sponges; Observatory.

ARCHAEOLOGICAL EVIDENCE OF A POSSIBLE PALEO-TSUNAMI AT THE TL'AADIIWA VILLAGE, WEST COAST TRAIL, PACIFIC RIM NATIONAL PARK RESERVE

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Summary

Huu-ay-aht and Ditidaht First Nations on the southwest coast of Vancouver Island have numerous oral historical accounts describing severe geological events in the ancient past (i.e., megathrust earthquakes, tsunamis, landslides)[1,2]. Despite the potential for such events to leave distinct traces in the archaeological record[3] (especially in this geologically active region), few archaeological studies have discussed the relationship between specific anomalous stratigraphic layers and ancient tsunami events[4]. This presentation will discuss results from a 2007 archaeological excavation conducted along the lower Klanawa rivermouth[5], an exposed alluvial spit on the West Coast Trail.

Methods

With the support of representatives from Parks Canada, the Huu-ay-aht, and the Ditidaht First Nations, the author conducted archaeological excavations at the traditionally named *Tl'aadiiwa* village (Site 39T/DeSf 6). This mitigative archaeological project was undertaken prior to the installation of replacement footings for the Klanawa cable bridge which had been damaged during the January 2007 windstorm.

Results

Three 50x80 cm excavation units were placed in a row paralleling the river approximately 5m above high tide line. Excavations uncovered a series of highly stratified precontact cultural layers. Below these deposits was a massive (~40-70 cm) layer of mottled beach sand containing sparse rounded cobbles and minimal cultural material. Another layer of cultural deposits was present below this massive sand layer (~170-190 cm). Preliminary analysis of diatoms present in the sand indicate a marine origin and radiocarbon dates indicate this area of the village was abandoned for several hundred years before reoccupation.

Discussion and conclusion

This presentation will consider multiple hypotheses which explain the stratigraphic anomaly and explore the potential significance this record has for understanding the cultural history of this ancient village and region.

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PROTECTED AREAS AND POVERTY REDUCTION: A CANADA AFRICA RESEARCH AND LEARNING ALLIANCE

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Summary
This poster presents the research program: Protected Areas and Poverty Reduction, A Canada Africa Research and Learning Alliance funded under the SSHRC/IDRC International Community University Research Alliance. It is relevant to the Barkley Sound Knowledge Symposium for several reasons, primarily its focus on Knowledge Mobilization and the geographical focus on the West Coast of Vancouver Island, Tla-o-qui-aht Tribal Parks and Pacific Rim National Park. The project is in its first year so we shall not be presenting findings but rather outlining the purpose and objectives of the research and the research plan. The purpose of the research is to address challenges of reducing rural poverty and ensuring environmental sustainability by focusing on protected areas and their adjacent communities in the three countries (Canada, Ghana and Tanzania). The four themes of the research are: Governance, Human-wildlife Interactions, Costs/Benefits of Protected Areas and Knowledge Mobilization. The research is being undertaken by 17 partners in Educational Institutions (Vancouver Island University, University of Victoria, Guelph University, Sunyani Polytechnic and Kwame Nkrumah Universities in Ghana and the College of African Wildlife Management in Tanzania), NGO's (Tla-o-qui-aht First Nations Tribal Parks, CPAWS, Clayoquot Field Station, Nature Conservation Research Center and Geosanda Enterprises, Ghana, and the Kesho Trust in Tanzania) and Government Agencies (Department of Fisheries and Oceans and Pacific Rim National Park Reserve of Canada, Tanzania Wildlife Research Institute, Serengeti District Council, Tanzania, Ghana Wildlife Division, Brong Ahafo Regional Coordinating Council, Ghana). We hope to stimulate discussion on the role of protected areas in development and livelihoods and effective ways to mobilize knowledge generated by the project to improve human and community well-being.

Methods or mode of knowledge
This is a five year project involving researchers, students and practicioners from the three countries, Canada, Ghana and Tanzania. It will incorporate a variety of ways of knowing and research methods including indigenous knowledge, interviews, focus groups, case studies, document and literature analysis.

Discussion and conclusion
As above, but we shall also take the opportunity to engage participants in discussion of their research and observations about the role of protected areas in poverty reduction, livelihood creation, and development. This will be a knowledge mobilization activity for the project.

Key words
Protected areas, development, livelihoods, human wildlife interactions, governance.

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THE DISTRIBUTION AND ABUNDANCE OF KELP-DERIVED DETRITUS OFF THE WEST COAST OF VANCOUVER ISLAND

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Summary
The extirpation of sea otters (*Enhydra lutris*) from the B.C. coast led to dramatic changes in near-shore ecosystem structure and function. By feeding on herbivorous invertebrates sea otters facilitate the establishment and growth of young kelp. Species of kelp such as bull kelp (*Nereocystis luetkeana*) and small giant kelp (*Macrocystis integrifolia*) can form dense forests that are refuges for fish and invertebrate communities. These communities can be two to three times more productive than areas without sea otters due to the kelp-derived carbon (Duggins *et al.* 1989)[1].

Living kelp can be directly consumed by invertebrates or as particulate detritus as it decays, breaks away and sinks to the bottom of the ocean. Due to currents the kelp-derived detritus may be spread over large areas, subsidize the diets of organisms, and increase productivity outside the immediate area. We will determine the distribution and dietary importance to zooplankton and invertebrates of kelp-derived detritus off the west coast of Vancouver Island. This will be possible due to the fact that different trophic groups generally have distinct carbon isotope values.

Methods or mode of knowledge
Our sampling will take place in two near-shore areas. The first area is near Kyuquot where sea otters have been present for more than fifteen years and has well established kelp forests. The second is near Bamfield where sea otters are absent and kelp forests are severely reduced. Two replicate transects perpendicular to the coast will be established from each near-shore area, and will be sampled twice each year for two years. Sampling will be conducted at 0, 0.5, 1, 2, 4, 10 and 25 km stations from the coast. At each station we will collect surface particulate organic matter (POM) samples, and zooplankton and benthic community samples. All samples will be analyzed for fatty acids, as well as carbon and nitrogen stable isotope values. Food source fatty acid profiles combined with a two end-member mixing model will be used to determine the original carbon sources (percentage of kelp- or phytoplankton-derived).

Results or observations
The first sampling took place in July 2009 and to date no samples have been analyzed.

Discussion and conclusion
Similar research off of the Prince Edward Islands, South Africa has produced significant and interesting results. Kaehler *et al.* (2000)[2] found that although POM was the primary food source,

kelp-derived carbon accounted for >30% of the near-shore animals' diet. In addition, Kaehler *et al.* (2006)[3] found that kelp-derived carbon and nitrogen is an important dietary subsidy to benthic and plankton communities and is not limited in distribution to the immediate area surrounding kelp beds. We expect to find similar results and with the help of fatty acid and nitrogen stable isotope analysis to better identify discrete trophic levels.

Key words
kelp detritus, phytoplankton, stable isotopes, trophic cascades, nutrient subsidies

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Seasonal Abundance and Distribution of Steller Sea Lions in BC's Coastal National Park Reserves

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Summary

Steller sea lions (*Eumetopias jubatus*) were listed as a Species of Special Concern in 2003 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). One limitation to protecting sea lions is a lack of understanding of the type and level of haulout use by Steller sea lions in BC. The Department of Fisheries and Oceans identified seasonal distribution as a priority research action for species-at-risk management planning. Under the Canada National Parks Act and the Species at Risk Act, Parks Canada has responsibility to protect Steller sea lions and their habitat within its protected areas. Together, the Gulf Islands (GINPR), Gwaii Haanas (GHNPR) and Pacific Rim National Park Reserves (PRNPR) protect two rookeries, eight year-round haulouts and 17 winter haulouts in BC. Alarge number of pups and nursing females have been observed in PRNPR. Haulouts and adjacent nearshore areas used by juveniles and pups are considered critical habitat in Alaska (Raum-Suryan *et. al.* 2004). Given the rates of declining Steller populations in the western portion of their range, a greater understanding of Steller sea lion haulout use in BC is warranted.

The objectives of this project are to determine the seasonal abundance and distribution of Steller sea lions in BC's coastal national parks and to characterize haulout use by gender and age classes (pup, juvenile, sub-adult, adult).This study is the first to investigate seasonal haulout use by Steller sea lions in Canada. Results will provide managers with information necessary for management planning and species recovery.

Methods or mode of knowledge

Monthly surveys were conducted in PRNPR between January 2006 and October 2009. In 2008, one survey per season was undertaken GHNPR and GINPR. Sea lions were counted during surveys and a series of overlapping digital photographs were taken to later verify counts and to identify numbers of animals for each gender and age class (pup, juvenile, sub-adult and adult). Change in abundance between seasons was determined by calculating the percent change in total counts at each site between surveys. A >30% change in the number or sea lions at a site was considered significant.

Results or observations

Preliminary results indicate a significant change in the seasonal abundance of Steller sea lions at all haulouts in PRNPR and the GINPR, and at most park haulouts in GHNPR. A marked seasonal difference in the gender and age classes of hauled animals has also been observed.

Discussion/Conclusion

Changes in the seasonal abundance and distribution of Steller sea lions in BC is most likely linked to upward forcing and the seasonal distribution of prey fish. This research however, has not been undertaken in Canada. Identifying the seasonal prey targeted by Steller sea lions would help understand their ecology, and ultimately benefit Steller sea lion management in BC.

Key words Steller sea lion, *Eumetopias jubatus*, species-at-risk, abundance, distribution.

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DECISION-MAKING FOR ECOSYSTEM SERVICES: VALUES, PROCESS AND STRUCTURE

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Summary

Managing social-ecological systems involves issues of both complexity and legitimacy. This is especially true on the west coast of Vancouver Island, where the re-introduction of sea otters, along with development and changing fishery regimes, are liable to significantly affect how people in the region are able to earn a living. In situations like this, in order to arrive at acceptable outcomes, managers need to integrate robust biophysical science with an accurate understanding of groups' and individuals' multiple values.

One response to this challenge is the emerging 'ecosystem services' approach. ‘Ecosystem services’ (ES) is a term and concept used to describe the processes whereby ecosystems render benefits to humans. According to this framework, two issues are critical: 1) understanding and accounting for the benefits people derive from ecosystems, and 2) how people value those benefits. As both a concept

and framework for management, ES has begun to gain significant worldwide prominence. However, as with any new approach, there is criticism and skepticism (e.g. charges of market centrism, incompatibility with rigorous environmental ethics and noted weaknesses in representing cultural values and issues of equity). Can such criticisms be adequately addressed? If so, how? These are the guiding questions of our research initiative.

We aim to work with a range of groups and individuals in Clayoquot and Barkley Sounds, both to allow them a chance to express their values, and to experiment with various approaches to decision-making. Our findings comprise part of the wider British Columbia Coastal Ecosystem Services (BCCES) project, which is aimed at collecting an array of scientific data on ecosystem change in the region. The overaching goals of our contribution to BCCES are to (1) find new ways to identify and measure the diversity of values amongst various stakeholders, (2) test the potential of a range of decision-making processes for their ability to acceptably measure and account for values associated with ES and, (3) examine the relationship between peoples' understanding of ecosystem processes and those put forth by an ES approach**.**

Methods or mode of knowledge

Through workshops, we will compare three different approaches to decision-making: (1) a largely technocratic expert-driven ES decision process; (2) an approach based on the school of deliberative democracy; and, (3) another drawing from multi-criteria decision-making. The goal of each will be held constant in that we will seek to derive ranks for a common set of management alternatives from each process so as to compare their strengths and weakness and improve on current best practices in managing for ES. Our second major task is to examine the extent of consistency and commonality between ES models of ecosystem processes and services, and those held by local stakeholders through semi-structured interviews or workshops with locals. The interviews or workshops will be aimed at assessing how feasible and helpful it is to represent social-ecological systems in situ in terms of ES.

Results or observations

This proposed research will provide a novel, empirical and systematic investigation of environmental decision-making approaches using both quantitative and qualitative methods so as to address the many criticisms aimed at ES literature and practice.

Discussion and conclusion

Our research initiative will break new ground by synthesizing cutting edge ES literature with that on social choice and group decision-making in a practical policy context. Our findings, including the output of our workshops and the rich data set on locals' ecological worldviews and preferences will be invaluable for both local decision-making bodies as well as relevant academic audiences.

Key words

Ecosystem services; decision-making; traditional ecological knowledge; local knowledge; deliberation; multi-criteria decision-making; valuation; non-market values

FACTORS AFFECTING THE PRODUCTIVITY OF PACIFIC HERRING (CLUPEA PALLASI) FROM THE WEST COAST OF VANCOUVER ISLAND

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Summary

The biomass of Pacific herring (Clupea pallasi) from the West Coast of Vancouver Island (WCVI) has varied considerably and is currently at an historic low. Results of analyses suggest that recruitment (the production of new spawners) varies because of variations in prey (the euphausiid (krill) *Thysanoessa spinifera* longer than 17 mm) and predator (Pacific hake *Merluccius productus*) biomasses. Adult mortality rates increase with age and are also affected by prey biomass; there is no apparent effect of marine mammal abundance on adult herring survival. Size of recruit fish is determined by prey biomass during each of the first three years of life. Size of older fish is a consequence of recruit size and is not affected by prey availability or the biomass of fish feeding on krill. It appears that the current status of the WCVI herring population is a consequence of depressed T. spinifera production.

Methods or mode of knowledge

This analysis took advantage of a time series (1972 – present) of sampling of herring from the West Coast of Vancouver Island (Barkley, Clayoquot and Nootka sounds), a time series (1985 – present) of fisheries oceanographic surveys along the southwest coast of Vancouver Island (see Tanasichuk et al., 1991) and a time series of euphausiid (krill)/zooplankton biomass from Barkley Sound (see Tanasichuk, 1998 a,b) which appears to be relevant to continental shelf waters.

Results or observations

WCVI herring biomass has varied substantially and is currently at an historic low. Size-at-age has been declining since 1985. Results of fisheries oceanographic surveys show that herring offshore feed exclusively on euphausiids (*T. spinifera, Euphausia pacifica*) longer than 17 mm and that herring are consumed by Pacific hake, the traditionally dominant fish species along the WCVI (Tanasichuk et al., 1991). Variation in recruitment to the WCVI herring population is explained by variations in: 1) the biomass of *T. spinifera* in August, the rapid growth period, during each of the first three years of life, and 2) the biomass of piscivorous (fish-eating) Pacific hake during the herring's first year of life (Tanasichuk, Submitted a). Adult mortality rates increase as fish get older but are also affected by the biomass of *T. spinifera* in August (Tanasichuk, Submitted b). August is the rapid growth period and it appears than mortality increases when prey biomass limits the amount of energy that can be stored for over-wintering and the development of eggs and milt. Variations in humpback whale (*Megaptera novaeangliae)* and stellar sea lion (*Eumetopias jubatus*) abundances do not appear to affect herring mortality. Herring growth is affected by prey biomass (Tanasichuk, In prep.) The length of new spawners (recruits, three year old fish) is affected by the biomass of *T. spinifera* in August of the first and third year of life. Recruit weight is influenced by the biomass of T. spinifera in August of the second and third years of life. The size of older fish appears to be determined by the size of fish at the beginning of the growth season. There are no additional affects of prey or competitive fish biomasses. This means that the size of a herring through its adult life is determined by prey biomass during the pre-recruit phase of the life history.

Discussion and conclusion

WCVI herring biomass has fluctuated substantially and appears to be a consequence of prey and predator biomass variations. These effects are strong enough to over-ride any influence of the herring population itself. Although we appear to understand why WCVI herring production fluctuates, and can anticipate how it will vary, we don't know why euphausiid and hake productivity varies. It is important to learn about these if we want to understand herring production comprehensively. The current status of WCVI herring and fish size mostly reflects persistent low *T. spinifera* production, but also recent high piscivorous hake biomass.

Key words

herring recruitment, herring mortality, herring growth, marine trophic interactions, biological variability

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FACTORS AFFECTING THE RETURNS OF COHO (ONCOHRYNCHUS KISUTCH), SOCKEYE (O. NERKA) AND CHUM (O. KETA) SALMON FROM THE WCVI

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Summary

Time series of marine zooplankton and euphausiid (krill) prey biomass, marine predator (Pacific hake, *Merluccius productus*) biomass, wild salmon parental abundances, and wild and hatchery smolt abundances were used to try to learn why Carnation Creek coho (*Oncohrynchus kisutch*), Somass River (Great Central and Sproat lakes) sockeye (*O. nerka*) and Nitinat River Hatchery chum (*O. keta*) returns vary. Coho returns are affected by number of spawners, creek discharge during the first

winter, and prey (the euphausiid (krill) *Thysanoessa spinifera*) biomass during August of the first marine year. Sockeye returns are influenced by variations in the biomass of euphausiid prey (*T. spinifera*) in May when fish are migrating through Barkley Sound. Nitinat River Hatchery chum returns are affected by the biomass of piscivorous (fish-eating) hake in May of their first year at sea.

Methods or mode of knowledge

There are time series of counts of returning fish that begin in 1975 for Carnation Creek coho, 1977 for Somass River sockeye and in 1980 for Nitinat River Hatchery chum. Information on smolt (juvenile) production exists for Carnation Creek coho beginning in 1974, for 1978 to 2002 for Somass River sockeye, and beginning in 1981 for Nitinat River Hatchery chum. Juvenile salmon have been sampled in Alberni Inlet/Barkley Sound in 1987-89 as part of DFO's Marine Adult Salmon Survival (MASS) study and then in 2000 and 2001; the more recent sampling also included continental shelf waters between Amphitrite Point and Lennard Island. The MASS study was designed to evaluate the effect of predation on salmon returns whereas the more recent study examined variations in migration timing, diet, size, distribution as well as hatchery/wild fish interactions. There is also a time series of prey (euphausiid (krill)/zooplankton) biomass in Barkley Sound that began in 1991, and a time series of piscivorous (fish-eating) hake (*Merluccius productus*) biomass. Hake is the dominant fish species along the West Coast of Vancouver Island (WCVI) and its biomass is estimated from hydro-acoustic surveys done be DFO or in cooperation with NOAA, the American National Oceanic and Atmospheric Administration.

Results or observations

Much of the variation in coho, sockeye and chum returns can be explained by effects of parental abundance, prey availability, and/or predator biomass. Carnation Creek returns are affected mostly by female spawner abundance, somewhat by Carnation Creek discharge in January of the first freshwater winter and least, but significantly, by krill (*Thysanoessa spinifera*) biomass. The biomass of krill is for animals 19 mm long, prey consumed by coho when they are on the continental shelf. Sockeye returns are influenced by variation in the biomass of 3 – 5 mm long *T. spinifera*, the euphausiid prey they consume in May when the juveniles are migrating through Barkley Sound (Tanasichuk, Submitted). Nitinat Hatchery chum returns are influenced strongly by the biomass of piscivorous hake during May of the first year of marine life.

Discussion and conclusion

It appears that we are developing a good understanding of why WCVI wild coho, Somass River sockeye and Nitinat Hatchery chum returns vary. Hopefully, this will help develop effective management strategies which will result in appropriate harvesting.

Key words

coho salmon return variability, sockeye salmon return variability, chum salmon return variability, marine trophic interactions, biological variability

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SESSION 5. INDICATORS FOR PLANNING AND DECISION MAKING

BLACK OYSTERCATCHERS – SHORELINE SENTINEL OF BARKLEY SOUND

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Summary

Black Oystercatchers (*Haematopus bachmani*) are marine shorebirds that inhabit the Pacific coast of North America. The Canadian Shorebird Conservation Plan identifies Black Oystercatchers as a shorebird species of high regional and national concern (Donaldson 2000). The global population is estimated to be about 11,000 individuals, of which >80% occurs in Alaska and BC (Andres & Falxa 1995). Black Oystercatchers are relatively abundant in Barkley Sound and a number of long term nesting records exist. The availability of suitable nest sites and rearing areas is likely a limiting factor for the species (Andres and Falxa, 1995). Pacific Rim National Park Reserve staff conducted an analysis of nest abundance records and concluded that some local populations are stable suggesting suitable available habitat within the area is fully occupied. In addition, recent banding and telemetry efforts have demonstrated nest site fidelity and year-round residency of Black Oystercatchers within Barkley Sound. This supports the theory that many BLOY conservation and management issues are most effectively addressed at a local level.

Black Oystercatchers have been described as a sentinel of rocky islet habitats and rocky inter-tidal health. Their sustained presence is generally indicative of minimal human disturbance, relatively pristine rocky islet habitat and a healthy rocky inter-tidal invertebrate community. Because these same habitat features support a multitude of other marine and avi-fauna species, Black Oystercatchers are considered to be an “umbrella species”. As such, efforts to protect them will generally yield positive benefits to the broader natural community.

Methods or mode of knowledge

Data on black oystercatcher nest occupancy in Pacific Rim and the surrounding area extend to late 1960s and early 1970s. However, data gaps exist (e.g. few observations between 1980 and 1990). The general purpose of the earlier surveys was an evaluation of the area occupied by black oystercatchers in and around the park, rather than monitoring aimed at detecting population trends. As a result, sampling was largely driven by a search for nesting black oystercatchers; different sites were visited in different years and at different times; or some sites received repeated observations within a year. Furthermore, different types of data were recorded for different sites and in different years including the number of breeding pairs, the number of nests, the number of adults present plus ancillary notes on observation of fledglings, etc. More recent surveys (started in 2001) focused on confirming current occupancy of historical nesting sites. A number of oystercatchers were fitted with individual band combinations and radio-tagged and followed year-round. This earlier effort provides a detailed picture of spatial distribution of breeding black oystercatchers in the Park and vicinity.

Results or observations

Radio-tagging and banding data suggest that oystercatchers are faithful to the area and pairs tend to remain within their nesting territories year-round, although loose winter-flocks do form as well. The population is healthy with some sites supporting constant bird numbers over a number of years, suggesting that habitat is saturated. At other sites, such as Florencia Island the numbers have increased over the past decade.

Discussion and conclusion

Black Oystercatchers have been described as a sentinel of rocky islet habitats and rocky inter-tidal health. Their sustained presence is generally indicative of minimal human disturbance, relatively pristine rocky islet habitat and a healthy rocky inter-tidal invertebrate community, which seems to be the case in the Broken Group Islands archipelago. Because these same habitat features support a multitude of other marine and avi-fauna species, Black Oystercatchers are considered to be an "umbrella species". As such, efforts to protect them will generally yield positive benefits to the broader natural community.

Key words

Black Oystercatcher, nesting, population trend, radio-tagging.

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POPULATION TRENDS AND DRIVERS OF ANNUAL VARIABILITY IN SEABIRDS IN BARKLEY SOUND

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Summary

Seabirds are prominent members of the inshore marine ecosystems considered to be sentinels of both local and broad environmental change (Hedd *et al.* 2006). Seabirds are often top-level marine predators. Apart from adult survivorship, persistence of their populations strongly depends on food base (small forage fish and crustaceans) and availability of nesting habitat free from disturbance (human visitation, predators) – factors operating both on regional and local geographical scales.

Demographic stability of seabird populations may serve as an integrated measure of health of the near-shore marine ecosystem of the west coast of Vancouver Island including the Barkley Sound.

This study reviews the April – September marine (at-sea) abundance trends of the more common and regularly encountered species of seabirds in Barkley Sound – common murre (*Uria aalge*), rhinoceros auklet (*Cerorhinca monocerata*), marbled murrelet (*Brachyramphus marmoratus*), pigeon guillemot (*Cephus columba*), pelagic (*Phalacrocorax pelagicus*)and Brandt's cormorants (*Ph. penicillatus*), the three scoter species (Black, White-winged and Surf) and phalaropes (Red and Red-necked)between 1994 and 2009 within the coastal waters.

Methods or mode of knowledge

At-sea seabird surveys were conducted in April - September 1994 - 1996 and 1999 – 2009 along three transects – two in the Broken Group Islands and one along the West Coast Trail. For the most part transect-specific counts were combined into one length-adjusted density estimate (birds/km). In 1994 only the WCT transect was surveyed.

The mean annual density estimate was used as a data point – individuals sitting or flying within 300 m from the boat were included. Marine data were obtained from the Department of Fisheries and Oceans website. Marine productivity data were obtained DFO researchers (Ron Tanasichuk) and the annual State of the Ocean Reports.

Regression analyses corrected for serial correlation in the data were used as appropriate to assess population tends and covariates associated with the trends.

Results or observations

Some species displayed a sharp reduction between mid 1990s and early 2000s but remained largely stable during the past 10 years. For example there has been >60% population reduction in the marbled murrelet and a similar decline in the rhinoceros auklet. Other species displayed mostly stable population trends. Year-to-year variability in most cases has been considerable. Much variance in the data was explained by marine conditions (e.g. SST – Sea Surface Temperature) and productivity (abundance of herring and crustaceans) in the coastal waters.

Discussion and conclusion

Annual abundances in many seabirds are likely associated with marine conditions such as SST via the mechanism of fish and crustacean recruitment. Poor recruitment of forage fish, such as Pacific herring and sandlance, and zooplankton usually occurs in years with warm sea surface temperature (Nagasawa 2001;Frederiksen et al. 2004; Hedd et al. 2006). This in turn may results in fewer seabirds congregating off the WCVI. We note, however, that in some cases even with the marine effects accounted for, the population still appears to be experiencing a downward trend.

Key words

Seabird, ENSO, herring, SST, population trend.

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THE IMPORTANCE OF BARKLEY SOUND AND ADJACENT SEAS TO THE GLOBAL SEABIRD COMMUNITY

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Summary

Barkley Sound and the ocean off southwest Vancouver Island are productive areas supporting a diverse avifauna of seabirds and waterfowl. Using data from repeated transect surveys done year-round in 1993-1995 we report density and distribution of birds in three marine zones: Nearshore (sheltered inland waters), Inshore (exposed coastal waters), and Offshore (continental shelf waters). There were strong seasonal trends in each zone, and marked differences in the species composition, foraging niches and densities among the zones. Most of the birds were non-breeding visitors from many parts of the Pacific and inland North America. Our data show the cosmopolitan nature of the avifauna and the global importance of the area as a foraging ground, migratory passageway and wintering ground.

Methods

We counted birds from vessels along fixed strip-transect routes within the Nearshore zone (sheltered inland waters within 1-2 km of shore; 43 km transect; 56 surveys), the Inshore zone (exposed coastal waters <50 m deep and <6 km of shore; 19 km transect; 39 surveys), and the Offshore zone (shelf and canyon waters >50 m deep and >6 km from shore; average 93 km transect; 29 surveys). Further details are in Burger et al. (2004, 2008).

Results

The Nearshore community was dominated by migrant waterfowl in winter and Marbled Murrelets (*Brachyramphus marmoratus*) in spring through summer, the Inshore community by Common Murres (*Uria aalge*) year-round and California Gulls (*Larus californicus*) and Sooty Shearwaters (*Puffinus griseus*) in summer and autumn, and the Offshore community by murres, California Gulls, shearwaters and some pelagic species. Variations in bird densities among years were relatively small but there were major seasonal fluctuations in all three zones. The bulk of the birds (63%, 79% and 86% in Nearshore, Inshore and Offshore, respectively) were non-breeding visitors which breed elsewhere in B.C., or in Washington, Alaska, the Arctic, inland North America, the southern hemisphere (shearwaters), Hawaii, or Mexico. Year-round densities averaged 23.4 $\pm$ 10.9, 40.0 $\pm$ 21.6, and 54.6 $\pm$ 59.2 birds km^{-2} in Nearshore, Inshore and Offshore zones, respectively. Seasonal and spatial variations in density in each zone are documented for 41 regularly occurring species.

Discussion/Conclusion

The seasonally high densities and widespread breeding distribution emphasizes the global importance of this region as a foraging ground for wintering and migrating seabirds. The area supports one of the highest densities of breeding Marbled Murrelets in the species' range.

Key words

Barkley Sound, southwest Vancouver Island, seabirds, Marbled Murrelets, wintering grounds.

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INTERANNUAL VARIATION IN EUPHAUSIIDS (KRILL) IN BARKLEY SOUND, 1991-2009

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Summary

An euphausiid (krill)/zooplankton monitoring programme in Barkley Sound has been in place since March, 1991. Samples are collected near Robbers Passage and Mackenzie Anchorage in Trevor Channel, and near Swale Rock and Effingham Island in Imperial Eagle Channel. To date there have been 157 sampling events, and samples are collected throughout the year. There are two common species (*Thysanoessa spinifera*, *Euphausia pacifica*) of euphausiid. Annual average biomass has varied by about 50-fold over the last 19 years, and the trends in variation differ between species. Additional studies, described in other Symposium presentations, have shown that very specific sizes of *T. spinifera* are important prey for herring, and sockeye, chum and coho salmon, and at very specific times of the year.

Methods or mode of knowledge

Euphausiid/zooplankton samples have been collected in Barkley Sound since 1991 (Tanasichuk, 1998a,b). Samples are collected at night using a bongo net towed from the M/V Alta, one of the Bamfield Marine Sciences Center's research vessels, and then preserved for laboratory analysis. Adults (animals longer than 9 mm) of each species are weighed and measured, and their sex and maturity are recorded. Larvae are identified to species and measured and their larval stage is recorded. The euphausiid database currently has information on 144,000 individuals.

Results or observations

Adult euphausiid biomass has varied substantially over the sampling period and the dominant species has changed from *T. spinifera* to *E. Pacifica*. *T. spinifera* biomass has varied 106-fold and *E. pacifica* biomass has varied 33-fold. Results of studies show that variations in the biomass of *T. spinifera* as prey affects WCVI herring and salmon production. Herring recruitment, mortality and growth (Tanasichuk Submitted a, Submitted b, In prep.) vary with the biomass of *T. spinifera* longer than 17 mm in August, when fish are growing most rapidly . Somass River sockeye appear to depend on 3-5 mm long *T. spinifera* as juveniles moving through Barkley Sound in May (Tanasichuk, Submitted c). Carnation Creek coho returns vary with the biomass of *T. spinifera* longer than 19 mm in August of the first marine summer for the fish (Tanasichuk, 2002).

Discussion and conclusion

Euphausiids in Barkley Sound have undergone large variations in biomass. This appears to a result of factors affecting euphausiid mortality when they transition from juvenile to adult animals. Hopefully the NEPTUNE project will provide insight about why euphausiid populations vary. Results of studies of fish production show that these variations have substantial implications for WCVI herring and salmon. This will help us understand and anticipate changes in fish population productivity.

Key words

euphausiids, fish production, herring, salmon, biological variability

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Spatial variability in eelgrass fish diversity in the Broken Group Islands, Barkley Sound

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Summary

The maintenance of biodiversity is an important element of Parks Canada's primary mandate of protecting ecological integrity in National Parks. As one measure of ecological integrity, fish species diversity is monitored in eelgrass meadows (*Zostera marina*), in the Broken Group Islands (BGI), Pacific Rim National Park Reserve of Canada. Eelgrass meadows provide a variety of ecological functions important for maintaining healthy fish populations, including high secondary production of invertebrates associated with epiphytes, and providing a 3-dimensional habitat for protection from predators. These properties make eelgrass meadows a magnet for young fish of more than 50 species and they are easily accessible for sampling on low tides in summer. Preliminary analyses indicate that fish assemblages are more similar within the same meadows re-sampled over 6 years compared to

fish diversity among 10 meadows sampled within the same year. Although a meadow is most similar to itself over time, most meadows are significantly dissimilar from each other; ten fish species primarily drive the spatial dissimilarity among meadows. Our preliminary analyses indicate that the lower similarity in fish diversity among meadows is not related to local meadow properties (e.g., sea surface temperature), but may be related to regional spatial factors, such as the distance between meadows. Ultimately, the spatial and temporal variability in eelgrass fish diversity is likely related to a combination of regional oceanographic and seascape factors, and requires further study. The outcomes of this research will become an important consideration for Park management actions such as zoning, and for understanding marine ecological integrity in the National Park.

Methods

To eliminate seasonal changes in eelgrass properties and eelgrass fish diversity in the Broken Group Islands unit of Pacific Rim National Park Reserve of Canada, ten meadows were re-sampled for fish and environmental parameters in July of each year from 2004 to 2009. For each meadow, triplicate beach seine sets for fish were completed on low morning tides using a 9.2 m long beach seine with 4 mm stretch mesh, having a 3.1 m drop in the centre and tapering to 1.1 m at the wings. Point measures of salinity, water temperature, nitrates, turbidity, fluorescence (related to chlorophyll) and above-ground eelgrass biomass samples were obtained from 9 randomly placed 0.1 m^2 quadrat samples after fish sampling. Changes in fish diversity among meadows and over time were summarized using the Bray-Curtis (BC) similarity coefficient, and patterns were analyzed using the non parametric multivariate methods of multi dimensional scaling and analysis of similarity. Differences in fish species diversity among meadows were further assessed using SIMPER, and assemblage patterns were compared to environmental and eelgrass data using BIOENV. All statistical analyses were carried out using PRIMER 6.0 (Gorley and Clarke 2006).

Results

The multi dimensional analysis of fish species diversity shows grouping and higher similarity for the same meadows re-sampled over 6 years (ANOSIM $p < 0.01$, Global $R = 0.667$), than for all 10 meadows sampled in any one year (ANOSIM $p > 0.05$, Global $R=0.072$). Spatially, meadows at Clarke and Wouwer are most dissimilar to the other 8 meadows. A SIMPER analysis indicates that the dissimilarity among all 10 meadows is primarily driven by ten fish species, including shiner perch, tide pool sculpin, silverspotted sculpin, penpoint gunnel, black rockfish, threespine stickleback, kelp greenling, crescent gunnel, plainfin midshipman, and English sole. The BIOENV procedure, which uses Spearman correlation to relate environmental variables to the patterns observed in the fish assemblages, did not find any combination of local environmental variables that clearly relate to the spatial separation observed in fish diversity among meadows. A seperate univariate analysis did however show a significant negative correlation between BC values and the physical distance among meadows. Meadows further apart have the least similar fish assemblages.

Discussion

To date, this research has determined that fish species diversity in eelgrass meadows in the Broken Group Islands is more similar within meadows re-sampled over 6 years compared to a suite of meadows sampled in any one year. Although the fish diversity in a meadow is most similar to itself over time, the causes of spatial differences in similarity among meadows have not yet been fully resolved. Preliminary analyses indicate that local meadow properties and environmental conditions are likely not driving among meadow differences in fish diversity. Future research will focus on the importance of regional factors and seascape properties in driving fish diversity in the Broken Group Islands.

Key words: eelgrass, diversity, similarity, fish assemblages, spatial variability

MEASURING THE CONNECTIVITY OF EELGRASS HABITATS IN BARKLEY SOUND: FINE-SCALE POPULATION GENETIC STRUCTURE OF THE BAY PIPEFISH.

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Summary

Seascapes are complex systems with features that both restrict and enhance dispersal and gene flow among individuals. Understanding factors shaping genetic diversity and genetic population substructure can assist in planning effective conservation areas. Eelgrass, ***Zostera marina***, provides spawning, rearing and year-round habitat for hundreds of marine species. Loss of eelgrass productivity affects ecosystem linkages from coastal to offshore ecosystems. Protecting eelgrass ecosystem integrity is important for conservation planning. The bay pipefish, ***Syngnathus leptorhynchus***, is an eelgrass-dependent fish. This species was used to access gene flow among eelgrass beds throughout Barkley Sound including the Broken Group Islands, Pacific Rim National Park Reserve (PRNPR). Pipefish population dispersal was restricted between East Barkley and South/North Barkley Sound. Seascape features were important in the degree of genetic connectivity throughout Barkley Sound. Within the Broken Group Islands, PRNPR, genetic divergence was high, likely due to the complexity of the local seascape. Pipefish genetic divergence between sites within and outside of the BGI was high.

Methods:

Study sites were located throughout Barkley Sound and within the Broken Group Islands, Pacific Rim National Park Reserve, to evaluate gene flow within and outside of the boundaries of the PRNPR. Pipefish were collected from 17 study sites in 2001. Genetic population structure was evaluated using five microsatellite loci.

Results:

There was evidence for closed population dispersal consistent with geography and two nascent genetic subpopulations encompassing East Barkley and South/North Barkley Sound. Pipefish genetic differentiation revealed patterns of local heterogeneity at small spatial scales within the BGI archipelago, but regional homogeneity at larger spatial scales. Coastal eelgrass habitats maintained genetic connectivity while features such as archipelagoes and deep-water barriers were found to be important in promoting genetic divergence at micro-geographic scales. Gene flow was restricted within the BGI archipelago but gene flow between localities inside the reserve and outside of the reserve was high. Genetic home range size estimates to maintain connectivity within a subpopulation ranged from 33 to 63 kilometres.

Discussion

Pipefish within the Broken Group Islands, PRNPR, are connected by gene flow to pipefish outside of the reserve boundaries. Maintaining abundant eelgrass habitats outside of the Broken Group Islands, PRNPR, is important to the population dynamics of the bay pipefish within its boundaries. In Barkley Sound, population genetic substructure and genetic diversity maybe more heavily influenced by the interaction of individuals within the spatial arrangement of habitats than by their dispersal potential. Seascapes, like landscapes, define animal movement and influence genetic variance and connectivity among populations at local spatial scales. Understanding factors shaping genetic diversity and genetic population substructure of species are important in planning local conservation areas.

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Annual to centennial scale variations in returns of Barkley Sound sockeye salmon as an indicator of ecosystem and human health

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Summary

More than 120 years of annual variations in catch and escapement of three populations of sockeye salmon returning to Barkley Sound are examined to consider the long-term effects of a succession of specific fishing regimes on the salmon, their ecosystems of origin and associated human communities. The impact of fishing regimes on salmon are examined within the context of both human-induced and climate-induced changes to salmon habitat during periods spanning prehistoric to contemporary intervals.

Methods or mode of knowledge

Assembly and analysis of observational data and accompanying information from both published and unpublished sources on Barkley Sound salmon populations, their ecosystems of origin and associated fisheries from the prehistoric to current period were used to compile a historic narrative. Methods and data sources for much of the material covered here have been previously documented.[1.] New information, serving as the basis for an updated historical narrative, has been largely compiled from a series of DFO Canadian Science Advisory Secretariat (CSAS) publications or the author's unpublished files.

Results or observations

Although highly incomplete, the prehistoric record suggests indigenous peoples enjoyed long periods of moderate subsistence catch interspersed by periods of scarcity when climate-induced fluctuations may have radically altered coastal ecosystems and the identity of the dominant species of fish occupying Barkley Sound waters. The historic record is more detailed and supports the identification of several specific fishery regimes including: a largely terminal, subsistence fishery that probably harvested no more than 50,000 sockeye salmon per year (pre-1900), a terminal beach-seine and gillnet fishery that provided catches as high as 125,000 sockeye (1900-1940), a more diffuse gillnet fishery that exploited mixtures of sockeye in Alberni Inlet and the outer waters of Barkley Sound yielding catches of 5,00 to 76,000 sockeye (1940-1971), a mixed gear, mixed-stock fishery in which commercial gillnetters and purse-seiners harvested between 150,000 and 1,200,000 sockeye per annum (1972-1985) and, more recently (1985-2009), a diverse set of community-oriented fisheries (First Nations, recreational and mixed-gear commercial) in which an average annual catch of some 360,000 sockeye has been shared.

Discussion and conclusion

Recognition of the need to implement effective systems of control over fishing effort by time and area by both indigenous and non-indigenous peoples have facilitated the maintenance of more than a century of sustainable fisheries for sockeye salmon which have contributed significantly to the well being of fishing communities in the Barkley Sound area. Although examples of both habitat degradation and enhancement have been clearly identified as contributing causes for decadal scale fluctuations in sockeye abundance, climate variation and change effects have recently been identified as exerting a major influence.

Key words salmon variations, fisheries, habitat and climate

Literature cited

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SESSION 6. ECOSYSTEM KNOWLEDGE FOR PLANNING AND DECISION MAKING

HOW ECOSYSTEM KNOWLEDGE WILL INFORM SUSTAINABILITY PLANNING IN BARKLEY SOUND AND THE WEST COAST OF VANCOUVER ISLAND

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Summary
The vision for the Barkley Sound Knowledge Symposium, "To assemble and share existing knowledge about Barkley Sound ecosystems, human uses, and values in a *living* and *open* knowledge-base for the support of sustainability planning initiatives," expresses the general goal of the Symposium, but there are specific elements within that goal that should be communicated. These include various elements of the Symposium and components of a broader strategy of knowledge collection and sustainability planning for Barkley Sound and the West Coast of Vancouver Island.

Methods
Components of the overall strategy for knowledge collection for the support of sustainability planning include Barkleypedia, other 'Aquapedia', and additional online tools such as a knowledge network and a spatial information atlas; surveys and series of interviews to assess and document ecosystem knowledge as well as socio-economic and socio-cultural knowledge; reviews and assessments of existing information not captured by the Symposium, surveys, and other approaches; data management systems for spatial and other data; quantitative tools for planning decision-support; and other components such as a document database and a Nuu-chah-nulth plants and animals dictionary. These approaches and tools are being developed initially for Barkley and Clayoquot Sounds, but they are designed to be expanded to the whole West Coast Vancouver Island area such that information from particular sounds and marine areas will be nested within integrated assessments and plans. In addition to the Barkleypedia, the spatial atlas, and other online resources, documentation of the collected knowledge will include edited Symposium proceedings and other ecological, socio-economic, and cultural assessments to be published as part of a nested Integrated Ecosystem Assessment (IEA).

Results
These resources will serve as the knowledge foundation for the development of an Integrated Coastal and Ocean Plan for the West Coast of Vancouver Island, including Barkley Sound. This plan may include Comprehensive Ocean Zoning plans for particular areas such as Barkley and Clayoquot Sounds and a more objectives-based plan for the broader West Coast of Vancouver Island area.

Discussion and conclusion
The vision of the overall project is integrated, collaborative, and participative coastal and ocean planning and management that will ensure the restoration and sustainability of the region's unique ecological, social, cultural, and economic values.

Key words Integrated Ecosystem Assessment, vision, ecosystem knowledge, sustainability planning

KEYNOTE ADDRESS 3: THE SAN JUAN ISLANDS AND PUGET SOUND PLANNING EXPERIENCES

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Puget Sound is the focus for several initiatives that seek to address issues of marine conservation, habitat restoration, marine stewardship, and ecosystem health. These initiatives cross institutional scales, from grassroots and local efforts to state and federal initiatives. The San Juan County Marine Stewardship Area is a local initiative to protect marine resources through structured planning. The Puget Sound Partnership, established by Washington State, is a broadly based community effort to restore and protect Puget Sound. The Northwest Straits Marine Conservation Initiative, authorized by the US Congress, is rooted in collaborative citizen action. These initiatives operate at different scales to achieve common objectives. Collectively, they signal a new approach to place-based management of Puget Sound.

SESSION 7. HABITAT AND SPATIAL CHARACTERIZATION

SPATIALLY CONSISTENT ROCKFISH RECRUITMENT ACROSS KELP AND EELGRASS HABITATS IN BARKLEY SOUND: IMPLICATIONS FOR RCA EFFECTIVENESS

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Summary
In the context of investigating the long-term effectiveness of Rockfish Conservation Areas (RCA), we examined spatiotemporal patterns of rockfish (*Sebastes* spp.) recruitment in eelgrass meadows (*Zostera marina*) and kelp forests (*Macrocystis integrifolia*) throughout Barkley Sound. Despite high inter-annual differences in recruitment between species and habitats, the relative intensity of rockfish recruitment was spatially consistent among years. Black rockfish (*Sebastes melanops*) recruitment decreased rapidly with increasing distance from the open coast and sea surface temperature, and decreasing tidal velocity and fetch. Our results support the hypothesis that coastal topography interacts with persistent nearshore physical oceanographic processes to create spatially predictable patterns of larval supply and recruitment. These findings hold important implications for spatially explicit management initiatives concerned with nearshore reef fishes.

Methods
Rockfish recruitment in 12 eelgrass meadows sites was measured annually (2002-2008) using beach seines. Rockfish recruitment in 30 kelp forest sites was measured approximately every 14 days, May through August (2005 and 2008) using SMURFs (Standard Monitoring Units for the Recruitment of Fish; Ammann 2004). To assess spatial consistency of recruitment we examined the correlations between mean annual black rockfish recruitment in all kelp forest and eelgrass meadow sites each year between 2005 and 2008. To explain spatial variability in rockfish recruitment we conducted a principle component analysis (PCA) using site-specific measures of distance to open coast, fetch, tidal velocity and sea surface temperature as variables.

Results
Black rockfish and CQB complex rockfishes (*S. caurinus*, *S. maliger*, and *S. auriculatus*), dominated recruitment at all sites. During a year of high black rockfish recruitment, recruitment was significantly higher at sites outside of the Broken Group Islands RCA. Site-specific recruitment was positively and significantly correlated among all year combinations (2005-2008). The first axis of the PCA explained 64.25% of the variability in these data and was strongly correlated all four variables.

Discussion
Our results suggest that the optimal habitat for rockfish recruitment in Barkley Sound lies outside of the Broken Group Islands RCA. To the extent that rockfish populations are recruitment limited and adult and juvenile rockfish habitats overlap, we propose that the long-term effectiveness of this RCA could be substantially improved by altering its boundaries to include outer coast habitat with high fetch and tidal velocity.

Key words
Rockfish Conservation Areas, larval supply, recruitment limitation, spatial consistency, coastal topography

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BUILDING A COMPREHENSIVE SUBSTRATE MAP FOR ECOSYSTEM ANALYSIS

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Summary
Detailed analyses of ecosystems, the services they provide, and the impact of management alternatives must start with a sufficiently realistic representation of the system of interest. In near shore ecosystems, this begins with a description of bottom type, or substrate, as this in turn contributes to the types of plant and animal communities that are likely to be associated with such habitat. Further, such a substrate map would ideally be comprehensive – that is covering the entire Canadian Pacific coast – to support spatial use decisions according to representativeness and uniqueness. To date, the only such map was developed as part of the British Columbia Marine Ecosystem Classification (BCMEC) (Zacharias et al. 1998). While this work was seminal at the time, the BCMEC has low spatial resolution and does not align with standard marine coastlines. Further, the attribute resolution is poor, showing only Mud, Sand, and Other classes. These limitations make it inappropriate for near shore studies intended to integrate data collected at much higher resolutions, and for ecosystem models, where the correct representation of important ecological processes requires a certain level of model complexity (Fulton et al. 2003).
I have therefore been developing an approach to creating a substrate map suitable for use in coastal habitat studies and spatial planning from provincial to local scales. In collaboration with the shellfish group at the Pacific Biological Station and others involved in the Near shore Habitat Working Group, we have designed a method to integrate data from field surveys, Fisheries and Oceans (DFO) sounding data, the BC ShoreZone classification, and recent multi-beam backscatter classification. The approach, which integrates point, line, and polygon data, creates a variable resolution substrate map

with two levels of attribution, based on best available data. A corresponding confidence map provides information on how reliable the classification is, given the agreement between source data sets.

The map has thus far been developed for the Strait of Georgia, as part of DFO's Ecosystem Research Initiative. It will be applied to the west coast of Vancouver Island in 2010, starting with Barkley and Clayoquot Sounds. As part of this presentation, I will describe the source data sets, the methodology, and the results to date. I hope to solicit feedback from the Barkley Sound community on their impressions of the approach, and on possible data sets for integration.

Methods or mode of knowledge

The approach is based on Thiessen polygons (TPs). These polygons describe areas of influence around individual points. They thus well represent the density, and consequently the resolution, of the point data. We use TPs directly to define the sphere of influence of field sampling data, and indirectly to extend the ShoreZone classification beyond the inter-tidal and into the shallow sub-tidal. Both the substrate and the confidence maps are based on combining the TPs derived from the different data sources according to simple rules about data quality.

Results or observations

Initial validation tests suggest that the substrate maps associate well with biological data on infaunal and epifaunal communities. Further validation assessing the degree of correspondence with both additional biological data sources and locally developed physical classifications, to be completed prior to the Symposium, will also be presented.

Discussion and conclusion

The comprehensive substrate map created using the methodology described is proving to be a biologically meaningful classification of near shore waters. With a more realistic attribute resolution than previous maps, it can serve as a description of bottom habitat for species-habitat relationships, and other ecosystem-level analyses.

Key words

Substrate, bottom type, classification, species-habitat relationships, Ecosystem model

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British Columbia Marine Conservation Analysis project: Generating information to support integrated marine planning

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** Indicates current participation with the Project Team as observers.*

Summary
Transparent, integrated, and collaborative approaches are increasingly promoted to advance ecosystem-based management. The British Columbia Marine Conservation Analysis project (www.bcmca.ca) is taking such an approach, resulting in opportunities and challenges. The project is an encouraging example of proactive collaboration among federal and provincial governments, academics, environmental non-governmental organizations, user groups, and aboriginal organizations. The project directly addresses the Barkley Sound Knowledge Symposium theme of "spatial and temporal distributions of natural resources, human uses, and related values". While the BCMCA is gathering spatial data on a Canadian Pacific scale, we will provide a **Summary** of collated data relevant to Barkley Sound.

Methods or mode of knowledge
The multi-organization project team is assembling spatial data representing the distribution of ecological features and human uses in Canada's Pacific Ocean to inform integrated marine planning. These data are the foundation for the project's two products: an atlas of ecological and human use maps and analyses, using Marxan[1] and Marxan with Zones[2], that identify areas of high conservation value which minimize overlap with areas important to human use. User groups are being invited to review human use data and provide direction on the use of these data in analyses. A committee of user group representatives — called the Human Use Data Working Group — provides overarching direction and advice to the Project Team about the analysis of human use data.

Results or observations
To date, the BCMCA has collated and integrated more than 150 ecological datasets and 85 human use datasets. Many of these datasets overlap with the Barkley Sound region.

Discussion and conclusion

Collating the best available spatial ecological and human use data is an enormous opportunity and challenge. The BCMCA project is adding value to largely disparate datasets by combining these data to create comprehensive maps, which can inform future marine planning efforts. The main challenge lies in sensibly combining datasets that were often collected using different methods and where metadata are not always available or complete.

The project's collaborative approach has created key opportunities to develop information products that can be widely perceived as credible and deliberate on how to represent humans as ecosystem components in analyses. One challenge has been managing communication among project team members, their "constituencies", and user groups. Additional challenges have included engaging user groups, accessing the wide range of expertise needed within the project, obtaining data, and reconciling the intended rate of the project's progress with the time requirements of all those engaged with the project. Recommendations for similar projects are to engage user groups early, work to understand the needs of data providers, and minimize the need for follow-up after engagement events with experts and user groups.

Key words

Spatial data, human uses, biodiversity, marine planning, ecosystem based management.

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COASTAL AND MARINE PLANNING INFORMED BY MAPPING AND VALUATION OF ECOSYSTEM SERVICES OF THE WEST COAST OF VANCOUVER ISLAND

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Summary

Coastal and marine areas of the West Coast of Vancouver Island (WCVI), Canada produce a wide range of services to people who live in and use the area. These services include seafood from fish, shellfish, and plants, recreational activities, protection of shorelines from erosion, energy generation, travel corridors, and cultural benefits. Ensuring the sustainability of these and other ecosystem services is fundamental to the health and wealth of current and future generations. It is also a guiding principal of the West Coast Aquatic Board (WCA), a government and non-government co-

management body for aquatic resources in WCVI. WCA aims to create a framework and coastal zone plan agreed upon by federal, provincial, First Nations, and municipal governments; coastal communities; and other key constituencies such as commercial, recreational, and aboriginal harvesting, processing, labor, aquaculture, tourism, environment, transportation, and energy. This effort requires understanding of how services vary across the region and how they might be affected by different plans and decisions.

Methods

To gain this understanding, WCA partnered with the Natural Capital Project, which includes people from Stanford University, The Nature Conservancy and World Wildlife Fund. The Natural Capital Project's Marine Initiative has recently embarked on a 2-year program to develop a tool called Marine InVEST (Integrated Valuation of Ecosystem Services and Trade-offs). Marine InVEST shares a number of key features with an InVEST tool that the Natural Capital Project has developed and applied on land. Marine InVEST: 1) maps and values ecosystem services under current and future management and climate change scenarios, 2) is highly flexible, for use with diverse habitats, policy issues, stakeholders, data limitations, and spatial and temporal scales, 3) is a collection of models for a variety of services (initial tool development to include modules for food from fisheries and aquaculture, recreation, coastal protection, and energy generation; future models will quantify and value nursery habitat, transformation and sequestration of wastes, cultural services), 4) includes process-based models that consist of a biophysical step where supply of the service is quantified, a use step where demand for the service is quantified, and an economic step for valuation in monetary terms. The tool runs in ArcGIS on map layers that describe ecosystem structure and human use.

Results and Discussion

We will introduce the partnership between WCA and the Marine Initiative of the Natural Capital Project, discuss progress to date, and outline how results are intended to be used in the WCA planning process. As this is one of the first applications of a comprehensive coastal-marine ecosystem service tool, this partnership and its products will be highly informative for coastal-marine spatial planning efforts in this and other areas of the globe.

Key words

coastal and marine ecosystem services, West Coast Vancouver Island, West Coast Aquatic, the Natural Capital Project

SESSION 8. COMMUNITY APPROACHES TO GOALS, OBJECTIVES, AND TARGETS

A WEB-BASED, FEDERATED, MARINE USE MANAGEMENT SYSTEM FOR SMALL COMMUNITIES

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Summary
The Gitga'at First Nation has built a web-based land and marine management decision-support system linked to their community and corporate websites. The Gitga'at Stewardship Office staff use this system to do basic map analysis when assessing marine use proposals and for planning. The Gitga'at marine use planning tools are part of a larger web-based system installed on their server that we call a *Community Information System* (CIS) (Burnett and Hayes 2009).

Methods
Recent developments in marine management have emphasized multi-stakeholder collaboration and decision-making, and spatial analysis and modeling as useful approaches to the challenge of managing marine areas (Canessa et al. 2007).

<u>Spatial Data Management:</u> A key strength of the system is that multiple sources of data can be accessed, including: (1) local spatial data stored in the content management system; (2) local web-mapping data served up using Open Geospatial Consortium (OGC) web-mapping protocols; and (3) spatial data hosted by partners.

<u>Consultation Tracking:</u> The Gitga'at system is built to track communications between the Stewardship Office, and proponents and government. A key element of the system is that it allows the Gitga'at to request that basic proposal/referral data be submitted electronically, including explicit proposal location (web-map or upload a Shapefile).

Simple Map Analysis and Report Generation: After enough information has have been collected from the proponent (or government), a report with maps and statistics can be using a one click system for running spatial queries on the GIS data.

Observations

The Gitga'at system runs on a basic small business server running standards-based, free, and open-source software, including Ubuntu Linux, Apache web server, Geoserver, and the Drupal content management system.

Discussion

The system has a heavy emphasis on local capacity building, and a key Gitga'at design goal was for the system to serve Stewardship Office needs, but also a broader spectrum of corporate users and community members, including teachers and students. The 'mode of knowledge' is hybrid in that it allows for the secure collection and storage of local ecological and traditional use knowledge, while allowing information to be included which comes from remote nodes.

The Gitga'at Nation acknowledges the support of Coastal First Nations / Turning Point Initiative.

Key words

Local knowledge, First Nation, coastal management, web-mapping, spatial data analysis, capacity building, consultation, referrals, free and open source software

Literature

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COMMUNITY BASED ECOLOGICAL MONITORING: LESSONS FROM THE BERING SEA

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Summary

Community based ecological monitoring can be a valuable source of information aiding conservation and management decisions. It can also be a useful tool for environmental outreach as well as a means to connect scientists with experienced field personnel. We have developed a system, referred to as BeringWatch, to facilitate monitoring efforts in Bering Sea villages. BeringWatch is an on-line

database tool for non-scientists in remote locations to record and communicate environmental and ecological events. Although the system is operational, it is still in its infancy and we are particularly interested in feedback from all sources.

Methods and Results

We combined existing environmental databases with a web-based access portal resulting in a system for remote communities to record and communicate local environmental and ecological events. We refer to the system as BeringWatch. The existing databases were developed and refined over the past 10 years by the Tanam Amgignaa (Island Sentinel) Programs on St. Paul and St. George Islands, Alaska. Two key features of BeringWatch are its internet home and its network design. Being web-based solves a number of equipment-related problems (i.e. compatibility of data entry and storage programs) and allows for widespread networking. A network approach means that permission to access data is granted at the local level providing local ownership, important to local stewardship. The network model is also well suited to incorporating rigorous data quality standards through continuous interaction between local observers, regional coordinators, data managers and scientific advisors.

There are two basic categories of environmental data: wide ranging descriptive data and detailed observations of specific species. The first category can be entered by anyone in a community with minimal training and is primarily narrative with supplementary photographs. Media documentation uploads (e.g. photos) are simple and are permanently linked to the record. Examples include environmental anomalies or local and traditional knowledge. The second category involves specific data on target species (e.g. local marine mammals). This level of data collection involves training and setting up a protocol for the target species and is most likely to only be carried out by dedicated and often paid observers such as the Sentinel Programs on the Aleutian and Pribilof Islands.

Discussion and conclusion

A central pillar of our program is a single premise that speaks to the relationship between conservation and community involvement: for conservation efforts to be maximally successful and sustained over long (i.e. biologically significant) time periods, there has to be activity and ownership at the local level. Ultimately we hope our efforts can translate to tangible lessons or even a community based ecological monitoring template that can be exported to other regions.

Key words

Community based ecological monitoring; Sentinel; Citizen Science; Stewardship

Historical and Future Climate Impacts for a Community-Based Resilience Analysis

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Summary
An understanding of change in complex social and ecological systems requires an interdisciplinary approach (Holling, 2001). A collaborative approach that integrates scientific and local practical knowledge is presented. This work contributes to our understanding of how climate change will affect coastal-marine ecosystems and communities, and the capacity of a coastal resource-connected community to absorb and accommodate these changes in Barkley Sound. In particular, the historical climate and projected future climate impacts for the region will be presented. In conjunction with Liston and Murdock (2010), the integrated analysis considers the potential impacts of climate change on coastal-marine resources for the region surrounding Ucluelet, the resilience of the community of Ucluelet to these impacts, and strategies to build resilience in the community to the impacts of climate change.

Methods or modes of knowledge
Methods for use of biophysical information will follow those used in several previous studies around British Columbia (e.g., Picketts et. al., 2009, Rodenhuis et. al. 2009). Historical variability and long-term trends will be analyzed using station-based and gridded climate data. Anticipated future climate impacts will be presented using a range of results from Global and Regional Climate Models and high-resolution downscaling. This information is augmented by community-based research that took place in Ucluelet over a ten week period in autumn 2009, in which one of the researchers worked closely with local resource managers, community planners, resource users and other community members to explore understandings of social and environmental change and resilience in the study area.

Results or observations
The Barkley Sound region is located in an area strongly influenced by El Niño, La Niña and the Pacific Decadal Oscillation. In this region, past temperature trends show to be less than other areas of British Columbia, but large in comparison to historical variability. This indicates that small trends could have large ecological and social impacts. Selected land-based and marine ecological impacts that may result from these changes will be shown. This biophysical analysis is enriched by the local knowledge gained in the community research phase (Liston and Murdock, 2010), which indicates that social and ecological resilience are closely tied in the Ucluelet community.

Discussion and conclusion
The integrated knowledge that emerges from this approach will contribute to our understandings of how climate change affects coastal and marine resources and the communities they support, and how

the capacity of a community to absorb and accommodate these changes may be increased. This will improve foundations for the design of sustainable and adaptive resource management and use systems at community-relevant scales. Moreover, the research will review how climate change may affect remote and resource-based coastal communities in Canada in general and how levels of resilience may be increased, on the basis of results obtained in the Ucluelet case study.

Key words
Climate change; climate trends; climate variability; climate change impacts; coastal communities; Barkley Sound; Ucluelet; vulnerability; adaptive capacity; resilience; integrated research; interdisciplinary research.

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BUILDING RESILIENT COASTAL COMMUNITIES IN THE FACE OF CLIMATE CHANGE IMPACTS ON COASTAL AND MARINE RESOURCES AND ECOSYSTEMS IN BRITISH COLUMBIA

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Summary
Canada's coastal communities have, throughout their history, experienced complex processes of social and environmental change. In these communities, changes in the natural environment have interacted with social, cultural, political and industrial factors to create a social and environmental landscape that is specific and unique to a coastal people and place. In many cases, however, these interactions have resulted in depleted resources and stressed communities where considerations of social and ecological sustainability and resilience were poor (Ommer, 2007; Berkes & Folke, 1998). Given these existing social and environmental stresses, coastal communities in Canada are potentially vulnerable to the impacts of climate change (Dolan & Walker, 2006). This research therefore seeks to understand the potential impacts of climate change on Canada's coastal and marine resources and ecosystems and the communities they support, and the capacity of a coastal resource-connected community to absorb and accommodate these changes. This research will be situated in the community Ucluelet, British Columbia. Specifically, the research will: review past and current processes of social and environmental (including climate) change in Ucluelet; assess the potential impacts of climate change on coastal and marine resources and ecosystems for the region surrounding Ucluelet; investigate the resilience of the community to the impacts of climate change on coastal and marine resources; identify strategies for building resilience in the community of Ucluelet; and, review how climate change, in the context of preexisting social and ecological stressors, may affect remote

and resource-based coastal communities in Canada in general and how levels of resilience may be increased, on the basis of results obtained in the Ucluelet case study.

Methods or modes of knowledge

This research recognizes the need to draw upon various methods, actors, knowledge systems and scales of investigation in order to improve our understanding of the relationship between complex processes of change and the well being of coastal environments and communities (Ommer, 2007; Berkes & Folke, 1998). Four key methodological dimensions will define this approach. First, the research is interdisciplinary, bringing together natural and social sciences to produce a more holistic view of how environmental change interacts with human systems on coasts. Second, the research is place-specific. This is necessary in order to situate broader processes of change within the specific and unique human and environmental landscape of a particular coastal place. Place-specific methods used in the scientific analysis of historic and future climate for the Ucluelet study area are described in Murdock and Liston (2010). This scientific analysis provides context for the community-based analysis discussed here. A community research approach is used to direct attention to the richness and diversity of the resources, ecosystems, society, history, economy and culture of the particular environment and community of study (Ommer, 2007). Methods used in the community-centered analysis of the Ucluelet community include focus groups, in-depth interviews, participant observations and community surveys. These methods were designed to provide a community-scale analysis rooted in the knowledge and experience of local actors. The third methodological dimension is an awareness of scale. Though the place-specific and community-centered analysis is important, it is at all times situated within the broader spatial (regional, national, global) and temporal (historic) influences that affect coastal people and places. The final dimension of the methodology is a focus on knowledge systems, and more particularly, the range of knowledge systems needed to engage with the physical and human dimensions of climate change and resilience in coastal places. The research therefore draws upon natural and social science and local, practical knowledge systems.

Results or observations

Biophysical analysis of the historic and future climate in the Ucluelet study are presented in Murdock and Liston (2010). This analysis is combined with the results of the community-centered analysis to provide a more holistic understanding of the potential impacts of climate change on the particular coastal resources and ecosystems of the Ucluelet study area, and the capacity of the community of Ucluelet to absorb and accommodate these changes. Community interpretations of past and current climate and community understandings of climate change will be presented. This will include a presentation of community member perceptions of the potential impacts of climate change on surrounding coastal and marine resources and ecosystems and the likely consequences for the community. This information will set the context for a discussion of adaptive capacity and resilience in Ucluelet. Community identified sources of stress (vulnerability) and community identified strengths and capacities will be explored. The analysis will close with a presentation of community identified strategies for building resilience, and ways in which these might be integrated into existing community practices and institutions.

Discussion and conclusion

Taken together, the different kinds of knowledge that have been produced and shared in this research will contribute to understandings of the potential impacts of climate change on coastal and marine resources and ecosystems in the Ucluelet study area, and the capacity of the community of Ucluelet to absorb and accommodate these changes. The discussion will include conclude with a review of how climate change, in the context of existing social and ecological stressors, may affect remote and resource-based coastal communities in Canada in general, and how levels of resilience may be increased in all cases, on the basis of results obtained in the Ucluelet case study.

Key words
Coastal communities; climate change; stress; adaptive capacity; resilience; Ucluelet; interdisciplinary research; community-centered research; case study; scale; knowledge systems

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PUBLIC AND EXPERT SURVEY OF ECOSYSTEM KNOWLEDGE, USES, VALUES AND PERCEPTIONS OF HEALTH, STRESSORS, AND SOLUTIONS FOR THE WCVI

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Summary
A survey was developed to identify coastal marine ecosystem knowledge and knowledge holders on the West Coast of Vancouver Island; to sample public and expert perceptions of marine ecosystem health, stressors, human activities and values, and the potential changes in those dimensions; to calibrate those perceptions with respect to baselines and the nature of respondents' knowledge; and to provide demographic texture for the purpose of adequately sampling different groups and to characterize the perspectives and preferences of different groups. Information obtained from the survey will guide the development of an Integrated Ecosystem Assessment for the West Coast of Vancouver Island, coordinated by West Coast Aquatic. Results of the survey, for example, will enable the identification of ecosystem indicators useful for management by providing a list of the major stressors of these ecosystems ranked by degree of exerted stress. The survey is one of several approaches developed to gather ecosystem and socio-cultural knowledge for the West Coast of Vancouver Island.

Methods
An online survey was developed using SurveyMonkey.com by the Ecosystem Science team at West Coast Aquatic in order to identify ecosystem knowledge and ecosystem knowledge holders as well as

to sample calibrated and demographically-specific public and expert perceptions of ecosystem health, stressors, human activities and values, and potential changes in these dimensions. It was designed for the broadest audience as the first phase of a broader survey program that would also include individual interviews. The survey includes demographic questions to allow revisiting of poorly sampled groups in the sense of a scoping survey that will help identify people and communities with particular knowledge that will be useful for future planning. These communities, including self-identified members, will be further investigated with more in depth follow-up interviews. Respondents can provide contact information if they have particular ecosystem knowledge, such as time-series observations, that they wish to share. The survey has undergone multiple reviews and edits by the staff of West Coast Aquatic as well as by university academics, stakeholder representatives, local First Nation and local non-First Nation designees, and other members of the public.

Discussion and conclusion

Surveys and interviews will be central tools in the collection of information for support of the integrated and nested coastal and ocean plan for the West Coast of Vancouver Island. Two types are mentioned here—online surveys and interviews. Each have advantages and disadvantages, and each are normally designed differently for optimal performance. There is a trade-off between the benefits of designing the two types consistently (i.e. comparable results) and tailoring them to each situation with respect to question type and length (i.e. optimal results) in an overall program where both will be utilized for the same purposes.

Sustainability planning on the coast will affect each person and community, so it is important that a representative sampling of people from each community have the opportunity to communicate their perspectives. It is also important, in some cases, that those with the most knowledge and perspective have a say and that survey results are calibrated with respect to the degree and nature of each respondents' knowledge. Such sampling is challenging and requires demographic texture, different sampling approaches, and stratified re-sampling when necessary.

Key words

Survey, uses, values, marine ecosystem, stressors, coast, public and expert perceptions

Enlisting Digital Fishers to Assess Data from the Deep and Elicit Judgment from the Crowd

Justin Longo[1], Dr. Rod Dobell[2]

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Summary
The Neptune Canada project at the University of Victoria recently received funding for a new project: "Data from the Deep, Judgment from the Crowd". The "Digital Fishers" component of this project is being carried out under the direction of UVic's Centre for Global Studies Senior Associate Dr. Rod Dobell, with technology and subject-matter contributions from eBriefings.ca.

Neptune Canada centres on the construction of the world's largest cabled seafloor observatory off the west coast of Vancouver Island. Data will be transmitted via high-speed fibre optic communications from the seafloor to a data archival system at the University of Victoria. This system will provide free Internet access to an immense wealth of data, both live and archived, throughout the life of this planned 25-year project.

The Digital Fishers component of "Data from the Deep, Judgment from the Crowd" focuses on the application of crowdsourcing / Web2.0 citizen-science techniques to the special problem of how to effectively assess the large volume of visual and audio data that will stream in from the seafloor observatory – data which is still largely undecipherable by current machine computation methods – without wasting the highly-skilled human resources represented in the Venus / Neptune science cadre in repetitive tasks that require very little training.

Much of the data collected through the NEPTUNE seafloor array will be reported as numerical observations that are best analyzed through machine computational methods (e.g., conductivity, temperature, depth, etc.). However, where inputs are not-so-easily decipherable by traditional computer analytical methods (e.g., camera imagery, full-motion video and audio signals), two alternative approaches are distinguished:

- Development of software agents that can learn to interpret these data, and
- Applying human intelligence and reasoning directly through human-based computation, analysis and observation.

In both these instances, the common approach to analyzing these data has been to assign trained personnel to accomplish these tasks – whether to assess the data or problem directly, or – where feasible – to provide rules and vocabulary through iterative interpretations in order to increase the accuracy of software agents. This approach can represent an inefficient use of scarce and valuable resources if the tasks are particularly simple and numerous. Our approach is to use crowdsourcing – also referred to as Web2.0-enabled citizen science – in order to apply volunteer labour as a first pass

effort. A related outcome is extended public engagement in ocean and marine sciences and the work of the Neptune project or the related Oceans2.0 initiative more generally.

The Digital Fishers crowdsourcing interface is planned for deployment in summer 2010. This citizen science project focusses on Human-Computer Interaction (HCI) user interface design, the integration of marine sciences and public engagement, and community-based knowledge mobilization. This is an opportunity for symposium participants to shape the development of the user interface and middleware. This hands-on session will give attendees a preview of the Digital Fishers prototype interface and allow for user feedback.

Key words: citizen science, crowdsourcing, Web2.0, cabled sea-floor observatory, Neptune Canada

Freshwater Hatchery Management Practices that Could be Incorporated to Rebuild Wild Stocks of Chinook Salmon

Carol Schmitt

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Abstract

The West Coast of Vancouver Island has many streams with extremely low escapement of wild stocks of Chinook Salmon. Intervention is required to rebuild these numbers. Conventional enhancement currently releases all progeny at the same time as an S0 smolt (i.e. eggs spawned in fall, juveniles released the following spring). Wild stocks naturally have ocean bound offspring as S0, S1, S2 or S3 (i.e. first year up to three years in fresh water prior marine waters). Genetics, freshwater temperatures and feed availability influence the time of smolt ocean migration. Limited resources and difficulties capturing the few returning Chinook make it essential that captured brood stock are managed to minimize losses and to maximize returns from the progeny release. Best management requires "an every fish is valuable approach", while incorporating a preventative management plan. i.e. why did a fish die, what else do we know that can affect the fish negatively, what can be done to prevent loss, ensure survival in the future". Some key management tools incorporates proper adult handling and spawning, adult disease screening, surface disinfection of eggs, smolt health checks, ensuring osmoregulation competency of early entries to net pens in estuaries, hatchery competency in view of water quality, incubator and rearing containers, multi age release strategy (integrate the S1 superiority), captive freshwater brood stock program (insures available eggs from year 4 to 7), cryopreservation of milt (saving a genetic pool) and feminization. It is important to use all of the management tools along with best resources available and to incorporate a multilevel plan that maximizes results for successful rebuilding of these stocks.

Knowledge

Carol Schmitt. A graduate from BCIT Fish, Wildlife, and Recreation Program. Knowledge through Employment includes Provincial Fisheries Field Tech, Federal and Private Fresh water Hatcheries, Ocean Fish Farm sites. Cultured Chinook, Coho, Sockeye, Rainbow, Steelhead, Atlantic, Sturgeon, Crayfish, and Sablefish. The fall of 2009 marks 31 years in a row culturing Chinook, in an array of programs growing S0, S1, S2 followed through in ocean grow out environments. Since 2000 have ongoing captive freshwater Chinook Brood stock programs. Builder, planner, owner, operator of private Freshwater Fish Hatchery est. 1988 and Ocean Sea Site est. 1986.

Components

Key ingredients for an effective all encompassing approach includes; Fish Hatchery, with optimum water quality in PH, Hardness, & Alkalinity, Temperature, Water Volume, fish free source. Incubators and circular rearing pools, that have self cleaning sloped bottom, made of non-porous material that can be disinfected between age classes. A Rearing environment that requires no sweeping or vacuuming as this suspends material and is a source of infection. Brood fish handled to minimize loss prior spawning due to stress and fungus, spawned in aseptic manner to prevent cross contamination of pathogens between fish, disease screened for common bacteria and viruses, with isolation of bacterial positive and discard of viral positive female's eggs. Eggs surface disinfected and set in individual tray, incubator set-up to facilitate removing dead eggs prior eyed and eliminate egg fungicide treatments.

Disease screening ensures you start with "clean progeny", stress and less than optimal incubation or rearing conditions can result in certain pathogens to show-up even after fish are disease screened "clean". Chinook are susceptible to bacterial kidney disease, so should be managed to have non-detectable levels. BKD is largely untreatable and will result in continual losses in the future, vigilance to manage in a pro-active manner, which involves routine sampling of juveniles during the fresh water rearing stage. Populations should be managed to be "clean" upon release. A smolt health certificate done on every stock of fish prior release back to stream of origin. The provides status of fish release and that they were not compromised and ensures no transference of pathogens from the fish hatchery back to the wild.

Intermediate estuary rearing, fish exposed to too high a salinity before they can properly osmoregulate will stress their bodies and result in bacterial kidney disease to proliferate at a later stage. A salt water challenge test on a sample size should be done to ensure the fish are salinity tolerant.

Discussion and conclusion

A female Chinook that spawn approximately 5000 eggs will result in offspring that are ready to migrate to the ocean at different stages. Depending on the rivers habitat, one could incorporate a multistage release strategy which releases a portion as swim-up fry, S0, S1 and S2's back into a stream. S0's are not recommended for low level stocks as farming experience shows they are highly susceptible to vibriosis post salt water entry. Most likely 85% or greater will die during first 4 month in seawater, whereas a S1 smolt is unaffected. A proper S1 release will have much higher survival due to earlier out migration from stream, quicker out migration, spend less time in estuary, has greater food availability, is largely unaffected by mackerel predation (whereas S0 have a large portion eaten), and will result in larger size adult returns. Additional components to saving and rebuilding low level stocks is to cryopreserve milt for genetic diversity, a fresh water captive brood stock program, which insures genetics are not lost and eggs available to restock from year 4 to 7 with the captive fish.

A smart, proactive approach through incorporating all information and best resources available is required to effectively re-build the wild west Coast Vancouver Island Chinook Salmon Populations.

Literature cited

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2. Taylor S. 2009 Fisheries and Oceans Canada, personal Communication for Stock Assessment Information

SESSION 9. PERSPECTIVES ON ECOLOGICAL CHANGE

SPECIAL SESSION 1: RESOURCE USERS PERSPECTIVES ON ECOSYSTEM CHANGE:

A FACILITATED CONVERSATION WITH INVITED GUESTS:

Bob Bowker, Odd Grydeland, Geoff Lindsay, Ian Macdonald, Peter Mieres, Rick Nookemus , Stella Peters

Facilitators: Tom Joe, Anne Stewart

SPECIAL SESSION 2: LONGTERM PERSPECTIVES ON ECOSYSTEM CHANGE:

A FACILITATED CONVERSATION WITH SPECIAL GUESTS:

Dr. Gordon Hartman (Retired DFO), Mr. Steve Rush (Uchucklesaht), Councilor Rob Dennis Jr (Huu-ay-aht), Councilor Willard Gallic Sr. (Tseshaht), Chief Anne Mack (Toquaht), Mr. Ladner Touchie (Ucluelet)

Facilitators: Tom Joe, Anne Stewart, Kim Hyatt

SESSION 10. ECOLOGICAL BASELINES: SHALLOW SUBTIDAL

KEYNOTE ADDRESS 4: SEA OTTERS, HISTORY AND NATURAL VARIATION; THE IMPORTANCE OF HAVING A BASELINE

DR. JANE WATSON

Biology Department, Vancouver Island University, 900 Fifth Street, Nanaimo, B.C. V9R 6R1

Summary

Sea otters, once abundant along the British Columbia coast, were extirpated in an intensive fur trade that started in the late 1700s. It is likely that sea otters were ecologically extinct from BC waters by about 1850, although the last sea otters were harvested in 1929[1]. From 1969 - 1972 Alaskan sea otters were reintroduced to the west coast of Vancovuer Island. Since this reintroduction the sea otter population has increased and expanded[2]. The interaction between sea otters (*Enhydra lutris*), sea urchins, and kelp is well know; by preying upon herbivores such as sea urchins, sea otters reduce grazing pressure and increase the abudance of fleshy algae[3,4,5]. Despite having achieved the status of an ecological paradigm this interaction has been poorly documented outside of Alaska, and its generality has been questioned, largely because marine systems are highly variable. In this study, conducted from 1987-2009, the effects of sea otters on nearshore community structure along the west coast of Vancouver Island was examined using two approaches. The results suggest that sea otters will have a profound effect upon community structure within Barkley Sound.

Methods or mode of knowledge

Two approaches were used to assess variability in shallow rocky subtidal community structure in areas without sea otters (Barkley Sound), recently occupied by sea otters (Kyuquot Sound) and continuously occupied by sea otters (Checleset Bay) off the west coast of Vancouver Island. Randomly-selected sites were used to provide a replicated, large-scale assessment of spatial and temporal variation in algal and invertebrate abundance, whereas annually-sampled permanently-marked plots were used to assess finer scale temporal variation. In the large-scale assessment, 20 randomly selected sites, in each of the three areas, were sampled in 1988, 1994 and 2007. At each site divers counted the abundance of invertebrates and algae in thirty $0.5m^2$ quadrats (0.7X0.7m). In the finer scale, but less representative approach, five 2X10m permanently-marked plots were established at each of two sites in areas with otters, four sites in areas occupied by sea otters during the study and two areas without sea otters. The sites were marked by stainless steel bolts set into the substrate 8-12m below MLW. These sites were monitored annually from 1987-2009.

Results or observations

The results of repeatedly sampling randomly-selected and permanently-marked sites in areas where sea otters were continuously absent, continuously present, or became reestablished during a 23 year study period, indicated that community structure could be predicted based upon the presence or absence of sea otters. Both sampling methods provided comparable results. In areas where sea otters were continuously present urchins were rare and algae dominated whereas in areas where sea otters were continuously absent, sea urchins were abundant and algae were rare and at sites occupied by sea otters during the study urchins became rare and algal abundance increased. Despite this overall predictability, the species composition and abundance of algae within otter-dominated sites and the abundance of urchins in otter free sites was spatially and temporally variable.

Discussion and conclusion

The results suggest that the community composition of nearshore rocky subtidal communities off Vancouver Island can be predicted based upon the presence or absence of sea otters. However, community structure was variable within each of the three areas (continuously occupied by otters, continuously otter free, or occupied by sea otters during the study). Most of this within area (among site) variability appeared to be a consequence of temporal changes rather than consistent spatial differences. The overall patterns observed indicate that dramatic changes in community structure will occur when sea otters reoccupy Barkley Sound.

Key words

Sea otters, subtidal community structure, kelp forest, alternate stable states

Literature cited

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EFFECTS OF SEA OTTER PREDATION ON SUBTIDAL ROCKY REEF FOOD WEB STRUCTURE AND PRODUCTIVITY ON THE WEST COAST OF VANCOUVER ISLAND

REBECCA G. MARTONE[1] AND RUSSELL W. MARKEL[2]

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Summary

The near extinction of sea otters (*Enhydra lutris*) as a result of the North Pacific Maritime Fur Trade is one of the most dramatic examples of human-induced impacts to the structure and functioning of nearshore marine ecosystems. Although the effects of sea otter predation on grazer populations and macroalgal communities are well known (Estes and Duggins 1995), the indirect effects of sea otters on food web structural properties, diversity, resilience, and ecosystem productivity are virtually

unknown. We are performing a comprehensive community-wide assessment of the relationships between sea otters and near-shore rocky reef food web structure, biomass distribution, and productivity. This project constitutes an integral component of a broader project ("*Coastal Ecosystem Services Amongst Trophic Cascades*") examining ecosystem services associated with sea otter reintroduction on the west coast of Vancouver Island.

Methods

Our sampling design consists of sampling three sites in Barkley Sound (sea otters absent) and Kyuquot Sound (sea otters present). At each site we performed replicate surveys of fish, invertebrates, and kelp density and size, using 30 x 2 m transects and 1m x 1m quadrats. Size and density measures were converted to biomass using length-weight relationships determined for individual species in the field. Using a modified underwater airlift system, we collected benthic algae and micro-invertebrates in replicate 25 x 25 cm plots at each site. Species and groups were identified in the field and lab to highest taxonomic resolution to determine the biomass and diversity of benthic assemblages. Individual fish, invertebrates and algae were collected for C and N stable isotope analysis to determine trophic position and the contribution of kelp-derived carbon in rocky reef food webs. Using these field data we are constructing and comparing food webs for each region and performing analyses of food web structure and function, including: (1) network analysis and dominator trees to determine the indirect effects of sea otters on food web properties such as stability, robustness, connectedness, and keystone species; (2) distribution of biomass within webs; and (3) estimation and comparison of productivity.

Results

Preliminary results will be presented in February.

Key words

Marine ecosystems, sea otter reintroduction, food web properties, biomass distribution, productivity

Literature cited

1. Estes, J. A. and D. O. Duggins. 1995. Sea otters and kelp forests in Alaska: Generality and variation in a community ecological paradigm. Ecological Monographs 65:75-100.

Impacts of sea otter foraging on intertidal communities: implications of sea otter re-establishment in Barkley Sound

Gerald G. Singh[1,2]*, Russell W. Markel[2,3]

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[2] Bamfield Marine Sciences Centre, Bamfield, BC, V0R 1B0, Canada
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Summary

Sea otters (*Enhydra lutris*) on the west coast of Vancouver Island are expanding their range, and will likely reach Barkley sound in a few years. Sea otters are important predators of marine invertebrates. We examined intertidal communities along the coast of Vancouver Island to understand how intertidal communities change with sea otter influence. Understanding the differences in intertidal community structure between areas along the coast where otters are present and absent can provide an understanding of how intertidal communities are likely to change as sea otters establish in Barkley Sound. Despite variability within the different areas sampled, intertidal invertebrates are generally smaller and biomass is lower where otters are present. Key intertidal invertebrates sampled include mussels (*Mytilus californianus*), sea stars (*Pisaster ochraceus*), and chitons (*Katharina tunicata*). These results support the hypothesis that otters are important predators of a diverse array of invertebrates and that they selectively eat larger individuals (Laidre and Jameson 2006).

Methods or mode of knowledge

Transects through intertidal communities were conducted in three sites in each of Barkley Sound, Clayoquot Sound, Kyuquot Sound, and Neah Bay. Mussel size structure and mussel bed depth were measured in all areas. Mussel biomass and biomass of species associated with mussel beds were measured in Barkley Sound and Kyuquot Sound. In the lower intertidal, abundances and size structure were recorded for invertebrate grazers and predators in all sites on Vancouver Island. Linear mixed effect models were used to examine differences between regions where otters are present and absent.

Results or observations

Mussels were largest at Barkley Sound, and decreased in size along a gradient of time since otters established in an area. Similarly, mussel bed depth, mussel biomass, and mussel-associated species biomass were lower in areas where otters are present then where they are absent. Biomass of seastars and chitons were also lower in areas where otters were present than in areas where otters are absent.

Discussion/Conclusion

Our results suggest that sea otters have a dramatic impact on intertidal invertebrates through predation. These results have implications for intertidal community dynamics and the harvesting of intertidal invertebrates. The decrease in sizes and biomass of important grazers (chitons) and predators (seastars) can increase the cover of intertidal kelps and decrease seastar predation in the intertidal. Potential food sources for people (mussels and chitons) may be less available for harvest.

Key words
Keystone predation, sea otters, intertidal communities, mussels, seastars, chitons, food webs

Literature cited

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ARE SEA OTTERS GOOD FOR FISH?

STEFAN J. DICK[1,2] AND RUSSELL W. MARKEL[1,2]

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[2]Bamfield Marine Sciences Centre, Bamfield, BC

Summary
The re-establishment of sea otters along the west coast of Vancouver Island has resulted in a significant increase in kelp abundance. This kelp may provide direct growth benefits to invertebrate organisms that feed on kelp or kelp detritus, and indirect growth benefits to higher-level consumers. While these effects may be important in structuring kelp forest communities, they remain poorly understood. In this study, we aim to assess the potential effects of kelp forest recovery on growth rates of nearshore fishes. We predict that larger kelp forests will support a higher abundance of forage fishes (e.g. herring), which will contribute to higher growth rates in generalist predators (e.g. rockfish and lingcod). To test this, we compared diet, trophic position and growth of a common nearshore fish, the copper rockfish (*Sebastes caurinus*), collected from an otter-present and an otter-absent region on the west coast of Vancouver Island. The results of this study will improve our understanding of the potential interactions between sea otters and fish. Understanding how nearshore fish populations will respond to sea otter re-establishment will be important to the success of future fisheries management and conservation strategies.

Methods
In this study, we compared diet, trophic position and growth of copper rockfish (*Sebastes caurinus*) collected from Kyuquot Sound (otter-present region) and Barkley Sound (otter-absent region). In each region we collected 50 adult copper rockfish by hook-and-line. Catch per unit effort (CPUE) data was recorded to quantify relative fish abundance. Laboratory analyses included: i) stomach content analysis (diet); ii) stable isotope analysis (trophic position); and iii) otolith age analysis (growth).

Results
Analyses of diet, trophic position, and growth are in progress. This section will be updated as analyses are completed.

Discussion and conclusions

This study represents the first investigation of the indirect effects of sea otter recovery on nearshore fish populations. The results of this study will provide us with a better understanding of how fish in Barkley Sound may respond to sea otter re-establishment. Understanding how nearshore fish populations will respond to sea otter and kelp forest recovery will be important to the success of future fisheries management and conservation strategies.

Key words

Rockfish, sea otters, indirect effects, conservation

USING ECOSYSTEM MODELS TO PREDICT EFFECTS OF SEA OTTERS RETURN TO THE WEST COAST OF VANCOUVER ISLAND

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Summary

Sea otters are widely regarded as a keystone species, able to structure nearshore marine environments by releasing macro-algae from grazing pressure. This restructuring can shift an invertebrate-dominated nearshore system (i.e., urchin barrens) into a kelp-dominated system, which is assumed to support a greater biomass, and higher species diversity than the urchin barrens[1,2]. The nearshore ecosystem on the west coast of Vancouver Island (WCVI) is experiencing these shifts due to the reintroduction of sea otters during the 70's[3], affecting (positively or negatively) those people who depend on the natural resources. The intent of this project is to build an ecosystem model to predict trophic cascade effects and socio economic impacts specifically to commercial fisheries caused by sea otter reintroduction to the area.

Methods or mode of knowledge

A linear ecosystem model was built in Ecopath with Ecosim (EwE). This software allows the inclusion of multiple species, trophic interactions, mediating effects, fisheries, and scenario analysis[4]. We defined the food web functional groups based on site sampling and literature review. We parameterised our model for Pacific Canadian waters, using the site sampling results, EwE models built for British Columbia, and existent databases. Fisheries information was collected from the Department of Fisheries and Oceans Canada (DFO) and integrated to the model.

Two main benefits provided by kelp forest were modeled, a) the contribution to primary and secondary production and b) the increased food availability for some species through prey retention[5]. For the former we included kelp detritus as a functional group and for the latter we used a mediation function available in Ecosim. Mediation function allows modeling impacts (positive or negative) of a third species to prey-predator relationships of two other species[6]. For the spatial representation we assumed the reintroduction of sea otters to one specific area and their reasonable expansion across the whole study area.

Results or observations

The model demonstrates the trophic cascade effects of sea otter reintroduction spreading from one end of the 300 km nearshore ecosystem of the West Coast of Vancouver Island to the other end over a period of 100 years. In areas where sea otters were present, shellfish populations declined; but some fish populations such as lingcod and forage fish increased. The model also demonstrates the contribution of kelp to primary and secondary production and the increased food availability for some predators. The inclusion of commercial fisheries in the model showed how they can or are likely to be affected by the sea otters expansion in the area.

Discussion/Conclusion

Although inclusion of information on habitats will help to better represent the trophic cascade effects and the inclusion of values derived from the ecosystem will improve the prediction of socio-economic effects; this model can provide an integrated understanding of the ecosystem dynamics, essential for responsible management.

Key words

Ecosystem models, trophic cascade effects, sea otter reintroduction

Literature cited

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KEYNOTE ADDRESS 5: THE KELP OF BARKLEY SOUND: DISTRIBUTION, HISTORY, ECONOMICS, AND LEISURE

DR. LOUIS D. DRUEHL

Professor Emeritus, Simon Fraser University and Bamfield Marine Sciences Centre

Professor Louis Druehl will provide a retrospective overview of his career-long interest in the kelp of Barkley Sound and the particular insights this may provide to understanding and monitoring change in the ecosystem. Professor Druehl has taught marine botany at Simon Fraser University and various marine stations for over thirty years. His ongoing research advances understanding of kelp ecology, evolution and cultivation, and his doggerel amuses. Louis and his partner, Rae Hopkins, have operated Canadian Kelp Resources (**www.canadiankelp.com**) out of Bamfield for over twenty-five years. CKR has a line of sea vegetables (Barkley Sound Kelp), provides kelp for pharmaceutical and cosmetic companies, and champions kelp farming and the development of kelp-based cottage industries locally and abroad.

SESSION 11. LOOKING TO THE FUTURE

This session will be comprised of ~10-minute presentations geared toward initiatives, outlooks, and aspirations for the future. These talks could focus on natural resources management, future plans or uses, and potential challenges that might be foreseen, and a vision for how to get to the destination. These presentations will be onboard the RV Francis Barkley during the return journey from Bamfield to Port Alberni. These short presentations could open up a group dialogue, or they could transition to individual discussions and sightseeing.

Presentation 1. (Huu-ay-aht) – Undecided
Presentation 2. (Ucluelet) – Marylin Touchie
Presentation 3. (Toquaht) – Chief Anne Mack
Presentation 4. (Tseshaht) – Undecided
Presentation 5. (Uchucklesaht) – Mr. Steve Rush
Presentation 6. (Hupacasath) – Tom Tatoosh

LOGISTICAL INFORMATION

REGISTRATION AND PRESENTATIONS

The registration desk will be located in the atrium (lobby) of the RIX Centre (See map on last page). Please visit the registration desk to pick up your nametag and symposium package. All symposium sessions will be held in the RIX, save for the special presentations to and from Bamfield onboard the MV Frances Barkley. Oral presenters are requested to submit their PowerPoint presentations to the registration desk within half a day before their sessions.

The poster session will occur the evening of the first day and will remain hung in the atrium of the RIX for the duration of the symposium. Authors with posters are requested to mount their posters on Tuesday, 9 February, at 5:30p.m. prior to dinner.

WIRELESS ACCESS

Wireless internet connections are available throughout most of the BMSC campus. Enter this WEP key to connect: **A2D5355687** Please note that wireless services are inherently insecure, and BMSC assumes no responsibility for any harm or loss incurred by the use of this service, where possible it is recommended that you connect with an Ethernet cable instead.

If you have any problems please contact the IT System Administrator: (250) 728-3301 ext. 228, kjurkic@bms.bc.ca

ON SITE HELP

If you have any inquiries or need any assistance during the Symposium, please ask the Symposium staff and volunteers who will be identifiable by their colour coded nametags. Special speakers and keynote speakers will also have colour coded nametags. The registration desk in the Rix Centre.

ACCOMMODATION

Details on accommodation purchased through the symposium website will be available at the registration desk in the RIX atrium during the symposium. Other accommodation is available in Bamfield.

MEALS

Meals at BMSC are normally served for the first 1/2 hour in the Dining Hall (refer to the BMSC site map on the next page) though the hall will remain open beyond this time. Second helpings are placed out after everyone has been served. A blessing will be given prior to each meal so pleaes be seated for the blessing before serving yourself. Serving times:

- Breakfast: 7:30 AM to 8:00 AM
- Lunch: 12:30 PM to 1:00 PM
- Dinner: 6:00 PM to 6:30 PM

*****PLEASE NOTE**: It is the responsibility of symposium participants to prepare their bagged lunch on Thursday, February 11th. The bag lunches are to be made by participants during breakfast on the 11th. These bags may be taken with you at breakfast or, labeled and stored at the dining hall cooler.

VENUE

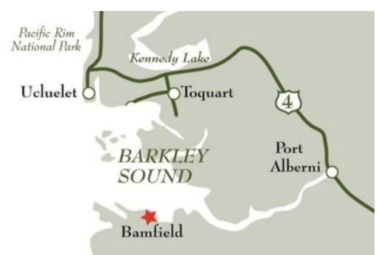
The Symposium will be held on board the *M.V. Francis Barkley* and continue upon arrival at the Bamfield Marine Sciences Centre. It will commence on the 8 am sailing of the *M.V. Francis Barkley* on Tuesday, February 9th, 2010. **Please arrive at 7:30a.m. to board the vessel.** The symposium will end on Thursday February 11th, 2010. If you are taking the boat back to Port Alberni **please be available for boarding with your bags packed at 12:15p.m**. Sailing time updates for the return trip will be announced following closing remarks on Thursday.

Lady Rose Marine Services (250) 723-8313
5425 Argyle Street, Port Alberni, B.C. (Next to Alberni Harbour Quay in south Port Alberni)

Bamfield Marine Sciences Centre (250) 728-3301
100 Pachena Rd, Bamfield, B.C.

DRIVING

Directions: http://www.bms.bc.ca/information/gettingtobamfield.html
Road Conditions: http://www.brsa.ca/recent-road-conditions/



CARPOOLING

Visit the BMSC *Rides to Bamfield Calendar* to view or post rides to and from Bamfield at this link: http://www.bms.bc.ca/information/rides.html
As well as the Carpooling Page on the symposium website:
http://www.westcoastaquatic.ca/barkleysymposium/content/carpooling-page

SIGHTSEEING

Bamfield is a pristine vacation destination that offers many outdoor activities. Popular activities include foraging for wild mushrooms and berries, mountain biking, salmon fishing, hiking, kayaking, scuba diving, cycling, whale watching, camping, beachcombing, bird watching, or you could arrange a field trip aboard the Barkley Star or M/V Alta (http://www.bms.bc.ca/facilities/vessels.html).

Day Treks and Sightseeing

- Brady's Beach
- Pachena Lighthouse and Beach
- Tapaltos Beach
- Keeha Beach
- Cape Beale Lighthouse
- Waterfront boardwalk

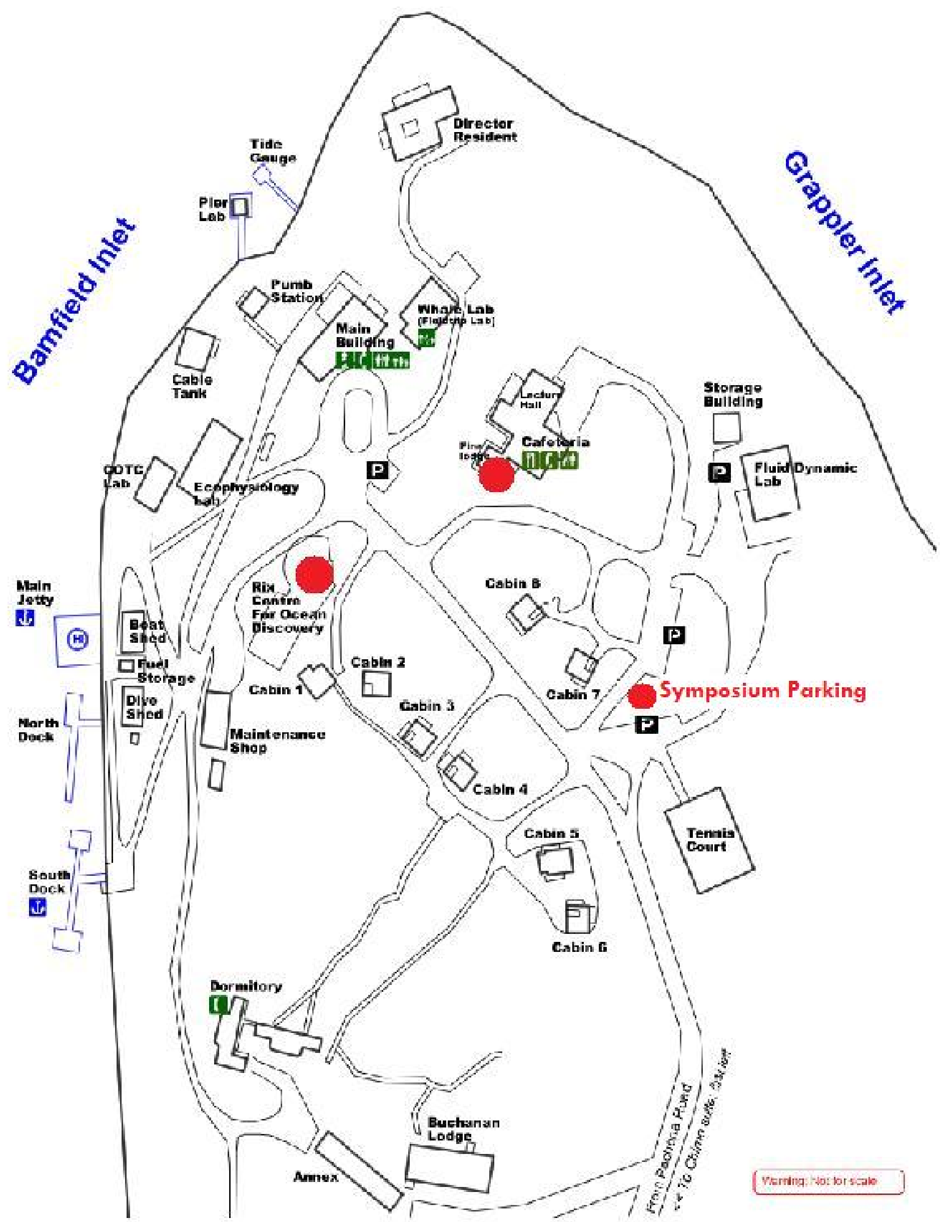
For more things to see and do consult http://www.bamfieldchamber.com/

If you have a few extra days prior to or following the symposium, consider spending a day or two outside of Bamfield. For Port Alberni and surrounding areas go to http://www.albernivalleytourism.com/

EMERGENCY CONTACTS

1. Siobhan Gray, First Aid & Safety Office**:** (250) 728-3301 ext. 222, **diving@bms.bc.ca**
2. Bamfield Health Centre, 353 Bamfield Road (PO Box 40), Bamfield, BC V0R 1B0, **Phone** (250) 728-3312

BAMFIELD MARINE SCIENCES CENTRE SITE MAP



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