untitled

2025-12-01

Negative direct effects of nutrient enrichment on the establishment of Fucus vesiculosus in the Baltic Sea

2003

Bergström, Lena; Berger, Rita; Kautsky, Lena

Paper URL

Abstract: The direct effect of nutrient enrichment on the early life stages of Fucus vesiculosus in the brackish Baltic Sea was followed in laboratory experiments. The effects of nitrate and phosphate on the rate of attachment, on germination and on the development of the primary rhizoid were assessed. The rate of attachment was slow compared with similar studies in a marine environment. The zygotes of the control reached only 9% attachment within the first 12 h. A significant negative effect of nitrate enrichment on the attachment rate and germination was observed. Germling survival was reduced by over 20% in moderate nitrate enrichment, and by over 50% in high nitrate (21 M) and high phosphate (1.0 M) enrichment during the first 10 days. The effect on the development of the primary rhizoid was also significant, but less severe. The results suggest that eutrophication may have a direct negative effect on the recruitment of Fucus vesiculosus, unrelated to the secondary effects normally attributed to the decline of Fucus in the Baltic Sea.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** nutrient_dynamics; species_sensitivity | **type__of__method__used:** lab_experiment | **adjacent__topic__to__m__cdr:** aquaculture | **adjacent__topic__to__fisheries:** aquaculture; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 7/10/2025

location
ocean_basin: atlantic | **geopolitical_area:** europe | **habitat_type:** not_applicable | **depth:** not_applicable | **experiment_location:** laboratory

species
species_common_name: NA | **species_scientific_name:** Fucus vesiculosus | **taxon:** macroalgae | **life_stage:** not_applicable

treatment
exposure: chemical | **chemical_mineral_added:** other | **response_observed:** biological_effect_observed

NOTES

summary_notes: Experiments investigating the effect of elevated nutrient concentrations (nitrate and phosphate) on the attachment, germination and rhizoid development of Fucus vesiculosus (seaweed). Eutrophication may have direct negative impacts.

mcdr_relevance_notes: Impact of nutrient fertilization (N, P) on Fucus vesiculosus

fisheries_relevance_notes: Seaweed cultivation and nutrient dynamics

Will Ocean Fertilization Work?

2003

Buesseler, Ken O.; Boyd, Philip W.

Paper URL

Abstract: Iron fertilization of the ocean—a potential strategy to remove CO2 from the atmosphere—has generated much debate among ocean and climate scientists (1–4). It is viewed as particularly attractive by geoengineers because the addition of relatively small amounts of iron to certain ocean regions may lead to a large increase in carbon sequestration at a relatively low financial cost. To assess whether iron fertilization has potential as an effective sequestration strategy, we need to measure the ratio of iron added (Feadd) to the amount of carbon sequestered (Cseq) (in the form of sinking particulate organic carbon, POC) to the deep ocean in field studies. We must then apply appropriate scaling factors to determine whether globally significant quantities of CO2 can be removed from the atmosphere to the deep ocean in this way. The Southern Ocean (see the figure) is the most important region for possible climate regulation by iron fertilization. In this high-nitrate low-chlorophyll (HNLC) region, large quantities of surface macronutrients return to the deep ocean via the flow of intermediate and deep waters. According to the "iron hypothesis" (5), adding iron to these nutrient-rich surface waters will increase phytoplankton biomass, resulting in increased uptake of CO2 by the phytoplankton living in the surface ocean.

TAGS

general
m__cdr__focus: specific_mcdr | **m__cdr__method:** ocean_fertilization | **paper__type:** perspective | **paper__topic:** biological_ecological_impacts; carbon_flux; environmental_impacts; ethics_best_practices; nutrient_dynamics | **type__of__method__used:** not_applicable | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** biologic_carbon_pump; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 5/12/2025

location
ocean__basin: southern_ocean | **geopolitical__area:** antarctica | **habitat__type:** not_applicable | **depth:** not_applicable | **experiment__location:** not_applicable

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** phytoplankton | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical__mineral__added:** not_applicable | **response__observed:** biological_effect_not_investigated

NOTES

summary__notes: SOFeX experiment assessed iron fertilization's impact on carbon sequestration. -Southern patch showed significant carbon export; northern patch did not. -Results indicate that OIF effectiveness is highly dependent on regional conditions. -Calls for cautious, site-specific application of OIF as a CDR strategy.

mcdr__relevance__notes: Demonstrates the potential and limitations of OIF in carbon sequestration. -Informs policymakers and researchers about the complexities involved in marine CDR methods. -Supports the development of targeted research to optimize OIF deployment.

fisheries__relevance__notes: NA

Phytoplankton growth and biological response to iron and zinc addition in the Ross Sea and Antarctic Circumpolar Current along 170°W

2003

Coale, Kenneth H; Wang, Xiujun; Tanner, Sara J; Johnson, Kenneth S

Paper URL

Abstract: Deckboard enrichment experiments were conducted during the US JGOFS Antarctic Environment Southern Ocean Process Study to determine the community response to added iron and zinc and their effect on phytoplankton growth. Seawater was collected into

acid-cleaned 20-l polycarbonate carboys and incubated with varying additions of iron and zinc. Cells representing individual taxa were counted before and after incubation. Chlorophyll a, particulate organic carbon, and particulate organic nitrogen were measured periodically throughout the experiments. Zinc is not a limiting factor on phytoplankton growth in both the Ross Sea and the Antarctic Circumpolar Current (ACC). The Ross Sea is less iron-stressed than the ACC, in particular at the southern site. However, iron addition largely increased phytoplankton growth and chlorophyll a in both regions. Community growth showed a stronger response to iron addition in high-silicate water than in low-silicate water. Dinoflagellates had the lowest abundance in both natural and iron-enriched seawaters. Prymnesiophytes and pennate diatoms were most sensitive to iron enrichment and were responsible for the bulk of the growth signal. In the high-silicate water of the ACC, Phaeocystis showed the strongest response to iron addition, increasing its abundance from <5% in natural seawater to 20% in 2.5nM Fe-enriched water. Its maximum growth rate was 0.57day−1 and the half-saturation constant was 0.27nM, which were higher than most of the diatoms (0.2–0.4day−1 and 0.05–0.13nM, respectively).

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; nutrient_dynamics | **type__of__method__used:** field_study | **adjacent__topic__to__m__cdr:** other | **adjacent__topic__to__fisheries:** lower_trophic; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 8/5/2025

location
ocean__basin: southern_ocean | **geopolitical__area:** not_applicable | **habitat__type:** open_ocean | **depth:** surface | **experiment__location:** field

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** phytoplankton | **life__stage:** not_applicable

treatment
exposure: chemical | **chemical__mineral__added:** other | **response__observed:** biological_effect_observed

NOTES

summary__notes: Nutrient enrichment experiences onboard US JGOFS cruise in the Southern Ocean. Iron and zinc were added and the growth response of individual phytoplankton groups was examined.

mcdr__relevance__notes: Nutrient enrichment applied to Southern Ocean waters

fisheries_relevance_notes: Iron and zinc limitation of growth of major taxonomic groups of phytoplankton

Aeolian iron input to the ocean through precipitation scavenging: A modeling perspective and its implication for natural iron fertilization in the ocean

2003

Gao, Yuan; Fan, Song-Miao; Sarmiento, Jorge L.

Paper URL

Abstract: Aeolian dust input may be a critical source of dissolved iron for phytoplankton growth in some oceanic regions. We used an atmospheric general circulation model (GCM) to simulate dust transport and removal by dry and wet deposition. Model results show extremely low dust concentrations over the equatorial Pacific and Southern Ocean. We find that wet deposition through precipitation scavenging accounts for 40% of the total deposition over the coastal oceans and 60% over the open ocean. Our estimates suggest that the annual input of dissolved Fe by precipitation scavenging ranges from 0.5 to 4 × 10 12 g yr −1 , which is 4–30% of the total aeolian Fe fluxes. Dissolved Fe input through dry deposition is significantly lower than that by wet deposition, accounting for only 0.6–2.4 % of the total Fe deposition. Our upper limit estimate on the fraction of dissolved Fe in the total atmospheric deposition is thus more than three times higher than the value of 10% currently considered as an upper limit for dissolved Fe in Aeolian fluxes. As iron input through precipitation may promote episodic phytoplankton growth in the ocean, measurements of dissolved iron in rainwater over the oceans are needed for the study of oceanic biogeochemical cycles.

TAGS

general
m_cdr_focus: specific_mcdr | **m_cdr_method:** ocean_fertilization | **paper_type:** original_research | **paper_topic:** natural_analogue; precipitation | **type_of_method_used:** modeling | **adjacent_topic_to_m_cdr:** acid_rain | **adjacent_topic_to_fisheries:** not_applicable

review_status
paper_review_status: abstract_reviewed | **date_last_reviewed:** 5/19/2025

location
ocean_basin: global | **geopolitical_area:** not_applicable | **habitat_type:** nearshore; open_ocean | **depth:** surface | **experiment_location:** not_applicable

species
species_common_name: NA | **species_scientific_name:** NA | **taxon:** not_applicable | **life_stage:** not_applicable

treatment
exposure: not_applicable | **chemical_mineral_added:** not_applicable | **response_observed:** biological_effect_not_investigated

NOTES

summary_notes: Modeling of dust deposition globally with general circulation model. Found that there is less deposition in the equatorial pacific ocean and southern ocean. Wet precipitation accounts for more deposition than dry precipitation but measurements of iron within rain are needed

mcdr_relevance_notes: Pertain to deposition of OIF and iron limited areas

fisheries_relevance_notes: Impacts fisheries but is not mentioned

Effects of patchy ocean fertilization on atmospheric carbon dioxide and biological production

2003

Gnanadesikan, Anand; Sarmiento, Jorge L.; Slater, Richard D.

Paper URL

Abstract: Increasing oceanic productivity by fertilizing nutrient-rich regions with iron has been proposed as a mechanism to offset anthropogenic emissions of carbon dioxide. Earlier studies examined the impact of large-scale fertilization of vast reaches of the ocean for long periods of time. We use an ocean general circulation model to consider more realistic scenarios involving fertilizing small regions (a few hundred kilometers on a side) for limited periods of time (of order 1 month). A century after such a fertilization event, the reduction of atmospheric carbon dioxide is between 2% and 44% of the initial pulse of organic carbon export to the abyssal ocean. The fraction depends on how rapidly the surface nutrient and carbon fields recover from the fertilization event. The modeled recovery is very sensitive to the representation of biological productivity and remineralization. Direct verification of the uptake would be nearly impossible since changes in the air-sea flux due to fertilization would be much smaller than those resulting from natural spatial variability. Because of the sensitivity of the uptake to the long-term fate of the iron and organic matter, indirect verification by measurement of the organic matter flux would require high vertical resolution and long-term monitoring. Finally, the downward displacement of the nutrient profile resulting from an iron-induced productivity spurt may paradoxically lead to a long-term reduction in biological productivity. In the worst-case scenario, removing 1 ton of carbon from the atmosphere for a century is associated with a 30-ton reduction in biological export of carbon.

TAGS

general
m__cdr__focus: specific__mcdr | **m__cdr__method:** ocean__fertilization | **paper__type:** original__research | **paper__topic:** biological__ecological__impacts; environmental__impacts; species__sensitivity | **type__of__method__used:** modeling | **adjacent__topic__to__m__cdr:** not__applicable | **adjacent__topic__to__fisheries:** lower__trophic; nutrient__dynamics

review__status
paper__review__status: abstract__reviewed | **date__last__reviewed:** 4/17/2025

location
ocean__basin: global | **geopolitical__area:** not__applicable | **habitat__type:** open__ocean | **depth:** deep__ocean; mid__depth; surface | **experiment__location:** not__applicable

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** phytoplankton; zooplankton | **life__stage:** not__applicable

treatment
exposure: not__applicable | **chemical__mineral__added:** not__applicable | **response__observed:** biological__effect__not__investigated

NOTES

summary__notes: Used an ocean circulation model to consider realistic scenarios of fertilizing small regions Found pulse did remove 2-44% of organic carbon through export, yet the recovery was sensitive to biological productivity and remineralization Long term impacts suggest there could be a reduction in biological productivity by removing nutrients from the surface and distributing them to the deep

mcdr__relevance__notes: Simulated small scale OIF deployments in a model

fisheries__relevance__notes: Look at general biological productivity from lower trophic levels

Offsetting the radiative benefit of ocean iron fertilization by enhancing N2O emissions

2003

Jin, Xin; Gruber, Nicolas

Paper URL

Abstract: Ocean iron fertilization is being considered as a strategy for mitigating the buildup of anthropogenic CO2 in the atmosphere. Assessment of this strategy requires consideration of its unintended consequences, such as an enhancement of ocean N2O emissions. This feedback could offset the radiative benefit from the atmospheric CO2 reduction significantly, because

N2O is a much more powerful greenhouse gas than CO2 itself. Our model results show that the magnitude of this offsetting effect is substantial, but is highly dependent on the location and duration of fertilization. We find the largest offsets (of the order of 100%) when fertilization is undertaken in the tropics, particularly when it is of limited duration and size. Smaller, but still substantial effects are found when fertilization is undertaken elsewhere and over longer periods. These results suggest that any assessment of ocean fertilization as a mitigating option is incomplete without consideration of the N2O feedback.

TAGS

general
m__cdr__focus: specific_mcdr | **m__cdr__method:** ocean_fertilization | **paper__type:** original_research | **paper__topic:** air_sea_gas_exchange; environmental_impacts; nutrient_dynamics | **type__of__method__used:** modeling | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 5/22/2025

location
ocean__basin: global | **geopolitical__area:** not_applicable | **habitat__type:** open_ocean | **depth:** surface | **experiment__location:** not_applicable

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** not_applicable | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical__mineral__added:** not_applicable | **response__observed:** biological_effect_not_investigated

NOTES

summary__notes: Modeling study that considers N2O feedback. Finds that it is signifant for small scale in the tropics. Smaller effects are at larger scale in other regions. Suggests that all OIF studies need to measure N2O to ensure GHG are not major feedbacks

mcdr__relevance__notes: Important for OIF and other mCDR techniques to consider N2O to ensure net reduction in GHG

fisheries__relevance__notes: N2O is intertwined with biologic processes and nitrogen cycling. N2O production also is related to marine biota, and can have implication on fisheries

Enhancing fish stocks with wave-powered artificial upwelling

2003

Kirke, Brian

Paper URL

Abstract: Ocean fisheries are declining worldwide due to overexploitation. Productivity could be enhanced and the problem alleviated by pumping nutrient-rich deep ocean water (DOW) to the surface to feed phytoplankton, the bottom end of a marine food chain, mimicking natural upwelling which sustains the most productive ocean fishing grounds in the world. Various pump types and power sources have been proposed for this purpose. The present article proposes a simple wave-powered pump to demonstrate the concept cost-effectively at prototype scale. Possible solutions to the problems of dilution and plunging of dense, nutrient-rich DOW are discussed. Two further possible benefits of this proposal are discussed: by extracting wave energy, relatively calm fishing grounds may be created close to markets, and by pumping up very large quantities of cold DOW, the surface temperature could be lowered enough to reduce coral bleaching on parts of the Great Barrier Reef.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** mcdr_method; tech_engineering | **type__of__method__used:** modeling | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** lower_trophic; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 9/8/2025

location
ocean__basin: not_applicable | **geopolitical__area:** not_applicable | **habitat__type:** not_applicable | **depth:** not_applicable | **experiment__location:** not_applicable

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** not_applicable | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical__mineral__added:** not_applicable | **response__observed:** biological_effect_not_investigated

NOTES

summary__notes: System design for artificial upwelling, focused on benefiting fisheries by stimulating phytoplankton growth.

mcdr_relevance_notes: Artificial upwelling system

fisheries_relevance_notes: Enhancement of fishing grounds

Changes in Conformation and Subunit Assembly of Cod Myosin at Low and High pH and after Subsequent Refolding

2003

Kristinsson, Hordur G.; Hultin, Herbert O.

Paper URL

Abstract: Conformational and structural changes of cod myosin at pH 2.5 and 11 and after subsequent pH readjustment to pH 7.5 were studied. Results suggest that on acid unfolding, the myosin rod may fully dissociate due to electrostatic repulsion within the coiled coil, while it does not dissociate at alkaline pH. Both pHs led to significant conformational changes in the globular head fraction of the myosin heavy chains, suggesting that it takes on a molten globular configuration. A large part of the myosin light chains are lost on both pH treatments. On pH readjustment to neutrality, the heavy chains take on a structural form similar to the native state with the coiled-coil rod reassociating from acid pH while leaving the globular head less packed, more hydrophobic and structurally less stable. The irreversible change brought about in the globular head region leads to the failure of light chains to reassemble onto it, a drastic loss in ATPase activity, and more exposure of reactive thiol groups. The acid and alkali processes therefore lead to substantial changes in the globular part of the myosin molecule and perhaps more importantly to different molecular changes in myosin, depending on which pH treatment is employed. Keywords: Cod myosin; acid pH; alkaline pH; conformational changes; molten globule; unfolding; refolding

TAGS

general
m_cdr_focus: mCDR_associated_fields | **m_cdr_method:** not_applicable | **paper_type:** original_research | **paper_topic:** species_sensitivity | **type_of_method_used:** lab_experiment | **adjacent_topic_to_m_cdr:** ocean_acidification | **adjacent_topic_to_fisheries:** higher_trophic

review_status
paper_review_status: abstract_reviewed | **date_last_reviewed:** 9/8/2025

location
ocean_basin: not_applicable | **geopolitical_area:** not_applicable | **habitat_type:** not_applicable | **depth:** not_applicable | **experiment_location:** laboratory

species
species_common_name: cod | **species_scientific_name:** NA | **taxon:** fish | **life_stage:** not_applicable

treatment
exposure: chemical | **chemical_mineral_added:** other | **response_observed:** biological_effect_observed

NOTES

summary_notes: Experiments testing response of cod myosin at pH 2.5 and 11.

mcdr_relevance_notes: High pH treatment in physiological response study

fisheries_relevance_notes: pH impact on fish muscle protein

Characteristics of Oceanographic Conditions in an Area Suitable for the Construction of Artificial Upwelling

2003

Kyu-Dae, Cho; Dong-Sun, K. I. M.; Sung-Eun, Park

Paper URL

Abstract: To evaluate the oceanographic conditions for the artificial upwelling we measured vertical stratification coefficients, current speed distribution and grain size distribution of bottom sediment in the vicinity of Gukdo and Somaemuldo near Geojedo. There were a strong stratification between surface and bottom layers in summer, the stratification was weak from autumn to winter, and the water was well mixed during winter. In summer nutrient concentration of the bottom layer was 4 times higher than that of the surface layer. Underwater currents were strong in the bottom layer. We conclude that the oceanographic conditions in the area will meet the basic requirement for the construction of artificial upwelling.

TAGS

general
m_cdr_focus: mCDR_associated_fields | **m_cdr_method:** not_applicable | **paper_type:** original_research | **paper_topic:** spatial_planning | **type_of_method_used:** field_study | **adjacent_topic_to_m_cdr:** not_applicable | **adjacent_topic_to_fisheries:** not_applicable

review_status
paper_review_status: abstract_reviewed | **date_last_reviewed:** 9/9/2025

location
ocean_basin: pacific | **geopolitical_area:** asia | **habitat_type:** not_applicable | **depth:** not_applicable | **experiment_location:** field

species
species_common_name: NA | **species_scientific_name:** NA | **taxon:** not_applicable | **life_stage:** not_applicable

treatment
exposure: not_applicable | **chemical_mineral_added:** not_applicable | **response_observed:** biological_effect_not_investigated

NOTES

summary_notes: Field study assessing conditions in a region near Geoje Island, South Korea for artificial upwelling. Established that the site met basic requirements.

mcdr_relevance_notes: Siting of artificial upwelling

fisheries_relevance_notes: Not relevant

CaCO3 precipitation kinetics in waters from the Great Bahama Bank: Implications for the relationship between bank hydrochemistry and whitings

2003

Morse, John W.; Gledhill, Dwight K.; Millero, Frank J.

Paper URL

Abstract: The source of whitings on the Great Bahama Bank and their relationship to major changes in the chemistry of Bank waters have been among the longest and most hotly debated topics in carbonate geochemistry. In this paper, we demonstrate that the reaction kinetics of calcite with Bank waters for a given saturation state are similar to, but somewhat slower (2 to 3 times) than with Gulf Stream water. The interpretation of the reaction kinetics of suspended Bank sediment with Bank water requires that the precipitating phase be about twice as soluble as aragonite. Good agreement at equivalent saturation states was found between experimental precipitation rates and those calculated for the rate of change of Bank water chemistry in the region of whitings. These results indicate that the dominant mode of carbonate removal is via precipitation on resuspended sediments rather than the rapid pseudo-homogeneous precipitation of calcium carbonate in the water column resulting in the formation of a whiting. Estimates indicate that single aragonite needles may be resuspended many times over a period of decades during which they experience repeated overgrowth. A major portion (>98%) of suspended calcium carbonate is outside the visually dramatic whitings. Thus, as visually spectacular as they are, whitings do not represent a short-term locally massive precipitation of carbonate on the Great Bahama Bank, nor are they even likely to be the dominant sites of carbonate removal in this region. Although future refinements are needed that include seafloor processes, we have at this point arrived at a mechanistic kinetic model that provides a reasonably quantitative explanation for the hydrochemistry of the carbonate system on the northern Great Bahama Bank.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** precipitation | **type__of__method__used:** observation | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** not_applicable

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 5/7/2025

location
ocean__basin: atlantic | **geopolitical__area:** not_applicable | **habitat__type:** open_ocean | **depth:** not_applicable | **experiment__location:** laboratory

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** not_applicable | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical__mineral__added:** not_applicable | **response__observed:** biological_effect_not_investigated

NOTES

summary__notes: Kinetic study of "whiting events" on the Great Bahama Bank, when calcium carbonate is precipitated locally or resuspended from sediments causing waters to turn white. Finds that carbon removal occurs through calcium carbonate precipitation on resuspended sediments, not rapid precipitation in the water column.

mcdr__relevance__notes: Generally relevant to OAE through calcium carbonate dissolution/precipitation kinetics.

fisheries__relevance__notes: Not relevant to fisheries.

Effects of high pH on a natural marine planktonic community

2003

Pedersen, Maria Fenger; Hansen, Per Juel

Paper URL

Abstract: A natural planktonic community was incubated for 2 wk to study its response to different levels of pH, ranging from 8 to 9.5. A general increase in phytoplankton biomass was observed over time in the pH 8 to 9 incubations. In the pH 9.5 incubation, the phytoplankton biomass decreased close to detection limit during the first week; however, at the termination of the experiment, the initial biomass level was regained. In the pH 8 and 8.5 incubations, the

diatoms Cerataulina pelagica, Cylindrotheca closterium and Leptocylindrus minimus became numerous, whereas in the pH 9 and 9.5 incubations, C. closterium solely made up the diatom biomass at the termination of the experiment. Photosynthetic dinoflagellates of the genus Ceratium, which were initially abundant, did not grow well in any of the incubations, probably due to the low nutrient concentrations. The protozooplankton biomass increased over time in the pH 8 to 9 incubations. In the pH 9.5 incubation, the protozooplankton biomass decreased close to detection limit during the first 3 d of the experiment and stayed at that level until the termination of the experiment. The biomass increase found in the pH 8 to 9 incubations was due to an increase in the number of ciliates, because the heterotrophic dinoflagellate number remained almost constant. Most protozooplankton species incubated at pH 9.5 died; however, the ciliate Myrionecta rubra survived at almost the same cell number as in the lower pH incubations. Overall a species succession occurred among both phototrophic and heterotrophic protists when pH approached 9. In the pH 9.5 incubation, the number of different protist taxa was reduced from 34 at the start of the experiment to 10 at the termination of the experiment. In conclusion, our study indicates that elevated pH (>9) in nature will affect the entire plankton community mainly by reducing the species richness and by favouring algal blooms due to loss of grazing.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; species_sensitivity; thresholds | **type__of__method__used:** lab_experiment | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** lower_trophic

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 5/15/2025

location
ocean__basin: not_applicable | **geopolitical__area:** not_applicable | **habitat__type:** not_applicable | **depth:** not_applicable | **experiment__location:** laboratory

species
species__common__name: diatoms; dinoflagellates; ciliates; copepods | **species__scientific__name:** Cerataulina pelagica; Cylindrotheca closterium; Leptocylindrus minimus; Ceratium; Myrionecta rubra | **taxon:** phytoplankton; zooplankton | **life__stage:** not_applicable

treatment
exposure: chemical | **chemical__mineral__added:** naoh | **response__observed:** biological_effect_observed

NOTES

summary__notes: Incubation experiment tested phytoplankton community response to pH levels 8 to 9.5. Phytoplankton biomass increased over time in pH 8 to 9 incubations. Decrease in biomass observed over 1 week in pH 9.5 incubation, followed by some growth. Included

ciliates, diatoms, dinoflagellates, copepods. Responses varied by species with differing pH thresholds for reduced growth/survival.

mcdr_relevance_notes: Effects of high pH on lower trophic levels relevant to assessment of biological impacts of ocean alkalinity enhancement.

fisheries_relevance_notes: Elevated pH (>9) will affect the entire plankton community, reducing species richness. Control of algal blooms by grazing would be reduced.

Effects of high pH on the growth and survival of six marine heterotrophic protists

2003

Pedersen, Maria Fenger; Hansen, Per Juel

Paper URL

Abstract: The pH tolerance of the ciliates Balanion comatum, Favella ehrenbergii, Rimostrombidium caudatum and R. veniliae and the dinoflagellates Gyrodinium dominans and Oxyrrhis marina was studied using laboratory cultures at specific pH levels and prey concentrations. The results of these experiments divided the tested species into 2 groups: pH-tolerant species and pH-non-tolerant species. The tolerant group consisted of B. comatum, which experienced a reduction in growth when pH exceeded 9.5, and O. marina, which maintained its maximum growth within the pH limit of the experiment (pH 9.9). The pH-non-tolerant group consisted of 3 ciliates and 1 dinoflagellate. The most pH sensitive species were F. ehrenbergii, R. caudatum and R. veniliae. Their growth rate became affected at pH 8.8 to 8.9 and they did not grow when pH exceeded 9.0. The more tolerant species of this group, G. dominans, experienced a reduction in its growth when pH exceeded 9.2, and negative growth when pH exceeded 9.4. In a different set of experiments with the same species, the algae were allowed to grow and thereby raise the pH. In these experiments, the pH-sensitive species F. ehrenbergii, R. caudatum and R. veniliae all died within 24 h when pH exceeded 9.3, whereas some cells of the more tolerant dinoflagellate G. dominans were able to survive at pH values around 10 for up to 5 d. Thus, heterotrophic protists differ in their pH limits for growth and in their survival response when exposed to pH exceeding their limits for growth. In nature, algal blooms may lead to elevated pH (>9). Our results suggest that such pH levels will kill many, but not all, heterotrophic protists. This may, at least temporarily, lead to a reduction in grazing control of such algal blooms, thereby further allowing their growth and persistence.

TAGS

general
m_cdr_focus: mCDR_associated_fields | **m_cdr_method:** not_applicable | **paper_type:** original_research | **paper_topic:** biological_ecological_impacts; species_sensitivity; thresholds | **type_of_method_used:** lab_experiment | **adjacent_topic_to_m_cdr:** not_applicable | **adjacent_topic_to_fisheries:** lower_trophic

review_status
paper_review_status: abstract_reviewed | **date_last_reviewed:** 5/15/2025

location
ocean_basin: not_applicable | **geopolitical_area:** not_applicable | **habitat_type:** not_applicable | **depth:** not_applicable | **experiment_location:** laboratory

species
species_common_name: ciliates; dinoflagellates | **species_scientific_name:** Balanion comatum; Favella ehrenbergii; Rimostrombidium caudatum; R. veniliae; Gyrodinium dominans; Oxyrrhis marina | **taxon:** zooplankton | **life_stage:** not_applicable

treatment
exposure: chemical | **chemical_mineral_added:** naoh | **response_observed:** biological_effect_observed

NOTES

summary_notes: Experimental study identified pH-tolerant and pH-non-tolerant plankton species using lab cultures at set pH levels and prey concentrations.

pH tolerant: B. comatum (reduced growth pH $>$ 9.5) O. marina (maintained growth up to pH 9.9)

pH non-tolerant: F. ehrenbergii, R. caudatum and R. veniliae (growth rates affected at pH 8.8 to 8.9, did not grow at pH $>$ 9) G. dominans (reduced growth pH $>$ 9.2, negative growth pH $>$ 9.4)

mcdr_relevance_notes: Effects of high pH on lower trophic levels relevant to assessment of biological impacts of ocean alkalinity enhancement.

fisheries_relevance_notes: Assess effects of high pH on lower trophic levels, suggests high pH will kill many but not all heterotrophic protists. Reduction in grazing control of algal blooms suggested as potential consequence.

Modelling the response of the planktonic food web to iron fertilization and warming in the NE subarctic Pacific

2003

Peña, M.Angélica

Paper URL

Abstract: A one-dimensional ecosystem model with two explicit size classes of phytoplankton was developed for the NE subarctic Pacific to investigate variations in the export of organic particles to the ocean interior due to potential changes in the environment. Specifically, the responses of the planktonic ecosystem to permanent removal of iron limitation and to warming

(of 2 and 5 °C) were explored. The ecosystem model consists of five components (small and large phytoplankton, microzooplankton, detritus and nitrogen), and includes grazing by mesozooplankton that varies in time according to long-term observations at Ocean Station Papa (OSP). The model addresses the role of iron limitation on phytoplankton growth and includes temperature dependence of physiological rates. The ecosystem model was forced with annual wind and solar heating from OSP. The model best reproduced the low chlorophyll high nitrate conditions of the NE subarctic Pacific when both small and large phytoplankton were limited by iron such that their maximum specific growth rate was reduced by 10 and 70%, respectively. Sensitivity analysis showed that model results depended on the value of the iron limitation parameter of large phytoplankton (LFe-L) and the grazing parameters of micro- and mesozooplankton. To explore the effect of iron limitation, simulations were carried out varying the iron limitation parameters while maintaining the nitrogen flux at the base of the model constant and the grazing pressure by mesozooplankton unchanged. In the warming case, simulations were carried out increasing ocean temperatures by 2° and 5 °C applied only to the ecological components, the flux of nitrate at the base of the model was increased to obtain a steady annual cycle, and grazing by mesozooplankton remained constant. When compared with the standard case, model simulations indicated that both permanent removal of iron limitation and warming cause changes in food web structure and the carbon cycle. The response was more dramatic in the iron-replete case where the phytoplankton community structure in spring changed from one dominated by pico- and nanoplankton to one dominated by large phytoplankton, and primary production increased until it consumed all the external nutrient (N) supply to the upper layer. However, reducing iron deficiency actually led to lower annual primary production due to a decrease in the regeneration of nitrogen in the euphotic zone. These changes in food web structure influenced the magnitude, composition and seasonal cycle of sinking particles.

TAGS

general
m__cdr__focus: specific_mcdr | **m__cdr__method:** ocean_fertilization | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; environmental_impacts; species_sensitivity | **type__of__method__used:** modeling | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** lower_trophic; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 4/17/2025

location
ocean__basin: pacific | **geopolitical__area:** united_states | **habitat__type:** open_ocean | **depth:** surface | **experiment__location:** not_applicable

species
species__common__name: NA | **species__scientific__name:** NA | **taxon:** phytoplankton; zooplankton | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical_mineral_added:** not_applicable | **response_observed:** biological_effect_not_investigated

NOTES

summary_notes: · This study modeled one-dimension ecosystem dynamics with two explicit sizes of phytoplankton. · Both permanent removal of iron limitation and warming cause changes in the food web. Phytoplankton changed to large sizes · Reducing iron deficiency led to overall lower annual primary production

mcdr_relevance_notes: Modeling of iron limitation

fisheries_relevance_notes: Looked at food web structure from phytoplankton and zooplankton, did not look at higher trophic levels

Carbon acquisition of bloom-forming marine phytoplankton

2003

Rost, Björn; Riebesell, Ulf; Burkhardt, Steffen; Sültemeyer, Dieter

Paper URL

Abstract: Carbon acquisition in relation to CO2 supply was investigated in three marine bloom-forming microalgae, the diatom Skeletonema costatum, the flagellate Phaeocystis globosa, and the coccolithophorid Emiliania huxleyi. In vivo activities of extracellular (eCA) and intracellular (iCA) carbonic anhydrase activity, photosynthetic O2 evolution, CO2 and HCO3− uptake rates were measured by membrane inlet mass spectrometry in cells acclimated to pCO2 levels of 36, 180, 360, and 1,800 ppmv. Large differences were obtained between species both with regard to the efficiency and regulation of carbon acquisition. While eCA activity increased with decreasing CO2 concentration in S. costatum and P. globosa, consistently low values were obtained for E. huxleyi. No clear trends with pCO2 were observed in iCA activity for any of the species tested. Half saturation concentrations (K1/2) for photosynthetic O2 evolution, which were highest for E. huxleyi and lowest for S. costatum, generally decreased with decreasing CO2 concentration. In contrast, K1/2 values for P. globosa remained unaffected by pCO2 of the incubation. CO2 and HCO3− were taken up simultaneously by all species. The relative contribution of HCO3− to total carbon uptake generally increased with decreasing CO2, yet strongly differed between species. Whereas K1/2 for CO2 and HCO3− uptake was lowest at the lowest pCO2 for S. costatum and E. huxleyi, it did not change as a function of pCO2 in P. globosa. The observed taxon-specific differences in CO2 sensitivity, if representative for the natural environment, suggest that changes in CO2 availability may influence phytoplankton species succession and distribution. By modifying the relative contribution of different functional groups, e.g., diatomaceous versus calcareous phytoplankton,

to the overall primary production this could potentially affect marine biogeochemical cycling and air—sea gas exchange.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; carbon_flux; species_sensitivity | **type__of__method__used:** lab_experiment | **adjacent__topic__to__m__cdr:** other | **adjacent__topic__to__fisheries:** lower_trophic

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 8/13/2025

location
ocean__basin: not_applicable | **geopolitical__area:** not_applicable | **habitat__type:** not_applicable | **depth:** surface | **experiment__location:** not_applicable

species
species__common__name: diatoms; flagellate; coccolithophorid | **species__scientific__name:** Skeletonema costatum; Phaeocystis globosa; Emiliania huxleyi | **taxon:** phytoplankton | **life__stage:** not_applicable

treatment
exposure: chemical | **chemical__mineral__added:** other | **response__observed:** biological_effect_observed

NOTES

summary__notes: Looks at CO2 and HCO3- update and mentioned differences across species with differnt amounts of CO2, which could affect bloom dynamics. Looks at Skeletonema costatum, the flagellate Phaeocystis globosa, and the coccolithophorid Emiliania huxleyi

mcdr__relevance__notes: Relevant to OAE and DOCCS

fisheries__relevance__notes: looks at lower trohpic level blooms

A Mesoscale Iron Enrichment in the Western Subarctic Pacific Induces a Large Centric Diatom Bloom

2003

Tsuda, Atsushi; Takeda, Shigenobu; Saito, Hiroaki; Nishioka, Jun; Nojiri, Yukihiro; Kudo, Isao; Kiyosawa, Hiroshi; Shiomoto, Akihiro; Imai, Keiri; Ono, Tsuneo; Shimamoto, Akifumi; Tsumune, Daisuke; Yoshimura, Takeshi; Aono, Tatsuo; Hinuma, Akira; Kinugasa, Masatoshi; Suzuki, Koji; Sohrin, Yoshiki; Noiri, Yoshifumi; Tani, Heihachiro; Deguchi, Yuji; Tsurushima, Nobuo; Ogawa, Hiroshi; Fukami, Kimio; Kuma, Kenshi; Saino, Toshiro

Paper URL

Abstract: We have performed an in situ test of the iron limitation hypothesis in the subarctic North Pacific Ocean. A single enrichment of dissolved iron caused a large increase in phytoplankton standing stock and decreases in macronutrients and dissolved carbon dioxide. The dominant phytoplankton species shifted after the iron addition from pennate diatoms to a centric diatom, Chaetoceros debilis, that showed a very high growth rate, 2.6 doublings per day. We conclude that the bioavailability of iron regulates the magnitude of the phytoplankton biomass and the key phytoplankton species that determine the biogeochemical sensitivity to iron supply of high-nitrate, low-chlorophyll waters.

TAGS

general
m__cdr__focus: specific_mcdr | **m__cdr__method:** ocean_fertilization | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; environmental_impacts; nutrient_dynamics | **type__of__method__used:** field_study | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** lower_trophic; nutrient_dynamics

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 7/29/2025

location
ocean__basin: pacific | **geopolitical__area:** not_applicable | **habitat__type:** open_ocean | **depth:** surface | **experiment__location:** field

species
species__common__name: diatoms | **species__scientific__name:** Chaetoceros debilis | **taxon:** phytoplankton | **life__stage:** not_applicable

treatment
exposure: not_applicable | **chemical__mineral__added:** not_applicable | **response__observed:** biological_effect_not_investigated

NOTES

summary__notes: Conducted a field trial of OIF and looked at the growth of diatoms and bloom

mcdr__relevance__notes: Conducted OIF field trial

fisheries__relevance__notes: Looked at lower trophic levels

Intestinal bicarbonate secretion in marine teleost fish—source of bicarbonate, pH sensitivity, and consequences for whole animal acid–base and calcium homeostasis

2003

Wilson, Rod W; Grosell, Martin

Paper URL

Abstract: Whole animal studies using seawater European flounder (Platichthys flesus) revealed that increasing intestinal [Ca2+] to 20 mM stimulated net HCO3− base secretion by 57%, but this was effectively balanced by an increase in net acid secretion, likely from the gills, to maintain whole animal acid–base status. Higher Ca2+ concentrations (40 and 70 mM) in ambient seawater resulted in reduced plasma total CO2. This indicates (1) imperfect acid–base compensation, and (2) that endogenous metabolic CO2 is insufficient to fuel intestinal HCO3− secretion, under hyper-stimulated conditions. Bicarbonate secretion plays an important role in preventing calcium absorption by precipitating a large fraction of the imbibed calcium as CaCO3. Indeed, under high Ca2+ conditions (20 mM), up to 75% of the intestinal Ca2+ is precipitated as CaCO3 and then excreted. This is undoubtedly important in protecting the marine teleost kidney from the need for excessive calcium excretion and risk of renal stone formation. Using an in vitro pH-stat technique with the isolated intestinal epithelium, the replacement of serosal CO2 with a HEPES buffered saline had no effect on HCO3− secretion, indicating that the endogenous supply of HCO3− from CO2 hydration within epithelial cells is adequate for driving baseline secretion rates. Further, in vitro data demonstrated a stimulatory effect of low pH on intestinal HCO3− secretion. Thus, both luminal Ca2+ and H+ can regulate HCO3− secretion but the precise mechanisms and their potential interaction are currently unresolved.

TAGS

general
m__cdr__focus: mCDR_associated_fields | **m__cdr__method:** not_applicable | **paper__type:** original_research | **paper__topic:** biological_ecological_impacts; species_sensitivity | **type__of__method__used:** lab_experiment | **adjacent__topic__to__m__cdr:** not_applicable | **adjacent__topic__to__fisheries:** higher_trophic

review__status
paper__review__status: abstract_reviewed | **date__last__reviewed:** 7/17/2025

location
ocean__basin: not_applicable | **geopolitical__area:** europe | **habitat__type:** not_applicable | **depth:** not_applicable | **experiment__location:** laboratory

species
species__common__name: Flounder | **species__scientific__name:** Platichthys flesus | **taxon:** fish | **life__stage:** adult

treatment
exposure: chemical | **chemical_mineral_added:** other | **response_observed:** biological_effect_observed

NOTES

summary_notes: Looks at intestinal function in a batch pH-stat reactor to investigate the functions under different conditions including varying pH. Looks at specific functions of HCO3- secretion and found it is enhanced by H+ and Ca+. Less mention about higher pH but seems to have tested both low and high pH

mcdr_relevance_notes: Relevant to OAE and DOCCS directly varying pH

fisheries_relevance_notes: RElevant to flounder biological function