Coastal shelf trophic structure and energy flow model from the Northern California Current, Georges Bank, the Gulf of Alaska, and the North Sea (Food Webs and Physical Contexts project)

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Project
» Analysis of Continental Shelf Ecosystems: Food Web Structure and Functional Relations (Food Webs and Physical Contexts)

Contributors	Affiliation	Role
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Abstract
End-to-end models were constructed to examine and compare the trophic structure and energy flow in coastal shelf ecosystems of four US Global Ocean Ecosystem Dynamics (GLOBEC) study regions: the Northern California Current, the Central Gulf of Alaska, Georges Bank, and the Southwestern Antarctic Peninsula. High-quality data collected on system components and processes over the life of the program were used as input to the models. Although the US GLOBEC program was species-centric, focused on the study of a selected set of target species of ecological or economic importance, we took a broader community-level approach to describe end-to-end energy flow, from nutrient input to fishery production. We built four end-to-end models that were structured similarly in terms of functional group composition and time scale. The models were used to identify the mid-trophic level groups that place the greatest demand on lower trophic level production while providing the greatest support to higher trophic level production. In general, euphausiids and planktivorous forage fishes were the critical energy-transfer nodes; however, some differences between ecosystems are apparent. For example, squid provide an important alternative energy pathway to forage fish, moderating the effects of changes to forage fish abundance in scenario analyses in the Central Gulf of Alaska. In the Northern California Current, large scyphozoan jellyfish are important consumers of plankton production, but can divert energy from the rest of the food web when abundant.

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Dataset Description

This dataset includes complete model parameter files (Northern California Current, Coastal Gulf of Alaska, Georges Bank, North Sea), code files for constructing end-to-end ecosystem models, code files for conducting structural scenario analyses, code files for conducting time-dynamic simulations, code files for Monte Carlo model generation, and documentation describing the use of the model code suite.

There is a manual with basic instructions on the use of the ECOTRAN code suite version 8/5/2018: “README_ECOTRAN-Manual_08052018.pdf”. All model code files are in Excel Visual Basic format or in Matlab (www.mathworks.com) format. A summary of submitted files: "ECOTRAN_model_subdirectories_v2018-08-05.pdf” The zipped file "ECOTRAN_08052018.zip" contains the following sub-directories and files: Sub - directory “/FoodWeb_models/ComparativeShelves_models/” includes mass-balanced food web models for the Northern California Current, Coastal Gulf of Alaska, Georges Bank, and the North Sea. There are two files for each model: 1) an excel Visual Basic .xlsm file used to construct the mass-balanced model, and 2) a .csv version of the model parameter set to be read and processed by ECOTRAN. Sub-directory “/FoodWeb_models/TEST_model/” includes a functional example “TEST” mass-balanced food web model. There are three files for the test model: 1) an excel Visual Basic .xlsm file used to construct the mass-balanced model, 2) a .csv version of the model parameter set to be read and processed by ECOTRAN, and 3) a .mat file containing an example set of 1000 generated Monte Carlo models. Sub-directory “/ECOTRAN_code/” includes the main function used to generate an ECOTRAN model from a provided mass-balanced food web model (ECOTRANuncertainty_05062016.m) and seven required supporting functions (f_AggregateResults_EwE_03122015.m, f_CalcPredationMatrix.m, f_ECOfunction_05142015.m, f_read_EwE_csv_02022016.m, f_read_EwE_csv_04292016.m, f_RedistributeCannibalism.m, f_WebProductivityWLoss.m). Sub-directory “/ECOTRAN_code/StaticScenario_code/” includes the main code to perform static scenario analyses (ECOTRAN_StaticScenarios_TEST_08052018.m) and three required supporting functions (f_CompileScenarioResults_08192013.m, f_ScenarioGenerator_08302013.m, p_PlotScenarioResults_02092018.m). Sub-directory “/ECOTRAN_08052018/ECOTRAN_code/TimeDynamic_code/” includes two main code files to perform time-dynamic model simulations within different physical settings (ECOTRANdynamic_context_08032018.m, ECOTRANdynamic_context_basin_08030218.m) and eight required supporting functions (f_ECOTRANode_DefinedBoundary_08032017.m, f_ECOTRANode_DefinedBoundary_basin_08032017.m, f_ECOTRANode_ReflectiveBoundary_05182017.m, f_ECOTRANode_ReflectiveBoundary_basin_05242017.m, f_FunctionalResponse_MonteCarlo_09122016.m, f_InitialProductionRates_05112016.m, f_MichaelisMenten_05152016.m, f_StaticProductionTimeseries_09042017.m). Sub-directory “/ECOTRAN_code/Footprint_and_Reach_code /” includes the main code to calculate footprint and reach metrics from an ECOTRAN end-to-end model (FootprintReach_TEST_07262018.m) and six required supporting functions (f_DietTrace_03152015.m, f_DietTraceDownward_03152015.m, f_Footprint_07272018.m, f_ProductionTrace_07272018.m, f_Reach_01212018.m, p_WebPlotter_01032017.m). Sub-directory “/ECOTRAN_code/MonteCarlo_method1_code/” includes three functions for generating Monte Carlo models for analysis of error propagation within ECOTRAN (f_E2E_MonteCarlo_08032018.m, f_E2E_pedigree_08032018.m, f_TerminalDetritus_08032018.m). Sub-directory “/ECOTRAN_code/MonteCarlo_method2_code/” includes an archival set of seven functions for generating Monte Carlo models using a prior and NO LONGER SUPPORTED method (EwE_MonteCarlo_01182015.m, f_DietPreference_Readjust_04052014.m, f_E2E_MonteCarlo_08032018.m, f_E2E_pedigree_08032018.m, f_EE_MonteCarlo_04092014.m, f_EwEinterval_MonteCarlo_04092014.m, f_EwEnormal_MonteCarlo_04092014.m). Sub-directory “/ECOTRAN_08052018/ECOTRAN_code/Physics_code” includes functions defining model geometries and for generating time-series of advection, mixing, and sinking rates for four different physical environments (f_ECOTRANphysics_upwelling_08022018.m, calcur_res.mat, f_ECOTRANphysics_downwelling_08022018.m, cgoa_ancyc.mat, f_ECOTRANphysics_bank_08022018.m, gb_ancyc.mat, f_ECOTRANphysics_basin_08022018.m, f_LightIntensity.m). Sub-directory “/ECOTRAN_code/MATLAB_ToolBoxes/” includes miscellaneous supporting function suites. The “JornDiedrichsenToolbox” includes modified boxplot functions currently used by the ECOTRAN code suite but can be substituted with other plotting functions. The “NaNSuite” expands upon the built-in Matlab NaN functions. The sub-directory “/ECOTRAN_08052018/ECOTRAN_code/MATLAB_ToolBoxes/ OtherTools/” includes three other required functions that appear in several of the ECOTRAN functions (f_OrdinalDate.m, round2.m, wprctile.m). Sub-directory “/TimeDynamic_simulations/” is an empty directory that is currently referred to by the time-dynamic simulation code files for storing model results.

Sub-directory CGoA-ECOTRAN_GulfOfAlaska_01292019 (separate file download: CGoA-ECOTRAN_GulfOfAlaska_01292019.zip) contains an expanded ECOTRAN end-to-end model for the western and central Gulf of Alaska. The main document is CGoA-ECOTRAN_Ruzicka_etal_01292019.docx which describes the model and the sources of the model parameter set. Document CGoA-ECOTRAN_ModelParameters_01292019.xlsx contains the model parameters themselves. Five EXCELVisualBasic files representing food webs for Gulf of Alaska are included for use with the ECOTRAN model code: CGoA_inner-Xa_01112019.xlsm, CGoA_MidEast-Xa_01112019.xlsm, CGoA_MidWest-Xa_01112019.xlsm, CGoA_OuterEast-Xa_01112019.xlsm, CGoA_OuterWest-Xa_01112019.xlsm. The ECOTRAN model code is written for the Matlab platform (www.mathworks.com) and is available online at the NSF Biological and Chemical Oceanography Data Management Office (https://www.bco-dmo.org/dataset/546765).

Older version:

Version 2018-08-05 replaces version 2015-01-20. Archived version of ECOTRAN 2015 code and model results. See Ruzicka et al (2013):
DATASET_Brink_etal_1-2015.rtf (submission form for 2015 version)
StructuralScenarios_Oceanography_Dec2013.zip
ECOTRANmodels_MammalAggregation_1-21-2015.zip
ECOTRANcode_StructuralAnalysis_1-21-2015.zip

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Data Files

File
ECOTRAN_model_links_Ruzicka_2015.csv (Comma Separated Values (.csv), 1.24 KB) MD5:1ce0d5ec3782911e117237bd3e8ed3dd links to ECOTRAN model code, static scenarios, and documentation J. Ruzicka (OSU) version: 2015-01-20

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Related Publications

De Haast, J. A., Treasure, A. M., Ruzicka, J. J., & Moloney, C. L. (2017). A donor-driven approach to modelling anchovy-sardine dominance shifts in the southern Benguela ecosystem. Journal of Marine Systems. doi:10.1016/j.jmarsys.2017.09.001
Results

Ruzicka, J. J., Brink, K. H., Gifford, D. J., & Bahr, F. (2016). A physically coupled end-to-end model platform for coastal ecosystems: Simulating the effects of climate change and changing upwelling characteristics on the Northern California Current ecosystem. Ecological Modelling, 331, 86–99. doi:10.1016/j.ecolmodel.2016.01.018
Results

Ruzicka, J. J., Steele, J. H., Brink, K. H., Gifford, D. J., & Bahr, F. (2018). Understanding large-scale energy flows through end-to-end shelf ecosystems - the importance of physical context. Journal of Marine Systems. doi:10.1016/j.jmarsys.2018.08.003
Results

Ruzicka, J., Steele, J., Gaichas, S., Ballerini, T., Gifford, D., Brodeur, R., & Hofmann, E. (2013). Analysis of Energy Flow in US GLOBEC Ecosystems Using End-to-End Models. Oceanography, 26(4), 82–97. doi:10.5670/oceanog.2013.77
Results

Treasure, A. M., Ruzicka, J. J., Moloney, C. L., Gurney, L. J., & Ansorge, I. J. (2015). Land–Sea Interactions and Consequences for Sub-Antarctic Marine Food Webs. Ecosystems, 18(5), 752–768. doi:10.1007/s10021-015-9860-2
Results

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Parameters

Parameters for this dataset have not yet been identified

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Deployments

Ruzicka_2015

Website	https://www.bco-dmo.org/deployment/547780
Platform	OSU-HMSC
Start Date	2013-03-01
End Date	2016-02-29
Description	Model

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Project Information

Analysis of Continental Shelf Ecosystems: Food Web Structure and Functional Relations (Food Webs and Physical Contexts)

Coverage: Northern California Current, Georges Bank, Gulf of Alaska, North Sea

Marine ecosystems are characterized by complex interactions among biological components and within the physical setting. The complexity of these systems makes them difficult to understand or interpret based on either observations or models, both of which suffer from incomplete knowledge of the natural system. Of interest to many scientific questions and to management is the utility of broad, simplifying concepts about how such systems operate and how they change over time. Among these concepts are bottom-up control (the idea that nutrient sources and lower trophic levels govern the ecosystem), top-down control (the idea that organisms at the highest trophic levels govern), and regime shifts (major restructuring of the system due to natural or anthropogenic, or combined, forcing).

A basic tenet of biological oceanography is the coupling between physical processes and population dynamics. The study of these connections has been based on certain simplifications, particularly the emphasis on one, or very few, trophic components. The parallel development of trophic network models (e.g., ECOPATH) represents an effort to study the relationships between a more complete spectrum of trophic groups from an energy transfer and predator-prey perspective. Yet, ecosystem structure, function, and behavior depend on the physical context: mixing, advection, water residence time, and seasonality, especially for shelf ecosystems. These terms define production, recycling, and export rates and set the scope of benthic-pelagic coupling, but they are rarely incorporated into trophic network models. There is clear need to develop portable methods of analysis that can illuminate physical-biological interactions across a wide range of ecosystems and demonstrate their effects on system productivity and resilience at all trophic levels. However, there is a simultaneous risk of such models becoming so complex that untangling the mechanisms and artifacts of model dynamics quickly becomes intractable.

A portable, coupled bio-physical model framework of intermediate trophic and physical resolution is a potential solution that will be developed in this project. The goal is to produce models simple enough to understand, but complex enough to be realistic. Thus, about 5 physical boxes and about 20 ecological compartments are expected to be included. The models will be developed for four contrasting, data-rich continental shelf ecosystems. This project will use the range of food webs and physical forcing characteristic of these four systems to do the following. 1. Assess the merits and disadvantages of studying community dynamics in terms of aggregated functional groups as the appropriate level of trophic resolution. 2. Compare the relative roles of physical processes and trophic network structure in determining system productivity, variability, and resilience across all trophic levels, including both pelagic and benthic food webs. 3. Test the applicability of broad concepts of ecosystem behavior such as bottom-up vs. top-down control of community dynamics, or of sudden regime shifts.

The project will contribute to the education of future scientists through participation in active research. The public will be informed about ocean ecosystem issues through development of a museum exhibit. Model code will be provided to the community for further use and development. Collaboration with NOAA scientists will foster application of project results to practical management issues.

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Funding

Funding Source	Award
NSF Division of Ocean Sciences (NSF OCE)	OCE-1258667

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