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In this Issue:

Ross Sea Cruise: PRISM Project

Processes Regulating Iron Supply at the Mesoscale

By Dr. John Klinck

RVIB Nathaniel B. Palmer leaving McMurdo Sound.

It was a sunny and cool Christmas Eve, a nice summer's day, as we left for seven weeks on the *RVIB Nathaniel B. Palmer.* Our path took us from Punta Arenas, Chile, to the west through Drake Passage and on to the Ross Sea, a transit of about two weeks. After the transit, we spent about five weeks sampling several areas of the Ross Sea looking for dissolved iron and its effect on primary production. On board the *Palmer* were groups from Old Dominion University, Virginia Institute of Marine Science, Woods Hole Oceanographic Institute, Bedford Institute of Oceanography and University of Southampton. This group was traveling to the Ross Sea to undertake the fieldwork component of the PRISM (Processes Regulating Iron Supply at the Mesoscale) project which focuses on understanding what makes the Ross Sea the most biologically productive area in the Southern Ocean.

The group from Old Dominion University, which was responsible for hydrographic measurements, included John Klinck, Pierre St-Laurent and Suriyan Saramul from CCPO, along with Stephanie Hathcock (an Old Dominion graduate student in the Department of STEM Education and Professional Studies) and Marco Pedulli (a graduate student in the School for Marine Science and Technology, University of Massachusetts, Dartmouth). The land-based project participants included Eileen Hofmann and Mike Dinniman. Peter Sedwick, also from Old Dominion, leads the iron chemistry part of the PRISM project and participated in the cruise.

The spring bloom (the initial growth of phytoplankton in the spring) in the Ross Sea stops before the plants use all of the available nutrients at the surface (a so-called High Nutrient-Low Chlorophyll or HNLC area). The proposed explanation for the nutrient surplus is that the plants need dissolved iron to grow and the iron runs out before the plants use all of the nutrients. Much of the new iron in the ocean comes from dust (from deserts) that is blown by the winds and settles on the ocean. Much of the high latitude Southern Hemisphere is either ocean or ice-covered so there are no deserts to supply iron. The dry valleys on the Antarctic continent are too small to have an important effect.

(Continued on page 2)

Ross Sea Cruise (Continued from page 1)

Four sources of iron have been hypothesized for the Ross Sea: melting sea ice, glacial melt from under the Ross Ice Shelf, re-suspended bottom sediments from shallow banks and oceanic water (Circumpolar Deep Water, CDW) which moves from the ocean onto the Ross Sea shelf. In addition to the needed source of dissolved iron, there must be some mechanism to move the iron-rich water into the upper ocean where there is sunlight for the plants to grow and perhaps to contain the iron to avoid having it disperse. Mesoscale ocean circulation features (eddies and fronts with horizontal sizes of 10 to 20 km) are thought to provide the needed movement and containment of the iron.

Finding such small ocean features requires measurements to be made at closely spaced horizontal intervals. The PRISM project used three approaches to measure such small horizontal scales: closely spaced CTD (conductivity, temperature and depth sensor) and XBT (expendable bathythermograph probe) stations; a vertically oscillating video plankton recorder (VPR); and a moving vessel profiler (MVP). The VPR was towed behind the moving ship; it is designed to identify plankton in the top 100 m of the ocean but it also has optical and environmental sensors.

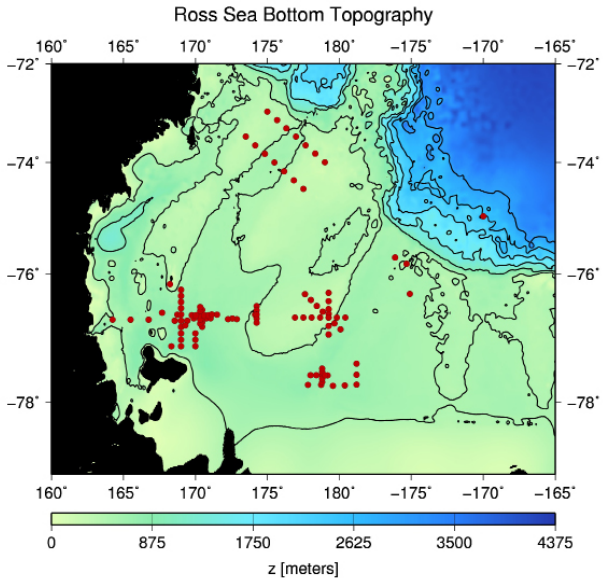


Figure 1: *Map of the Ross Sea showing the depth of the continental shelf (indicated by color). These data are a combination of depth measurements from a number of cruises along with mapped depth extracted from gravity measurements from satellites. The track of the Palmer during the PRISM cruise is indicated by the red dots.*

The MVP is also towed behind the ship and profiles every few minutes to about 200 m with optical and environmental sensors. Because of the rapid vertical motion of these sensors, they measure horizontal variations in ocean properties on scales of a kilometer or so, small enough to characterize the mesoscale environment. Finally, a free-drifting, profiling mooring (SeaHorse) provided information on tidal and wind-driven flow. Throughout the cruise, we were in frequent contact with Mike Dinniman who compared the ship measurements to results from a Ross Sea numerical circulation model. We were delighted to find close agreement in many aspects of the model and measurements.

At the end of the cruise, we met the *Italica,* the supply vessel for the Italian Antarctic program, in McMurdo Sound, which extends northward from McMurdo Station, where we were to leave the ship. The *Italica* re-fueled the *Palmer* for its return to Punta Arenas. Within two days of arriving at McMurdo Station, the PRISM group left the *Palmer* and a new group moved to the ship for the long ride back to South America. The real work of the cruise is now beginning as we sort through the samples and observations. Analysis of the extensive data sets collected during the PRISM cruise will allow us to evaluate our hypotheses about various iron sources for the Ross Sea.

Figure 2: *Pierre St-Laurent, CCPO, with a CTD Rosette. The CTD is attached to a frame fitted with a number of large water-collecting bottles called Niskins. The instrument together with the bottles is called the CTD Rosette.*

Figure 3: *View of McMurdo Station from Observation Hill, Antarctica.*

Notes from the Director

John Klinck, *Professor and Director, CCPO*

Science is a public endeavor, even if the public perception is of a lone person working in a lab or office. Science publication is critical; we all know that "If you don't publish your results, they did not really happen." I am impressed with the range of scholarly publications, meetings attended, and presentations made recently by folks at CCPO, as well as the variety of topics being investigated. Some topics are familiar: circulation at various time and space scales in a number of areas. Other topics are more exotic: hurricane forecasting, shellfish genetics and physiology, and larval transport.

Ongoing research projects at CCPO involve collaborations with ODU personnel beyond our department, such as Stephanie Hathcock and Dr. Dan Dickerson in the Department of STEM Education and Professional Studies, as well as a number of people at other institutions, such as Rutgers University, the Virginia Institute of Marine Science, and the Woods Hole Oceanographic Institution. Some of these collaborative efforts are profiled in this issue.

Finally, I am glad to see that many CCPO graduate students are attending national and international meetings. Not only does this provide publicity of the science research at CCPO, but it also serves to develop the next wave of scientists. These graduate students are our most important legacy.

The Ocean Sciences Meeting is an international gathering of more than 4,000 attendees that is sponsored by The Oceanography Society, the American Society of Limnology and Oceanography, and the American Geophysical Union. This year's meeting, held Feb. 20-24 in Salt Lake City, UT, included many interesting topics, posters and exhibits. One exhibit by NASA was a high-resolution image of sea surface temperature (in real time) displayed on a large screen, which allowed the meeting participants to follow El Niño across the Pacific.

Twice during the week, there were special sessions held for students during the lunch hour. Some of the topics included: organizations offering jobs or opportunities to students, information on government positions in Washington, D.C., and the newly created Southern Ocean Observing System (SOOS). Another session was a workshop on the art of presenting science in interesting ways. The presenters discussed what made seminars and lectures boring, and how to change presentations to overcome this and give an interesting tack. They gave tips for creating presentations that keep people interested by limiting the focus to the three main points that will actually be remembered.

There was even a Jam Session, which allowed meeting participants to enjoy the musical talents of fellow scientists. Quite a following has developed among both musicians and audience members. The meeting had something for everyone: informative workshops, creative posters, entertaining social events and opportunities for professional development.

--CCPO researchers Andrea Piñones and Stefanie Mack attended the Ocean Sciences Meeting and contributed to this article.

Collaborative Shellfish Modeling Fosters Better Shellfishery Management

By Dr. Daphne Munroe
Haskin Shellfish Research Laboratory, Rutgers University

How do species evolve disease resistance? What are the genetic consequences of fishery management options? What are the long-term ecological consequences of rare storm events such as Hurricane Irene? These are some of the questions being addressed by the ongoing collaboration between CCPO and the Haskin Shellfish Research Laboratory (HSRL) at Rutgers University. Numerical models developed during ongoing collaboration between Drs. Eileen Hofmann and John Klinck (CCPO) and Eric Powell and Daphne Munroe (HSRL) are the vehicle by which these broad, multidisciplinary questions are being addressed.

The Dynamic Population Genetics Engine (DyPoGEn) is an individual-based model platform developed by the CCPO/HSRL modeling group to simulate population dynamics and genetics for an oyster metapopulation. The model simulates and tracks the genetics of individual animals from a series of spatially explicit populations. Although DyPoGEn can be applied to a range of shellfish species and geographic regions, recent research has focused on the oyster populations in Delaware Bay.

The team has been using the model to look at the mechanisms by which oysters in Delaware Bay are able to evolve genetically in response to disease pressure. Oyster diseases in many areas, including Delaware Bay, can lead to high annual mortality which in turn leads to lost harvest from the wild oyster fishery. A greater understanding of the ways that oyster populations can respond to these diseases will help to create a more stable and sustainable fishery.

A series of post-settlement oyster populations are modeled simultaneously within this individual-based framework using observed population dynamics as a guide. Larvae are dispersed among the populations using dispersal characteristics predicted by a ROMS-based Lagrangian model implemented by Diego Narváez, CCPO postdoctoral researcher, who studied larval connectivity of oysters in Delaware Bay. By combining the individual-based genetics, spatially explicit population dynamics, and bio-physical larval connectivity, this metapopulation model framework represents a tool that can be used to examine a wide range of questions, from theoretical ecology and evolution, to applied fisheries management and economic predictions.

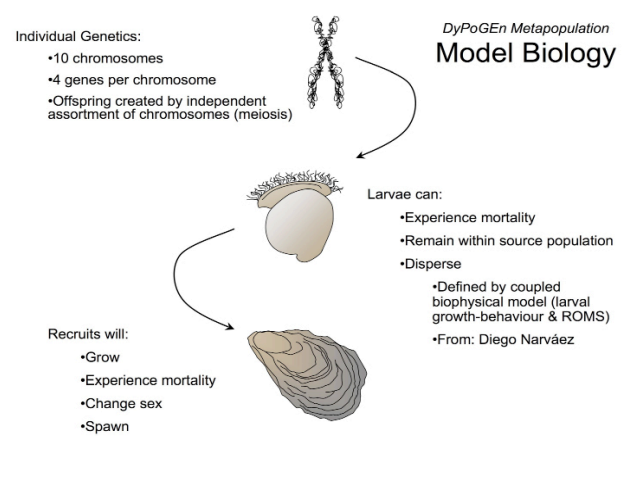
Haskin Shellfish Research Lab technicians cooperate with oyster fishermen to conduct annual surveys of oyster abundances in Delaware Bay. These annual survey data are used for parameterization of DyPoGEn model simulations.

As in other fisheries, managers of oyster fisheries are faced with various management options including what fishing rates to allow and what size limits to impose. These management decisions have many implications to the managed populations, including how management strategy influences genetic connectivity and ultimately impacts wild stock genetics. DyPoGEn is being used to simulate and study genetic connectivity under a range of possible oyster fishery management strategies, the results of which will develop a greater understanding of the effects of management decisions and allow for more informed strategies. (*Continued on page 5)*

Collaborative Shellfish Modeling (*Continued from page 4*)

The model has also been used to make predictions about the length of recovery times for oyster beds impacted by flooding in 2011 associated with Hurricane Irene and Tropical Storm Lee. These two storms caused high mortality in the upstream areas of Delaware Bay as a consequence of extended exposures to extremely low salinity waters. These extreme and unexpected mortalities have important consequences to fishery quotas and local economies, and prediction of the timescales for recovery provides important information to people involved in or dependent upon the industry. Estimates from recovery times using DyPoGEn suggest that $17 million to $30 million in economic damage will accrue from these 100-year storm events.

Modeling tools, such as this one, are key to understanding complex ecological processes such as genetic connectivity. The information gained from research using such tools is critical not only for a more thorough understanding of natural ecosystems, but also for understanding how human activities like fishing interact with these ecosystems and can be managed in a way that ensures long-term sustainability of both the wild populations and the social economies reliant on them.



Schematic of the basic biological processes and interactions included in DyPoGEn to simulate genetic connectivity of a Delaware Bay oyster metapopulation.

CCPO Student Profile

Brit Nicholson

Brit Nicholson came to CCPO in August 2011. He is from Minneapolis, Minn. During his free time, he enjoys spending time outdoors with his 4-year-old son. Brit earned his B.S. in applied mathematics from ODU in 2009. He then studied gravity anomalies in the Scotia Sea for his M.S. in geological oceanography at ODU, for which his proposed graduation date is August 2012. His master's thesis is titled "Gravity anomalies along the East Scotia Ridge: Constraining the relative importance of magmatic and tectonic controls on crustal accretion." As of fall 2012, Brit is a Ph.D. candidate at CCPO. His current project is ocean modeling of the Amundsen-Bellingshausen Sea region with a proposed graduation in 2014-2015. After graduation, Brit plans on doing more research, possibly as a postdoctoral researcher at a university.

Graduates

Diego Narváez, Ph.D. Defense, Modeling the dispersion of Eastern Oyster Larvae *(Crassostrea virginica)* and its effects on the movement of disease resistant genes in the Delaware Bay Estuary, Advisor, J.M. Klinck.

Publications

Ezer, T., W.D. Heyman, C. Houser, and B. Kjerfve (2012). Extreme flows and unusual water level rise near a Caribbean coral reef: Was this a case of a "perfect storm?" *Ocean Dynamics*, *Vol. 62,* doi:10.1007/s10236-012-0545-5.

Gatski, T. and M.O. Deville (2012). *Mathematical Modeling for Complex Fluids and Flows.* Springer: Heidelberg, 264 pages.

Mueller, R.D., L. Padman, **M.S. Dinniman,** S.Y. Erofeeva, H.A. Fricker, and M.A. King (2012). Impact of tide-topography interactions on basal melting of Larsen C Ice Shelf, Antarctica, *Journal of Geophysical Research,* 117, C05005, doi:10.1029/2011JC007263.

Padman, L., D.P. Costa, **M.S. Dinniman,** H.A. Fricker, M.E. Goebel, L.A. Huckstadt, A. Humbert, I. Joughin, J.T.M. Lenaerts, S.R.M. Ligtenberg, T. Scambos, and M.R. van den Broeke (2012). Oceanic controls on the mass balance of Wilkins Ice Shelf, Antarctica, *Journal of Geophysical Research,* 117, C01010, doi:10.1029/2011JC007301.

Scully, M.E. and W.R. Geyer, (2012). The role of advection, straining and mixing on the tidal variability of estuarine stratification. *Journal of Physical Oceanography,* doi:10.1175/JPO-D-10-05010.1.

Smith, W.O., Jr., D.G. Ainley, R. Cattaneo-Vietti, and **E.E. Hofmann** (2012). The Ross Sea continental shelf: Regional biogeochemical cycles, trophic interactions, and potential future changes, In A.D. Rogers, N.M. Johnston, E.J. Murphy, and A. Clarke (Eds.), Antarctica: An Extreme Environment in a Changing World, Blackwell Publishing Ltd., 213-242.

Presentations

Arzeno, I.B., R. Beardsley, B. Owens, R. Limeburner, L. Padman, M. Williams, C. Stewart, C. Lee, **M.S. Dinniman,** and S. Springer, Tides under the Ross Ice Shelf Front: Contribution to mixing and melting, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Atkinson, L., National Earth Observing Policy and the Oceans, American Geophysical Union Science Policy Conference 2012, invited presentation, Washington, DC, May 1-2, 2012.

Atkinson, L., Old Dominion University's Climate Change and Sea Level Rise Initiative, Presentation to the City of Norfolk, Norfolk, VA, February 16, 2012.

Atkinson, L., Old Dominion University's Climate Change and Sea Level Rise Initiative, Virginia Wind Energy, Computer Engineering Group, Norfolk, VA, February 24, 2012.

Atkinson, L., Old Dominion University's Climate Change Sea Level Rise Initiative, Civic Leadership Forum, Old Dominion University, Norfolk, VA, March 8, 2012.

Atkinson, L., Virginia Offshore Wind – Studies and Resource, ODU Business Gateway EConference, Norfolk, VA, April 10, 2012.

Bender, M., **R. Tuleya,** I. Ginis, and T. Marchok, 2012 Upgrades to the Operational GFDL/GFDN Hurricane Model, Interdepartmental Hurricane Conference, Charleston, SC, March 6, 2012.

Corlett, W.B. and **M.E. Scully**, Impact of winter SST anomalies on Eastern Seaboard summer surface wind variations, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Dinniman, M.S., J.M. Klinck, and W.O. Smith, Jr., Sensitivity of modified Circumpolar Deep Water in the Ross Sea to changes in the surface winds, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Ezer, T., A study of the environmental and physical factors that influence the movement and survival of beluga whales in Cook Inlet, Alaska Marine Science Symposium, Anchorage, AK, January 16-20, 2012.

Ezer, T., W.D. Heyman, and C. Houser, Observations and high-resolution modeling of small-scale flow-topography interactions near Caribbean coral reefs, #B2067, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Friedrichs, C.T., M.A. Friedrichs, A.J. Bever, **M.E. Scully**, and W. Long, Results of the US IOOS testbed for comparison of hydrodynamic and dissolved oxygen models of the Chesapeake Bay, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Hofmann, E.E, F. Castruccio, D.B. Haidvogel, **J.M. Klinck,** R. Mann, D. Munroe, **D.A. Narváez**, and E.N. Powell, Interactions of behavior, growth and circulation on dispersal of marine larvae, poster presentation, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Hofmann, E.E., F. Castruccio, D.B. Haidvogel, **J.M. Klinck,** R. Mann, D.M. Munroe, D. Narváez, and E.N. Powell, Lagrangian modeling studies of marine larvae dispersal, oral presentation, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Hofmann, E.E., Southern Ocean Food Webs - Current Understanding and Challenges, Eminent Scholars Lecture Series, University of South Florida, St. Petersburg, FL, April 5-6, 2012.

Hofmann, E.E., Modeling tools at Old Dominion University, Mini-workshop on Physical-Biological Modeling, Bergen, Norway, April 17, 2012.

Hofmann, E.E., Southern Ocean Food Webs - Current Understanding and Challenges, Weekly Seminar, Institute of Marine Research, Bergen, Norway, April 18, 2012.

Lavery, A.C., W.R. Geyer, **M.E. Scully,** G.L. Lawson, P.H. Wiebe, W.J. Lee, T.K. Stanton, and J.R. Fincke, Development of high-frequency broadband acoustic scattering techniques for imaging, classification, and quantification of stratified turbulence and zooplankton, 2012 Ocean Science Meeting, Salt Lake City, UT, February 20-24, 2012.

López-Duarte, P.C., **D.A. Narváez**, D.A. Kreeger, D.B. Haidvogel, and E.N. Powell, Effects of food abundance on oyster recruitment: Results of a biophysical model, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Mack, S., J.M. Klinck, and L. Padman, Observing a diurnal tidal effect on sea ice concentration in the Ross Sea using AMSR-E satellite data, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Munroe, D.M., E.N. Powell, R. Mann, J.M. Klinck, and E.E. Hofmann, Response of metapopulation genetic connectivity to regime shifts and fishing: When are marine protected areas useful? oral presentation, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Munroe, D.M., E.N. Powell, R. Mann, **J.M. Klinck,** and **E.E. Hofmann,** Underestimation of primary productivity on continental shelves: Evidence from maximum size of extant surfclam populations, oral presentation, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Narváez, D.A., J.M. Klinck, E.N. Powell, **E.E. Hofmann**, J. Wilkin, D.B. Haidvogel, and D. Hedgecock, Effects of larval dispersion on the movement of disease resistant genes between oyster populations, poster presentation, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Piñones, A., E.E. Hofmann, K. Daly, **M.S. Dinniman** and **J.M. Klinck,** Modeling early life stages of Antarctic Krill under present and future environmental conditions on the West Antarctic Peninsula, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Powell, E., **J.M. Klinck**, K. Ashton-Alcox, **E.E. Hofmann,** and J. Morson, The rise and fall of *Crassostrea virginica* oyster reefs: The role of disease and fishing in their demise and a vignette on their management, oral presentation, Benthic Ecology Meeting, Norfolk, VA, March 21-24, 2012.

Saramul, S. and **T. Ezer**, Forcing mechanisms for the coastal dynamics of the upper Gulf of Thailand, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

Scully, M.E., Observations of wind-driven ventilation and vertical oxygen flux in Chesapeake Bay, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

St-Laurent, P., J.M. Klinck and **M.S. Dinniman,** Cross-shelf exchanges induced by troughs, 2012 Ocean Sciences Meeting, Salt Lake City, UT, February 20-24, 2012.

St-Laurent, P., J.M. Klinck, and **M.S. Dinniman,** Cross-shelf exchanges in Antarctica in the presence of troughs, 2012 International Polar Year Meeting, Montréal, Québec, April 23-27, 2012.

St-Laurent, P., and F. Straneo, Freshwater exchanges between Arctic shelves and the open ocean: Insight from an idealized model, 2012 International Polar Year Meeting, Montréal, Québec, April 23-27, 2012.

Tuleya, R.E., The Evolution of Hurricane Numerical Modeling, AMS Annual Meeting, special symposium on technological advances: Impacts on Hurricane Research and Forecast Improvements. New Orleans, LA, January 25, 2012.

GO GREEN

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Center for Coastal Physical Oceanography
Fall 2012 Seminar Series

During the academic year, CCPO invites distinguished scientists to present seminars, which take place in Room 3200, Innovation Research Building 1, Old Dominion University. Lectures begin at 3:30 p.m., with a reception prior at 3 p.m. Eileen Hofmann, professor of oceanography, coordinates the seminar series. Specific topics are announced one week prior to each seminar; abstracts can be found at www.ccpo.odu.edu/seminars_fall2012.html.

Date	**Speakers**
September 3	No Seminar, Labor Day
September 10	Poornima Madhavan, Department of Psychology, ODU
September 17	Lt. Abigail Higgins, NOAA Atlantic Hydrographic Branch
September 24	Kam Tang, Virginia Institute of Marine Science
October 1	Amelia Shevenell, University of South Florida
October 8	No Seminar, ODU Fall Break
October 15	Andrea Piñones, CCPO
October 22	Hongsheng Bi, Chesapeake Biological Laboratory
October 29	William Moore, Hampton University
November 5	Chet Grosch, CCPO
November 12	James Todd, NOAA Climate Change Office
November 19	David Eggleston, North Carolina State University
November 26	Jason Schaffler, Center for Quantitative Fisheries Ecology, ODU

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