Phytoplankton growth and grazing rates from R/V Wecoma multiple cruises in the Northeast Pacific coastal waters off states of Washington and Oregon from 2004 to 2006 (RISE project)

Website: https://www.bco-dmo.org/dataset/3252
Version: 30 January 2009
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Project
» River Influences on Shelf Ecosystems (RISE)

Contributors	Affiliation	Role
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Dataset Description

RISE - Phytoplankton growth and grazing rates

Methods & Sampling

Methods for In Situ Phytoplankton Growth and Grazing Rate Measurements

Growth rate and microzooplankton grazing rates on total, >5 and < 5 µm phytoplankton were measured on the Washington and Oregon coasts on three RISE cruises from 2004-2006.
Note: No growth rate experiments were conducted on RISE3W/W0508 (Aug/2005)

Estimates of in situ phytoplankton growth rate (µ, d-1) and grazing (g, d-1) of size-fractionated Chl a (< 5 µm and > 5 µm) were determined simultaneously using the seawater dilution technique (e.g., Landry et al. 1995). Seawater was collected from the depth corresponding to 50% surface irradiance and was typically between 3 and 5 m depth. Particle-free filtered seawater (FSW) was made by first pooling the water of several Niskin bottles into a 50 L polyethylene carboy and then gravity filtering this water through an in-line cascade of 3 µm and 0.2 µm Pall-Gelman pleated capsule filters and into a 20 L polycarbonate carboy. Experimental bottles (2.5 L polycarbonate bottles) were filled to pre-determined levels with FSW. All containers, tubing, and in-line filters were acid-cleaned prior to use with 5% (v/v) HCl acid and rinsed copiously with deionized water. Clean techniques were used throughout all experimental and sample manipulation.

Whole seawater (WSW) was drained from several Niskin bottles (same cast as FSW) using silicone tubing wrapped with 200 µm mesh into a 50 L polyethylene carboy. The WSW was kept well-mixed by gentle stirring with a polyethylene plunger. The WSW was siphoned from the 50 L WSW carboy into the experimental bottles containing the PFW to reach either three (0.1, 0.5, and 1.0 WSW) or five (0.1, 0.2, 0.4, 0.7, and 1.0 WSW)

target dilution levels. Experimental bottles were amended with nutrients to achieve enrichments of 10 µmol L-1 nitrate (NaNO3), 0.63 µmol L-1 phosphate (NaH2PO4 * H2O), 10 µmol L-1 silicic acid (Na2O3Si * 9H2O), and 3 nmol L-1 Fe (Fe in 2% HCl) to the ambient water concentrations. An additional set of 1.0 WSW bottles were filled without nutrient amendments to test for potential nutrient limitation phytoplankton communities. Duplicate samples were randomly taken from the WSW carboy during water disbursement for chlorophyll, preserved samples and nutrients.

Dilution treatment bottles were placed in clear Plexiglas tubes covered with mylar film to simulate the in situ irradiance. The tubes were secured to a revolving wheel (1 rpm) submerged in a Plexiglas on-deck incubator and incubated for 24 h. The temperature inside the incubator was maintained near in situ levels by continuously flowing surface seawater. Incident photosynthetically active radiation (PAR, µmol quanta m-2 s-1) was measured with a Hobo Par Smart Sensor and data logger mounted on the incubator, and water temperature was monitored with a submerged Hobo Water Temp Pro data logger.

In each replicate dilution bottle, the nutrient-amended net growth rate (kn) was determined according to kn = ln(N1/N0)/t1-t0, where N1 and N0 are the final total and size-fractionated Chl a concentration at time 1 (t1) and time 0 (t0), respectively. The intrinsic rates of growth (µ, d-1) and mortality due to grazing by microzooplankton (g, d-1) of the size fractionated Chl a were calculated by linear regression of net growth rate (kn) in each nutrient amended dilution bottle against the fraction of WSW, Di. Growth (µ) was determined by extrapolation of the regression to the ordinal intercept, where Di (proportional to grazing mortality, g) becomes zero, and hence, kn = µn. Because nutrients were added to the treatment bottles, if phytoplankton growth is limited by in situ nutrient concentrations, µn is a potential growth rate. When nutrient-limited growth was observed in the 1.0 WSW control bottles, the in situ intrinsic rate (µun), was estimated from µun = kun 1.0 + g, where k un 1.0 is the net growth rate in the 1.0 WSW treatment without added nutrients (Landry et al. 1995). Microzooplankton grazing on Chl a size fractions was determined by the slope of linear regressions of kn and Di. On two occasions dilution regressions showed evidence of saturated grazing kinetics (Gallegos 1989). For these experiments, µ was calculated using the linear portion of the regression, while g was calculated using g = µn - kn1.0, where kn1.0 is the net growth rate in the nutrient-enhanced 1.0 WSW dilution treatment.

Further details on methods and measuring Pseudo-nitzschia-specific rates in these experiments can be found in:
Olson, M.B., Lessard, E.J., Cochlan, W.P., Trainer, V.L., 2008. Intrinsic growth and microzooplankton grazing on toxigenic Pseudo-nitzschia spp. diatoms from the coastal northeast Pacific. Limnol. Oceanogr. 53, 1352-1368.

Data Processing Description

BCO-DMO Processing Notes
Generated from original single sheet xls file contributed to BCO-DMO by Evelyn Lessard

BCO-DMO Edits
- spaces in Cruise text field converted to "_"
- Date formatted to YYYYMMDD
- decimal data values padded to consistent decimal places
- "<",">" symbols in parameter names changed to "lt","gt"
- Cruise changed from "RISE_1,2,3,4" to RISE04W1, etc for consistency with other data sets

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Data Files

File
Growth.csv (Comma Separated Values (.csv), 7.15 KB) MD5:a5b8354beec92bdc45cab361213371b4 Primary data file for dataset ID 3252

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Parameters

Parameter	Description	Units
dilexptID	Experiment number	text
Cruise	Cruise name and number	Text
CTD	CTD number	Text
Station	Standard station ID	Text
lon	Longitude	Decimal degrees
lat	Latitude	Decimal degrees
date	Local date	YYYYMMDD
depth	Depth of sample	Meters
tot_chl	Initial total chlorophyll concentration for dilution experiments	micrograms l-1
gt5_chl	Initial chlorophyll concentration > 5 µm	micrograms l-1
lt5_chl	Initial chlorophyll concentration	micrograms l-1
tot_u	In situ phytoplankton growth rate of total community	d-1
gt5_u	In situ phytoplankton growth rate of total community on the >5 µm phytoplankton	d-1
lt5_u	In situ phytoplankton growth rate of total community on the	d-1
tot_g	In situ microzooplankton grazing rate of total phytoplankton	d-1
gt5_g	In situ microzooplankton grazing rate on the >5 µm phytoplankton	d-1
lt5_g	In situ microzooplankton grazing rate on the	d-1

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Instruments

Dataset-specific Instrument Name	Niskin bottle
Generic Instrument Name	Niskin bottle
Generic Instrument Description	A Niskin bottle (a next generation water sampler based on the Nansen bottle) is a cylindrical, non-metallic water collection device with stoppers at both ends. The bottles can be attached individually on a hydrowire or deployed in 12, 24, or 36 bottle Rosette systems mounted on a frame and combined with a CTD. Niskin bottles are used to collect discrete water samples for a range of measurements including pigments, nutrients, plankton, etc.

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Deployments

W0407A

Website	https://www.bco-dmo.org/deployment/58008
Platform	R/V Wecoma
Report	http://bcodata.whoi.edu/RISE/CruiseReports/RISE-1_Wecoma_CruiseReport.pdf
Start Date	2004-07-08
End Date	2004-07-28
Description	W0407A, RISE-1, RISE1W, RISE04W1 This cruise is the first of four cruises in the RISE program aboard the R/V Wecoma, which was charged with the task of conducting hydrographic surveys. The R/V Pt. Sur conducted studies of the Columbia R. plume frontal structure, mixing processes and zooplankton dynamics concurrently with this cruise on the R/V Wecoma. Cruise Objectives The purpose of this cruise was to make physical, chemical and biological measurements within the plume of the Columbia River and over the shelves north and south of the river mouth, with the objective of determining the effect of the river plume on regional productivity. Historical observations have shown that in spite of weaker upwelling winds the Washington shelf is more highly productive than much of the Oregon shelf. Comparative measurements of biological rates, chemical constituents including iron and other micro nutrients and plankton growth and grazing as well as community distributions were made in the three regions. These data complement data from three moored arrays deployed in the study area, data from a second ship, the R/V Pt. Sur, that focused on mixing rates and large scale physical, nitrate, fluorescence surveys as well as frontal processes, and data from remote sensing and model studies. RISE-1 Figures: Cruise Track Stations and Moorings Wind Events

W0505C

Website	https://www.bco-dmo.org/deployment/58010
Platform	R/V Wecoma
Report	http://bcodata.whoi.edu/RISE/CruiseReports/RISE-2_Wecoma_CruiseReport.pdf
Start Date	2005-05-29
End Date	2005-06-21
Description	W0505C, RISE-2, RISE2W, RISE05W2 This cruise is the second of four cruises in the RISE program aboard the R/V Wecoma, which was charged with the task of conducting hydrographic surveys. Cruise information and original data are available from the NSF R2R data catalog. The R/V Pt. Sur, concurrently with this cruise on the R/V Wecoma, conducted studies of the Columbia R. plume frontal structure, mixing processes and a Triaxis survey of the shelf

W0508

Website	https://www.bco-dmo.org/deployment/58012
Platform	R/V Wecoma
Report	http://bcodata.whoi.edu/RISE/CruiseReports/RISE-3_CruiseReport_Daily.pdf
Start Date	2005-08-04
End Date	2005-08-26
Description	W0508, RISE-3, RISE3W, RISE05W3 This cruise is the third of four cruises in the RISE program aboard the R/V Wecoma, which was charged with the task of conducting hydrographic surveys. The R/V Pt. Sur, concurrently with this cruise on the R/V Wecoma, conducted studies of the Columbia R. plume frontal structure, mixing processes and a Triaxis survey of the shelf Stations and Moorings

W0605B

Website	https://www.bco-dmo.org/deployment/58015
Platform	R/V Wecoma
Report	http://bcodata.whoi.edu/RISE/CruiseReports/RISE-4_Wecoma_CruiseReport_F_TDP.pdf
Start Date	2006-05-21
End Date	2006-06-13
Description	W0605B, RISE-4, RISE4W, RISE06W4 This cruise is the fourth of four cruises in the RISE program aboard the R/V Wecoma, which was charged with the task of conducting hydrographic surveys. Cruise information and original data are available from the NSF R2R data catalog. The R/V Pt. Sur, concurrently with this cruise on the R/V Wecoma, conducted studies of the Columbia R. plume frontal structure, mixing processes and a Triaxis survey of the shelf

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Project Information

River Influences on Shelf Ecosystems (RISE)

Website: http://www.ocean.washington.edu/rise

Coverage: Northeast Pacific, coastal waters off states of Washington and Oregon

River Influences on Shelf Ecosystems (RISE) - A Study of the Columbia River Plume
A Multi-Institutional Collaborative Project Sponsored by the National Science Foundation

In 2004 an interdisciplinary study "River Influences on Shelf Ecosystems" (RISE) was initiated to determine the extent to which alongshore gradients in ecosystem productivity might be related to the existence of the massive freshwater plume from the Columbia River. RISE was designed to test three hypotheses: - During upwelling the growth rate of phytoplankton within the Columbia plume exceeds that in nearby areas outside the plume being fueled by the same upwelling nitrate.
- The plume enhances cross-margin transport of plankton and nutrients.
- Plume-specific nutrients (Fe and Si) alter and enhance productivity on adjacent shelves.

Within those constraints, RISE provides the first comprehensive interdisciplinary study of the rates and dynamics governing the mixing of river and coastal waters in an eastern boundary system, as well as the effects of the plume formed by the mixing processes on rates, standing stocks and community structure of plankton in the local ecosystem. The RISE project, includes 4 field and two different numerical model applications. We collected simultaneous measurements of water chemistry, phytoplankton growth and grazing rates, zooplankton populations, water currents, and turbulent mixing. These are being combined with data from satellites, radar, and moorings, as well as detailed numerical simulations, to develop a deeper understanding of this important ecosystem.

The overall RISE sampling strategy was to compare mixing rates, nutrient supply, and phytoplankton production, grazing and community structure within the plume and outside the plume; i.e. on the shelf to the north of the river mouth, presumed more productive, and on the shelf to the south of the river mouth, presumed less productive, as well as in the important "plume lift off" area (the region where the plume loses contact with the bottom) near the river mouth and the plume "near field". The backbone for this project consists of data collected during four cruises that took place in the seasonally high-flow period (May-June) in each of three years (2004-06) and in a low-flow period in the second year (August, 2005). The sampling was spread over three years to attempt to include interannual differences in processes related to wind and river flow variability. The 21-day length of the cruises ensured that a variety of circulation and growth regimes, including upwelling and relaxation/downwelling and neap/spring tides, were observed.

The field studies used two vessels operating simultaneously. The R/V Wecoma obtained primarily biological and chemical rate data: a) at individual stations on cardinal lines north and south of the river mouth (off Grays Harbor, WA and Cape Meares, OR) and near the river mouth; b) at selected process study stations; and c) at fixed stations near the river mouth during strong neap and spring tides (time series). A towed sensor package was used to obtain micronutrient samples near the sea surface on cardinal lines and other selected transects. Underway measurements included macronutrients (N, P, Si), dissolved trace metals (Fe, Mn), supplemented with discrete samples from the underway system (microscopy, FlowCAM and particulate trace metals). At CTD stations vertical profiles (0-200 m where possible; and 500 m at selected stations) of T, S, vertical shear and currents, dissolved O2, in vivo fluorescence, PAR, chlorophyll a, dissolved macronutrients (NO3, NH4, urea, PO4, SiO4), dissolved trace metals, and heterotrophic and autotrophic plankton composition were obtained. Surface drifters were used to follow the mixing of individual plumes and to provide information on surface currents.

On the R/V Pt. Sur, synoptic mesoscale and fine-scale features were sampled with underway measurements of near-surface T, S, velocity, particle size and concentration, PAR, transmissivity and fluorescence and nitrate+nitrite. The Pt. Sur's Triaxus tow fish provided high-resolution sections of T, S, zooplankton (Laser-OPC), PAR and transmissivity, fluorescence, particle size and concentration (LISST-FLOC25X), UV absorption and nitrate (Satlantic ISUS) and radiance/irradiance (7 channels) through the upper water column to 50 m. Rapidly-executed transects of turbulence and fine-structure were also carried out using the Chameleon profiler; these provide full-depth profiles of T, S, optics (880 nm backscatter and fluorescence), turbulence dissipation rates and turbulent fluxes every 1-3 minutes. During selected periods, transects were repeated hourly to capture the high-frequency evolution in the plume's nearfield and river estuary. Acoustics (surface-deployed 1200 kHz ADCP and 120 kHz echosounder) were used to image fine-scale features of the velocity and backscatter fields, resolving fronts, nonlinear internal waves, and turbulent billows.

The temporal context for observed variability was provided by an array of moored sensors deployed in the plume near field as well as on the shelf north and south of the plume (complemented by the pre-existing long-term estuarine and plume stations of the CORIE/SATURN network. To better resolve regional differences, moorings were moved farther north and south to the cardinal sampling lines after the first year of the program. Surface currents were mapped hourly from shore using HF radar with two simultaneously operating arrays, one with a 40 km range and a 2 km range resolution, the other with a 150 km range and a 6 km range resolution. Satellite ocean color, sea surface temperature, turbidity and synthetic aperture radar (SAR) were also obtained when available.

Two modeling systems were developed or enhanced during RISE. The system developed specifically for RISE employed a structured grid model (ROMS) and was used in hindcast mode (MacCready et al., 2008). The CORIE/SATURN modeling system (Baptista, 2006)- based on two unstructured-grid models (SELFE, Zhang and Baptista, 2008; and ELCIRC, Zhang et al., 2004)- was used in both near real-time prognostic mode and multi-year hindcast mode. Both modeling systems incorporated the estuary in the simulation domain (although at different resolutions) and used realistic river, ocean and atmospheric forcing conditions, tidal forcing, and Columbia River estuary forcing. Wind/heat flux model forcing for ROMS was derived from the 4 km MM5 regional wind/heat flux model. SELFE and LCIRC were also forced by MM5. Conditions on open boundaries were provided by ~9 km resolution models from the Navy Research Laboratory (NRL) (NCOM); ROMS used the smaller domain NCOM-CCS NRL model, SELFE and ELCIRC used the larger domain Global-NCOM model. The biological model is a four-box ("NPZD") nitrogen-budget model that tracks nutrients, phytoplankton, zooplankton, and detritus in every cell of the ROMS grid. The rich RISE biological dataset allowed model validation against not just stocks (chlorophyll, microzooplankton, nutrients) but rates (phytoplankton growth and grazing) directly, a level of validation that is seldom possible. These rate observations also allowed the setting of key model parameters (e.g., zooplankton ingestion rate and mortality) empirically (Banas, et al., 2008).

References:

Banas, N. S., P. MacCready, and B. M. Hickey (2008), The Columbia River plume as cross-shelf exporter and along-coast barrier, doi:10.1016 Cont. Shelf Res., 2008.03.011

Baptista, A. M. (2006), CORIE: the first decade of a coastal-margin collaborative observatory, Oceans'06, MTS/ IEEE, Boston, MA.

Hickey, B.M., and the RISE PIs. River Influences on Shelf Ecosystems: Introduction to the RISE Volume, Cont. Shelf Res., in press.

MacCready, P., N. S. Banas, B. H. Hickey, E. P. Dever, and Y. Liu (2008), A model study of tide- and wind-induced mixing in the Columbia River Estuary and Plume, ,doi:10.1016/j. Cont. Shelf Res. 2008.03.015.

RISE Cruise Reports and Figures:

2004 RISE-1

RISE04W1=R/V Wecoma, W0407A, July 8-28, 2004
Cruise Report
Cruise Track
Stations and Moorings
Wind Events

RISE2004=R/V Point Sur, (tbd), July 8-28, 2004
Cruise Report

2005 RISE-2

RISE05W2=R/V Wecoma, W0505C, May 29-June 21, 2005
Cruise Report
Cruise Track
Stations and Moorings
Wind Events

RISE2005a=R/V Point Sur, (tbd), May 29-June 21, 2005
Cruise Report

2005 RISE-3

RISE05W3=R/V Wecoma, W0508, August 4-August 26, 2005
Daily Cruise Report
Lessard Cruise Report
Peterson/Shaw Zooplankton Report
Cruise Track
Stations and Moorings
Wind Events

RISE2005b=R/V Point Sur, (tbd), August 2-August 27, 2005
Cruise Report
Cruise Log

2006 RISE-4
RISE06W4=R/V Wecoma, W0605B, May 21-June 13, 2006
Cruise Report 1
Cruise Report 2
Cruise Track
Stations and Moorings
Wind Events

RISE2006a=Leg 1, R/V Point Sur, (tbd), May 21-May 31, 2006
Cruise Report Leg 1
RISE2006b=Leg 2, R/V Point Sur, (tbd), June 2-June 12, 2006
Cruise Report Leg 2

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-0239089

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