size of the consumed bivalves were subsequently identified from the shells. Only shells with fresh remains of soft tissues were considered to represent the observed foraging dive. Three species of bivalves (*Mya truncata, Hiatella arctica* and *Serripes groenlandicus*) were consumed. The number of bivalves eaten during 10 dives made by 5 different walruses averaged 53 ± 5 (mean ± SE, all species pooled) per dive which lasted 5-7 min. This corresponds to 150 ± 19 g shell free dry weight per dive.

OS42E-158 1330h POSTER

Feeding Ecology and Migration Characteristics of a Northern Population of Arctic Charr, Salvelinus Alpinus (L.) in N.E. Greenland

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Anadromous arctic charr, Salvelinus alpinus (L.) are salmonids that adopt a migrant life history strategy to take advantage of access to marine environments and richer feeding areas during the short but intense summer season of the colder high latitude regions. If the migrant charr population is large and consumption rates are high then Arctic charr may have a significant impact on various trophic levels within a local region. In an attempt to increase our understanding of their potential regulating role in a local marine environment the feeding ecology and migration characteristics of an anadromous arctic charr population was studied in Young Sound, N.E. Greenland (74°18'N; 20°15'W). Results from 290 stomachs (charr lengths; 16-69cm) sampled in 1997 and 2000 showed a variable selection of prey items according to seasonal and annual changes in prey availability. Amphipods (54% occurrence and 40% weight) and mysids (55% occurrence and 33% weight) along with fish (40% occurrence and 21% weight) constituted the dominant prey in 1997, whereas pelagic snails (90% occurrence and 60% weight) and to a lesser extent crustaceans and fish were the dominant prey in 2000. The small size group (< 40cm) tended to feed almost exclusively on crustaceans suggesting ontogenic changes in diet. Seasonal changes in diets reflected a feeding pattern according to the Optimal Foraging Theory as charr chose a broader variety of food items during the early part of the summer when prey was scarce and fewer types of prey in the latter part of summer when food was more abundant. The median length of charr migrating upstream decreased significantly during the migration period as a comparatively greater proportion of smaller individuals ascended the river during the latter part of the summer. Charr in this population first migrated to the sea from the age of 6 years (overall age; 6-22 years). Peak abundance of returning charr in the latter part of the study period corresponded well with increases in river discharge and highest daily tide levels. The potential role of anadromous arctic charr within the marine food web is discussed in relation to ongoing studies of changes in marine arctic production in Young Sound. (http://www.dmu.dk/LakeandEstuarineEcology/CAMP/).

OS42E-159 1330h POSTER

Ice-Associated Organic Carbon in the Bering Sea Water Column During Winter

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Algae growing on the under-surface of fast ice or pack ice can be important to foodwebs in the upper water column, and to providing inoculum for spring blooms as the ice edge recedes. Much of this algal carbon may be released in dissolved form. However, seldom have there been measurements of dissolved and total organic carbon (DOC, TOC) underneath pack ice in winter to evaluate the importance of ice algal contributions throughout the water column. During the unique winter of 2001, pack ice in the Bering Sea had receded north of St. Lawrence Island (65°N) by 15 February, but by 15 March had advanced again to 62°N. In our sampling during March, this variable pack allowed us to examine effects of ice cover on DOC and TOC at surface, middle, and bottom depths in water ranging from 50-90 m deep, over an area of about 900 km^2. The Bering Sea ice pack advects southward at a highly variable rate of about 15 km/day. In March 2001, newly-formed pack ice less than 1-2 weeks old rapidly developed ice algal communities. Sample stations covered by pack ice (n = 23) had higher levels of TOC at surface ($P = 0.023$) and middle depths ($P = 0.019$) than did stations with open water or newly-formed pancake ice (n = 14). In contrast, DOC concentrations did not differ between ice cover types ($P > 0.474$), suggesting that a baseline concentration of DOC was augmented by particulate carbon derived from ice algae. Our findings indicate that even new pack ice can rapidly develop ice algae capable of contributing significant organic carbon throughout the water column long before onset of the spring bloom.

OS42F HC: Hall III Thursday 1330h

Biophysical Factors Affecting the Growth and Survival of Aquatic Organisms IV

Presiding: **J Ackerman,** University of Northern British Colombia

OS42F-160 1330h POSTER

The Effect of Small-Scale Turbulence on the Morphology and Growth Rate of *Eucampia zodiacus* Ehernberg (Bacillariophyceae)

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The role of size and shape in the ecology of planktonic diatoms has been debated since the latter part of the 19th century. Elaborate shapes have been hypothesized to influence flotation, orientation of the particle within the water column, or to confer protection from grazers. More recently, it has been argued that differences in shape could interact with small-scale mixing processes to increase the flow of nutrients to the cell surface, thus enhancing growth rate. In order to explore potential biological-physical interactions, we examined the effect of small-scale turbulence on the morphology, size and growth rate of the diatom *Eucampia zodiacus* Ehrenberg. Colonies were grown in 20 L batch cultures, in 5 levels of turbulence (quantified with an ADV), and compared to a quiescent control. The resulting colony length was directly related to the level of turbulence under which E. zodiacus was grown. Helical colonies up to 4 mm in length, each composed of hundreds of cells, were formed at epsilon values $\sim 10^{-8}$ to 10^{-7} m^2 sec^{-3}. Only short fragments of colonies were formed at epsilon of $\sim 10^{-6}$ to 10^{-5} m^2 sec^{-3}. At epsilon $\sim 10^{-4}$ to 10^{-3} m^2 sec^{-3}, colonies were not formed at all: only single cells and pairs of cells occurred. Some turbulence was necessary in order for *E. zodiacus* to form morphologically normal colonies. In the non-stirred control tank, many colonies were abnormally twisted. If formed, helices were often irregularly coiled. *Eucampia* also modified its shape in response to turbulence. Over the range of epsilon values where colonies were formed, the pitch of the helix decreased with increasing turbulence. Differing levels of turbulence also led *E. zodiacus* to alter the mechanical strength of the connection between cells. The silicon processes that connect adjacent cells in a colony were largest under the conditions that led to the formation of the longest colonies. We did not observe statistically significant changes in growth rate amongst the different turbulence treatments. Changes in morphology, but not in growth rate, indicate that this diatom adapts to the level of turbulence under which it is grown, but that the changes may be related to altering the mechanical strength of the colony, rather than modification of nutrient uptake dynamics.

OS42F-161 1330h POSTER

Bioconvection in Oceans and Lakes

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It has been recently stated that bioconvection is a feedback mechanism from the biology to the physics that requires investigation in an oceanographic context. Bioconvection has previously been studied with regards to experiments of shallow suspensions of motile micro-organisms. It describes the mechanism by which upward-swimming organisms aggregate near the surface, causing an overturning instability because the surrounding water has a lower density than the organisms. When viewed from above, a variety of patterns can be seen.

Here, we consider the potential for an alternative form of bioconvection to occur. Subsurface chlorophyll maxima are commonly-observed aquatic features. Models show that, under the right circumstances, a chlorophyll-rich layer of water can become heated more than the water above it, creating an unstable situation. We model such a scenario to investigate the potential for creating scaled-up versions of the bioconvection patterns observed in the small-scale experiments (albeit by a different process).

Our model consists of the full Navier-Stokes equations, plus equations for phytoplankton biomass, irradiance (which is modified by the phytoplankton), water temperature (which is modified by the irradiance) and water density (which is modified by the temperature). The resulting convection can advect the phytoplankton, and thus could be a mechanism for creating horizontal patches of phytoplankton in lakes and oceans.

URL: http://www.chebucto.ns.ca/~english

OS42F-162 1330h POSTER

Chaos or Critters?: Distinguishing Turbulence from Zooplankton in Acoustic Profiles of Turbulent Environments

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Recent work has shown that zooplankton feeding is improved when the animals are exposed to certain levels of turbulence and that some species may seek preferred levels of turbulence in the mixed layer. Acoustic backscatter is a common tool to study zooplankton distributions. In turbulent regions it may be difficult to identify the source of acoustic backscatter because both turbulent microstructure and zooplankton scatter sound. Multiple frequency sounding is helpful because turbulence and plankton have different spectral signatures, but there remains a pressing need to verify the models of backscatter with in situ measurements of turbulence and zooplankton, so that plankton density can be unambiguously related to turbulence.

We made simultaneous measurements of turbulent microstructure and fine-scale zooplankton distribution in a local fjord (with sill-generated turbulence) by mounting forward looking sounders (44 and 307 kHz) and a video recorder on a towed vehicle designed for taking velocity and temperature microstructure measurements. The footprint of these sounders is small (radius less than 2 m at the maximum range of 20 m) and the approach of reflectors can be tracked to within 2 m of the turbulence sensors at the front of the towed vehicle.

In turbulent areas, the sounders on the towed body showed mostly large-scale, diffuse scatter (likely turbulence) that was punctuated by the occasional strong, discreet target when a zooplankter (or group) passed by. The ship-board sounders (12, 40, 100 and 200 kHz), on the other hand, have a broad footprint at the range of interest, and only show diffuse backscatter in turbulent regions with no evidence for scatter from plankton. The zooplankton layers (visible in low-turbulence regions away from the sill) appear to be dispersed near the sill, making the zooplankton density too low to be detected with the ship-board sounders.

THU

OS42F-163 1330h POSTER

A Non-Stationary Riverine Tidal Model to Assess Impacts of Historical Changes in Columbia River Discharge on Juvenile Salmonid Habitat

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Tides, river stage (S) and river flow control current velocities and the extent of shallow-water habitat and tidal wetlands in the Lower Columbia River (CR), playing a major role in juvenile salmonid habitat. Since CR discharge has changed historically, due to hydroelectric regulation and climate variability, there is a need to assess changes in salmonid habitat coupled to hydrodynamic changes. Varying river discharge causes tidal propagation to be non-stationary, rendering the tidal prediction via harmonic analysis unsuitable. As an alternative, we have developed a river flow dependent model for the diurnal (D1), semidiurnal (D2) tidal species and tidal range (R) based on solutions to the linearized St. Venant equations. The wave number of D1 and D2 and the damping modulus of D1, D2, and R were shown to linearly depend to first order on two inputs: a) river flow and b) the square of incoming tidal ocean amplitude divided by the square root of river flow. A simple first order model relates S linearly to river flow. These models were calibrated and verified using a linear regression of the normalized tidal phases, amplitudes, and S. With an optimized filter bank, time-series of D1, D2, R, and S were retrieved from tidal height data collected (1980 -2001) at gauging stations below Bonneville Dam (230 km from the ocean). In contrast to harmonic tidal analysis, our model accounts for non-stationary tidal phases and amplitudes under the restriction that their time changes are small within a tidal wave period. The model was capable of predicting D1, D2, and R amplitudes with an average root mean squared error of 2.5, 2.8, and 3.0 cm respectively. Our method has offered a new view of the prediction of riverine tides, enabling us to reconstruct historical CR tidal properties. Historical tides in the Lower CR were larger than at present, except during spring freshets. Further, tides were historically much smaller and river stage much higher during the downstream migration of juvenile salmonids than at times of modern flow regulation. Modern flow regulation reduces overbank flow and access to previously available salmonid habitat.

OS42F-164 1330h POSTER

A Hydrodynamic Model for Free-Swimming Copepods: The Significance of Being Self-Propelled

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The classic solutions for the Stokes flow around a translating sphere are often used to calculate the flow field around a sinking copepod or the flow field of a copepod feeding current. Comparison with published observations show that the Stokes solutions for a translating sphere do not correctly model the flow field around free-swimming copepods. Theoretical considerations show this failure is due to the fact that a free-swimming copepod is a self-propelled body, i.e. the copepod beats its cephalic appendages to gain thrust from the surrounding water in order to counterbalance the drag force by water as well as its excess weight. The wake of a self-propelled body decays much quicker (in both space and time) than the wake of a translating body which is moving due to an external force.

Here, we propose a simple, self-propelled model for the free-swimming copepods. We employ this model to understand the relationship between copepods swimming behavior, flow geometry, feeding efficiency and sensory mechanisms in detecting prey particles.

OS42F-165 1330h POSTER

Mechanosensitivity of Dinoflagellate Flow-Induced Bioluminescence: Role of the Actin Cytoskeleton

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Bioluminescent dinoflagellates are remarkably sensitive to fluid motion, responding to disturbances with bright flashes of light nearly instantaneously. Previous studies have indicated that bioluminescent dinoflagellates are most sensitive to shear forces. Above threshold, shear-stimulated bioluminescence (BL) is directly related to the magnitude of shear stress. Thus, BL is an excellent indicator of flow sensation in a single cell. Because measuring and quantifying BL is relatively easy, bioluminescent dinoflagellates can be used as a model to study the cellular mechanisms that underlie flow sensing and mechanosensitivity. The mechanisms linking fluid motion detection to light emission in dinoflagellates are poorly understood. The same is true for the cellular mechanisms underlying any flow-induced response, particularly those of a free-floating cell. A cells internal skeleton is believed to play a role in mechanosensitivity in two ways: (1) modifying mechanosensitivity by affecting cell stiffness, or (2) imparting mechanosensitivity through force-transferring linkages to membrane-embedded receptors or channels. By modifying the cytoskeleton, we can examine its role in flow sensation. This study focuses on the role of one component of the cytoskeleton: the filamentous actin (f-actin) in flow-induced BL. We report the response of a population of cells as well as individuals of the species, *Pyrocystis fusiformis* (a large, autotrophic, non-motile dinoflagellate), to levels of steady-state fluid shear between 0.75-4.65 dynes/cm^2 following treatments with f-actin-inhibiting cytochalasin-D. Approximate Couette-flow conditions were created within the gap between a stationary vial and a rotating inner cylinder. BL measurements were made with an integrating sphere photometer. The effect of different concentrations of the drug on mechanosensitivity was determined. We found that *P. fusiformis*, as reflected by its BL response, retains mechanosensitivity to fluid shear following treatment with high doses of f-actin-inhibiting drug. These results show that the f-actin cytoskeletal element is not necessary in *P. fusiformis* for reaction to flow and suggest that bioluminescent dinoflagellates are an excellent model for investigating the cellular mechanisms of mechanosensation.

OS42G HC: Hall III Thursday 1330h

Circulation in Marginal and Semienclosed Seas II

OS42G-166 1330h POSTER

Observations of Internal Waves in the Strait of Georgia

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The propagation and interaction of internal waves moving in different directions is an important but not well studied topic. Although in general observations of subsurface motions are difficult, near surface internal waves often have a surface expression which is visible to the eye. Observations suggest that the Strait of Georgia has many such internal wave packets close to the surface, and hence might be an ideal geophysical laboratory to study these processes. Some preliminary work was carried out in the summer of 2001 in this region. Ocean surface images were taken by digital cameras in an airplane. A hovercraft with an Acoustic Doppler Current Profiler (ADCP) and a CTD was guided by the airplane to a wave packet. By combining the surface visual observations with the subsurface current and stratification data, we are able to practically follow one wave packet, keeping track of individual wave crests to provide a more complete picture of wave propagation and evolution. On July 4th, we observed internal waves with a wavelength of 50-100 m, an amplitude of up to 4 m, and a phase speed of 1 m/s. The observed phase speeds, wave length and the orientation of wave propagation were obtained from a time series of photogrammetrically rectified surface slick images. The wave amplitudes and periods are provided by the ADCP data. By combining both data sets we have a unique set of observations of wave propagation, evolution, and wave-wave interaction.

OS42G-167 1330h POSTER

Observation and Modeling of the Circulation in the Gulf of Elat

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Since 1988 long-term observations employing current meters have been concentrated at two stations at the northern end of the Gulf of Elat: one near the northern tip of the Gulf (NT) and the second 11 km from the gulf's north end along the western shore (MBL) where a very complicated circulation pattern with velocities exceeding 15-20 cm/sec were observed. The current varies in both space and time and its direction nearly follows the local bathymetry. During February of each year the progressive vector diagram of the daily averaged velocity at 12 m near MBL indicates a peculiar reversal of the current direction. This reversal of flow is not observed along the Gulfs northern end. In addition to the current reversal, a conspicuous disappearance of the semidiurnal signal in the power spectrum of the currents in winter was observed during all of these years. This disappearance of the semidiurnal signal in the long-shore velocity was not accompanied by an observable decrease in the M2 component of the sea surface height.

In order to supplement and further understand the field measurements, a three dimensional numerical model have been applied (the Princeton Ocean Model, POM) to study the relative roles of the wind, tidal forcing, and seasonal stratification in driving circulation in the entire Gulf. The model was adapted to the Gulf by imposing the local topography, tidal and wind forcing, and initializing it with seasonal hydrographic profiles. The results indicate that the circulation consists of a series of gyres that occupy the entire width of the gulf and that are aligned along the main axis of the basin. Their locations and number are determined primarily by the shape of the coastline and the bathymetry while their diameters are determined by the seasonally changing depth of the thermocline. The MBL is close to the transition point between the northernmost gyre and the next gyre to the south. As the northern gyre contracts in winter and expands in summer the direction of the simulated currents near the MBL reverses with the seasons. Similarly, the disappearance of the semidiurnal peak in the current power spectrum in winter is related to the deepening of the thermocline in winter. As the mixed layer deepens, the effects of the barotropic tidal flux through the southern entrance to the Gulf (Straits of Tiran) are distributed over a thicker layer so the signal in the velocity power spectrum at a particular depth weakens. While the model appears to successfully simulate the large-scale circulation patterns of the Gulf, it does not properly reproduce the current direction fluctuations observed near the north beach.

OS42G-168 1330h POSTER

Evolution of the Open-Sea ALGERS98 Eddy in the Algerian Basin: from Lagrangian trajectories and Sea Surface Temperature

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For the fist time the westward evolution of an open-sea anticyclonic eddy along the Algerian basin (Western Mediterranean Sea) was tracked with in-situ observations (15 buoy trajectories and CTD transects) complemented with daily composite infrared images. Initially the eddy was located (1.8°E-38°N) in front of the Ibiza Island. The buoy trajectories described more than 45 loops at periods of 4 to 21 days, for about 3 months. Along the Spanish continental shelf, some buoy trajectories were released from the eddys flow, describing a predominantly south-southwest mean flow. The eddys movement, translation and swirl velocities around the eddy center, were separated with a kinematic model.The mean translation speed of the eddy was 2 km/day, showing well agreement with the value