## Index

Note: f = figure; m = map; t = table. mean, 153, 170f Absorption, 239 and surface winds, 185-188 Adsorption, 239 Auks, 405, 407 Advection, 58 Aeolian supply, of sediment, 85, 139 Avifauna, 390-391, 392t-395t. See also Birds Azores high, 153 Agar agar, 384 Air, pollution of, 141 Bacteria, 9, 281, 302. See also Organic temperature of, 189. See also Temperature Airborne material, 11, 236-245 matter Baltic Sea, 82, 277 Air masses, warming of, 161 Barometric pressure, 154f, 156f, 157f Air-sea interactions, 7, 55, 154, 163 Baseline study, of estuaries, 389 Airstreams, cold, 177-179 Bathymetric profile, 249 Albedo, 238 Aldrin, 142, 476 Bays, China clay in, 422 Beaufort forces, 187 Algae, benthic marine, 387 Benthos, 9, 267, 362 colour scale of, 252 filter feeders among, 363 photic layer of, 252 production of, 254, 258, 260-261, 384 and shoreline dumps, 417 species distribution among, 420f, 421f and sewage sludge, 433 surveys of, 418-422 Alginate, 384 BHC, 476 Aluminum salts, 294 Bioaccumulation, 475-476 American Geographical Society, 372 Biodegradation, 13, 362, 363 Amino acids, 302 Ammonia, 11, 306, 388 Biology, recommendations on, 8-10 Biomass, benthic, 364 estimates of, 305 measurement of, 299 of birds, 402, 407, 408t of copepods, 261 and plant production, 301 in Rhine water, 322 estimate of, 261 in Wadden Sea, 371 Ammonium, 300, 302 Birds, 392t-395t, 481 Amphipods, 417, 431 Anticyclones, 161 biomass of, 408t predatory, 400, 409 Azores, 162 as resource, 390-391, 400. See also Avinorthern, 153 fauna; Seabirds; Shorebirds; Wildfowl polar, 161 BOD load, 472, 474. See also Oxygen subtropical, 153 Boron, 293 Antimony, 142 Bottom-sea interactions, 55 Arsenic, 141, 294, 312 British Hydrographic Office, 21 in estuaries, 318, 388 Brookhaven National Laboratory, 240 Asteroids, 431 Bromine, 293 Atlantic Ocean, 364 and atmospheric pressure anomalies, 162-Brown Bank, 137 Cadmium, 13, 141, 294 and mud supply, 82 airborne, 11 Atmosphere, deposition rates in, 6 scale of motions in, 237 in Rhine estuary, 324 in Rhine river, 312 and surface roughness, 238 Calanus finmarchicus, 278 Atmospheric circulation, 153-182 Carbamates, 142, 143 global, 168-171 Carbon, organic, 300 North Atlantic, 155, 174 Atmospheric pressure, 60 Carbonates, 294 anomalies in, 161f, 162, 164f, 165f, 166f, Carbon dioxide, assimilation of, 362 167f, 174 Carbonyls, 319 continental influence on, 183 Carboxyls, 319 Carnivores, in kelp holdfast, 387t

distribution of, 183, 185, 201m-206m

Carrageenan, 384 Containers, disposal of, 145, 468 "Cement pit," 417 Continental coastal water mass, 17 Central North Sea water mass, 17 Continental shelf, 251, 361 minerals from, 442 Cerium, 141 Cesium, 141 Continuous Plankton Recorder, 269 Convergence, Flamborough bed-load, 116 Chaetognatha, sampling of, 269 sand, 113 Chemicals, organic, 142 Cooling water, 465, 468 in sewage discharge, 472 Co-operation in the Field of Scientific and transport of, 468 Chemistry, estuarine, 10 Technical Research (COST), 37 recommendations on, 10-11 Copepods, 252, 254, 255f of sea water, 48 biomass of, 261 China clay, discharge of, 418, 423 plankton recorder counts of, 262t Chlorides, 141 and pollutants, 283 Chlorinated hydrocarbons, 7t, 11, 423 sampling of, 269 Chromium, 13, 141, 142, 314 Copper, 141, 142, 293, 294, 321 in bioaccumulation, 476 in bioaccumulation, 478 contamination with, 313 in estuaries, 318, 319 in Rhine estuary, 324 in estuaries, 318, 319 in Rhine river, 312 in food web, 389 Ciliates, 283, 284 in Rhine estuary, 324 in Rhine river, 312 Circulation, water, 4. See also Currents; in shellfish, 294 Current systems Cleaver Bank, 90, 136 in tropical rivers, 320 Cliffs, erosion of, 82, 139 Crabs, 374, 381 Climate, anomalies in, 153-182 and sewage sludge, 433 fluctuations in, 178, 199 and shoreline dumps, 417 influence of continent on, 183 Crustaceans, 371 Currents, bottom, 21-22, 30, 39 long-term variations of, 8, 173 Climatology, of North Sea, 183-236 ebb- and flood-, 137 wave. 3 longshore, 309 North Sea, 24f Cloudiness, 184, 186-197 Coal dust, dumping of, 433 oscillatory, 122, 124 residual, 3, 26, 111, 139 Coalfish, 337, 339, 349 landings of, 338, 350t, 359f, 360 surface drift, 22f, 23f tidal, 3, 4 Coal wastes, 415-418 Coastal erosion, 113 vertical variations in, 4 Coastal zone, 13 Current systems, 21-37 Cobalt, 141, 142, 293 and atmospheric circulation, 153 Böhnecke's, 30, 32, 34, 36, 39 in estuaries, 318 bottom residual, 27f in tropical rivers, 320 Cockles, 87, 371, 376, 377f of North Atlantic, 153 Cod, 337, 339-341 residual, 25, 28f, 30, 31f, 33f, 34, 39 landings of, 338, 359f, 360 surface, 25 nursery ground for, 379 wind drift, 25-26 spawning of, 364 Customs and Excise, H.M., 439 2-year-old, 330 Cyanide, 388 Codlings, 376 Cyclones, eastern Atlantic, 178 Colliery wastes, 145, 415, 417, 465, 477 Cyclonic activity, 161, 162, 164, 167, 177 Compensation depth, 254 Conservation, 398 Dabs, 422 DDT, 7t, 13, 142, 143, 476 of momentum, 50

Degradation, biological, 144

Construction, and sea's edge, 364

Delta Project, 322, 365, 376 Deltas, heavy metals in, 308-325. See also	Ecology, "altered," 303, 304t Ecosystem, detritus-based, 385
Estuaries	North Sea, 8
Demersal stock, 12, 262, 263, 362. See also Fish	Eddies, horizontal, 62 Eddy diffusion coefficients, 63, 66
Denmark, fishing effort of, 357	Edge, of North Sea, 364-365
Deoxygenation, of North Sea, 474-475	EEC, 37
Deposit feeders, 363, 417, 418, 419, 431	Effluents, 469, 482, 485m
and sewage sludge, 433	industrial, 302, 303, 469, 472, 473-474
Deposition rates, 6, 7t	liquid, 464
Depth, distribution of, 251	study of, 305
Depth chart, of North Sea, 132f	Eiders, 403
Depth regions, of North Sea, 253f	Ekman current, 62, 153
Detergents, 332	Ekman's formula, 51
Deutsches Hydrographisches Institut (DHI),	Ekofisk oil field, 453
26, 30, 32	Ems estuary, 316
Diatoms, maintenance of, 333	Ems river, heavy metals in, 310
Dieldrin, 142	mud in, 309
Diffusion, definition of, 58, 61, 62, 237	pollution of, 308
Diffusion velocity, 69	Endosulfan, 142, 143
Dilution, process of, 61	Endrin, 142, 476
Dinoflagellates, 283	Energy, sources of, 61-62
Dispersion, 11, 58. See also Diffusion	Energy transfer, 61
Dogger Bank, 20, 306	English channel, 82
gravel off, 136	English coastal water mass, 17
plaice off of, 344	English Lake District, 80
Dogger Bank Swirl, 21, 25-26, 30, 32	Enrichment, 303, 304t. See also Eutrophica-
Dolioletta gegenbauri, 275f	tion; Nutrients
Dolomite, 447, 448	Estuaries, ammonia in, 388
Dover Straits, sand traps in, 101. See also	birds in, 401
Straits of Dover	chemistry of, 10
Dredgers, 443	cyanide in, 388
Dredged spoil, 417, 424, 465	industry and, 465
Dredging, 88, 442	liquid wastes in, 465
harbour, 465	mobilization of metals in, 321
of navigational channels, 465	mud in, 86
of sand and gravel, 443	pollution of, 387–390, 477
Drilling, 455-457	residence time in, 10
Drilling platform, 456. See also Platforms	Rhine-Meuse, 86, 142
Drogden (lightship), 83	waste metals in, 142
Drums, dumping of, 145	Euphasids, 262
Ducks, 400, 403, 404t, 408	Euphotic zone, 331
Dumping, 145, 424	Eutrophication, 283, 303, 476-477
monitoring of, 435	Evaporation, rates of, 153
offshore, 417-418	Evapotranspiration, 80
shoreline, 415-417	Evolution, equations, 44–45, 50
Dust, coal, 415, 433. See also Coal wastes	prediction of, 43, 48
Dyestuff, discharge of, 469	Experiments, 9, 44
,	in diffusion research, 62-70
	drift-bottle, 25
East Greenland current, 179	RHENO, 26, 65
Ebb tide, 371	with rhodamine, 68
Echinoderms, 431	with Woodhead seabed drifters, 30

Exports, value of, 466f shrimp, 376 trawl, 350. See also Trawlers volume of, 467 Fishing effort, 337 Export trade, in marine aggregates, 439t catch per unit, 338 international, 338, 339, 340, 342, 343, 345, Fair Isle gap, 302 346, 356, 357 for plaice, 341 Farming, mussel, 374, 376 Fjords, as sediment traps, 87 oyster, 372, 374 Fladen Ground, 90 of sea, 379 Flamborough bed-load convergence, 116 Farne Islands nature reserve, 391, 396f, Flamborough Head, 113, 137 397, 398 Flatfishes, 361 Fats, 302 Fauna, bivalve, 431 Flora, algal, 387. See also Algae bottom, 366. See also Benthos Fluorescence, 60 and sewage sludge, 427 Fluoride, 294 Fly ash, 433, 465, 477 Fertilizers, 332, 472 Filter feeders, 363, 366, 371, 419 Fog, 184, 193, 195-196 frequency of, 227m-229m Firth of Forth, 21, 104 Food chain, 264t Fish, annual production of, 262 availability of, 337 detritus-based, 385 commercial stocks, 9 heavy metals in, 390 demersal, 262, 263, 362 mercury in, 314 ecology of, 12 shellfish in, 371 suspension feeders in, 385 eggs, 281 Food web, commercial fish stocks in, 9 metals in, 294 inshore, 385-387 North Sea catch, 263t and kelp, 387 O-group, 9 micro-organisms in, 9 pelagic, 262, 263, 362, 434 predatory, 409 Foraminifera, 76, 91 Forecasts, of sand and gravel demand, 446 productivity of, 263 France, fishing effort of, 349 recruitment of, 12, 48 Fisheries, 337, 464 Gadoids, 361 and China clay, 423 coalfish, 337 Gales, 187 Galloper (lightvessel), 20 cod, 337 Gas, from coal reserves, 451 commercial, 481 crab, 417, 472 drying of, 458 haddock, 337 exploration for, 454 herring, 337, 355 hydrocarbon, 451 industrial, 337, 339 natural, 437, 464 lobster, 417, 472 production of, 451, 453, 457–458 mackerel, 337 Gas fields, 451, 452f, 458 salmon, 397 Gas separators, 458 and scabirds, 409 Gaussian distribution, 66, 67f and sewage sludge, 433 Geese, 403 and solid wastes, 415-436 Geology, of North Sea, 451-454 Fisheries Charts, 131 recommendations on, 5-6 Fisheries Laboratory, Lowestoft, 26, 32, 34 German Bight, 20, 21, 251 Fishery, 361-362 banks of, 104 Bløden, 353, 357 sand waves in, 109 drift-net, 350 sedimentation rate in, 113 plaice, 345 temperatures in, 236 purse-seine, 355 tidal flats in, 106

German Federal Institute for Soil Research Holoplankton, 267 (BFB), 448 Homothermal area, 249 Germany, fishing effort of, 358 Hormones, 302 Goeree (lightship), 109 Humidity, 184 Goose, Brent, 404 Hydraulics Research Station, 442, 443 Grab sampling, 441 Hydrocarbons, 13, 437 Gravel, 131-136, 464 Hydrodynamic models, 4, 46 demand for, 437-449 active dispersion, 5 deposits of, 441 passive dispersion, 4 distribution of, 134f steady state, 47 dredged, 440f, 445 Hydrographic regions, 250f export of, 439t Hydrography, plankton and, 271-277 extraction of, 14 Hydroxides, 294 prices of, 444 Hydroxyls, phenolic, 319 production of, 438t, 439 river, 136 Ice, drifting, 183 and surface waves, 136 "Iceland" low, 153 Great Fisher Bank, 251, 258 ICES, pilot network, 32, 37 Greenness, 255f, 257f, 259f report, 469 Grey seal, 391, 397 stations, 22f, 34 Grey Seal Act, 397 Ilmenite, 448 Gulls, 401, 405, 406, 407 Imports, value of, 466f volume of, 467f Haddock, 281, 339, 341 Incineration, of wastes, 473 fishing effort for, 342f, 355 Incompressibility, condition of, 50 landings of, 338, 359f, 360 Industry, chemical, 473 Harbours, mud deposition in, 88 and river contamination, 308 Heaps' model, 51 sand and gravel, 441, 443 Heavy metals, 320, 473 steel, 472 in deltas, 308-325 Institute of Geological Sciences, 441 in estuaries, 388 Institute of Petroleum, 456, 463 in food chain, 390 International Council for the Exploration mobilization of, 320-321, 322 of the Sea (ICES), 268 in sludge, 423. See also Metals; specific International Rhine Commission, 328 metals Iodine, 293 Heligoland oyster bank, 372 Iron, 142, 144, 293 Herbicides, 142, 143 in estuaries, 318 Herbivores, 385 mobilization of, 320 in kelp holdfast, 387t in tropical rivers, 320 Herring, 337, 339, 349-355 Iron salts, 294 Bank stock, 353, 354 Buchan stock, 353 Jarke's map of grade, 117 Downs, 350, 354, 360 Joint North Sea Information System eggs of, 361 (JONIS), 37, 38f fishing of, 337, 355, 362 immature, 353, 358, 422 landings of, 338, 351f, 352f, 353, 359f, 360 Kelp, depth range of, 386f larval abundance of, 354t fauna associated with, 385 forests, 383 nursery ground for, 379 spawning of, 256, 364 habitat provided by, 385 Hg-procedure, 310 production of, 383, 384t Holderness peninsula, 82

Holocene deposits, 117

Kelp holdfast, infauna of, 387

Kraav's model, 51, 53f, 54f

Krylov-Bogolioubov model, 47 Manganese, 141, 142, 293, 294, 312 in estuaries, 318 Kuro Shiwo current, 178 immobility of, 321 in soils, 312 Lagrangian drift, 111 in tropical rivers, 320 Lake Laitaure, 81 Lake Yssel, 322 Marine aggregate, processing of, 445 Marine Biological Association Laboratory, Landings, average annual, 338t of coalfish, 350f, 359f, 360 at Plymouth, 293 Marine environment, effect of sewage sludge of haddock, 341 of herring, 351f, 352f, 359f, 360 on, 433 of mackerel, 356, 359f, 360 human activity and, 302, 363 and nutrient levels, 303 of marine aggregates, 439 of Norway pout, 357t, 359f, 360 and solid wastes, 415-436 of plaice, 338, 344f, 359f, 360 Marine Laboratory, Aberdeen, 34 of sandeel, 357t, 359f, 360 Marine mining, 437, 448 of sprat, 358t, 359t, 360 Marine system, diagram of, 45f Lanthanum, 318, 321 equilibrium of, 47 Mathematical models, 43 Larvae, decapod, 262 of air-sea interactions, 7 herring, 281 classes of, 4 planktonic, 267, 281 Lead, 13, 141, 142, 294, 313 construction of, 44 airborne, 11 of fish ecology, 12 in bioaccumulation, 476 hydrodynamic, 4, 5, 46, 47 deposition rates for, 7 input to, 3 in estuaries, 318, 319 of North Sea, 46-50, 398 phases, 49 in food web, 389 of plankton production, 44 in Rhine river, 312, 324 population, 46 in sludge; 431 Lemon sole, 281 for storm surges, 50-55 for tides, 50-55 Licenses, exploration, 453 Lightvessels, 20, 21, 36, 37. See also specific of wind and sea waves, 7 Meiobenthos, 9 lightvessels and lightships Limestone, 448 Meio-fauna organisms, 366 Mercury, 13, 141, 294, 314 Lincolnshire eddy, 32 Lindenacs Swirl, 21, 26, 30 airborne, 11 Living resources, 12-13, 383, 481, 483m deposition rates for, 7t in estuaries, 316, 318, 319 Lobsters, 379 in food chain, 314 and clay waste, 423 measurement of, 310 and sewage sludge, 433 mobilization of, 315, 320, 321 and shoreline dumps, 417 Luders' map, 76 organic forms of, 294 in Rhine discharge, 315 in Rhine estuary, 316t, 324 Mackerel, 339, 355 in Rhine river, 312 in China clay zones, 422, 434 in Rhine sediments, 142, 314 fisheries for, 337 landings of, 338, 356f, 359f, 360 toxicity of, 476 Macrophytes, benthic, 383-385 Meroplankton, 267 Metals, analyses of, 310 distribution of, 389 in deltas, 315-320 production of, 384t mobilization of, 321 Magnesia, 447, 448 pollution associated with, 141 Magnesia plant, 447 Magnesite, 447 in Rhine discharge, 315t

in sea water, 293

Main Chain Decca, 108

Metals (continued) Natural Environment Research Council, 441 solubilization of, 319, 321 Navier-Stokes equations, 50 in suspended material, 323. See also Heavy Neap tide, and sediment transport, 123 metals; specific metals Nekton, toxic effects of sludge on, 431 Meteorology, 6-8 Nephtyds, 427 Methane, 451, 458 Netherlands, fishing effort of, 349, 355, 356f Methyl mercury, 294 Newfoundland Banks, 156 Micro-organisms, in food web, 9. See also New Waterway, to Rotterdam, 88 Plankton; Zooplankton Nickel, 141, 142 Microzooplankton, 9 Nihoul's model, 49 Migration, of birds, 402, 407 Nitrates, 293, 295, 297f of fish, 362, 371 distribution of, 305 Minerals, from continental shelf, 442 intermediate forms of, 302 Mitropolsky model, 47 measurement of, 299 Molluscs, 371, 419, 427 and plant production, 301 Molybdenum, 142 in Rhine water, 322, 362 Monitoring systems, 6, 43 winter abundance of, 300 of algae growth, 389 Nitrite, 300, 302 of dumping, 435 estimates of, 305 ecological, 475 measurement of, 299 of metals, 294 Nitrogen, 299 Moray Firth, 21, 258 deposition rates for, 7t Mud, 75, 77-81t, 131, 139-141 estimates of, 305 areas of, 76-77, 78f, 79f, 94, 114 inorganic forms of, 293 budget of, 89–91 and phosphorus, 301 and cliff erosion, 82 and plant production, 301 deposition of, 89, 91, 92f, 93 in river water, 333 deposition rates of, 75-76, 94 supply of, 326 dumping of, 145 Norfolk Banks, sand waves on, 137 entrapment of, 86, 94 North Atlantic Drift Current, 302 "erosion," 314, 323 North Atlantic Ocean, and atmospheric cirin estuaries, 86-87 culation, 165 manganese in, 309f Northern North Sea water mass, 17 movements of, 309f North Hinder (lightship), 82 origin of, 308-309 North Sea, area of, 76 "original," 323 algae production in, 260-261 outflow of, 89 average cloud amount in, 197f removal of, 86-89 climatology of, 183-236 Rhine-Meuse, 139 diffusion experiments in, 63-66 river transport of, 91, 308 edge of, 364-365 sandy, 90, 366 as educational value, 391 soft, 366 fertility of, 295 in suspension, 139 fish supply of, I transport of, 80t, 93, 102t, 308-309 greenness in, 259f Mussels, 87, 374, 375f and human activity, 13-14 density of, 371 Kraav's model of, 51, 53f, 54f farming, 374, 376 mathematical models of, 46–50 parasites on, 374-376 muddy water in, 101. See also Mud seed, 374 northern, 77 oil and gas in, 454f Namias effect, 178 nutrients in, 295 Nanoplankton, 9 oscillating motions of, 47 National Institute of Oceanography, 441 productivity of, 249-266

North Sea (continued) regions of, 249-252 sediment transport in, 102t southern, 77, 78f morphology of, 138f oil and gas in, 454 primary production in, 331 three-dimensional models of, 50 water budget of, 3 water masses in, 273f zooplankton of, 267-289 Norway, fishing effort of, 355, 356f Norway pout, 337, 355-357 landings of, 338, 357t, 359f, 360 Norwegian Deep Water, 251, 252, 295 Norwegian Rinne, 17 Norwegian Trough, 76, 77, 78f Norwegian Trench, mud in, 120 Nursery grounds, 12, 365-371 and dredging, 442 edge of North Sea as, 361-382 for plaice, 341 Nutrients, concentrations of, 295 distribution of, 11 role of, 293 in sludge, 423 stocks of, 302 supply of, 326-328 and toxins, 306 Nutrition, trace metal, 306

Ocean currents, heat content of, 164. See also Currents; Current systems Ocean data stations, 39 Oil, 437, 464 blow-outs, 457 contamination of sea water by, 459 in English Channel, 454 exploration for, 454 production of, 458–459 spilled, 144, 457 transport of, 468. See also Tankers Oil companies, 457 Oil fields, 458 distribution of, 459 small, 451, 452f potential, 453 Omnivores, 385 in kelp holdfast, 387t "Operation Scafarer," 405 Optimization, 43 Organic matter, accumulation of, 363 biodegradation of, 362

budget for, 326-333 deposition rates for, 7t and oxygen balance, 332 river supply of, 331 in sludge, 423, 427 supply of, 326 in suspended material, 385 transport of, 326-333 in Wadden Sea, 371 Organochlorine compounds, 142, 143 Organo-metallic complexes, 320 Orkney Islands, and algae production, 258 Outfall, submarine, 474 Overfishing, 372, 374 Oxides, 294 Oxygen, data for, 305 depletion, 434 dissolved, 415, 424, 469, 472, 474 in North Sca, 332 Oxygen demand, 415 in sludge, 423 Oyster farming, 372, 374 Oyster Grounds, 139 Oysters, 372 deep water, 374 European flat, 373f Oystercatchers, 400, 401

Paraquat, 143 Particles, in North Sea, 139 deposition rates for, 7t pollution associated with, 141 Patchiness, of zooplankton, 278-281 Pedogenesis, 323 Pelagic stocks, reduction of, 12. See also Fish Pelagic zone, 9 Pentland Firth, 113 Periwinkles, 376 Pesticides, 473, 476 Petrochemicals, 469 Phenols, in estuaries, 388 Pharmaceuticals, discharge of, 469 Phosphates, 295 distribution of, 293, 305, 329f inorganic, 296f measurement of, 299 organic, 302 in Rhine discharge, 362 surveys of, 331 uptake of, 301 winter abundance of, 300 Phosphate cycle, 293 Phosphorus, 299, 300

Phosphorus (continued)	danger areas, 12
inorganic forms of, 293	of estuaries, 389, 469
and nitrogen, 301	and fish stocks, 360
supply of, 326	industrial, 477. See also Waste and kelp,
Photosynthesis, 424	385
Phytoplankton, 24, 295, 333, 363	of nursery grounds, 379
changes in, 332	oil, 144, 463. See also Oil
nutrient uptake by, 9	organic, 427. See also Organic matter
periodic blooms of, 476	of oyster beds, 374
photosynthetic activity of, 424	scabed, 131, 141-145. See also Benthos
seasonal cycle of, 49	and sea's edge, 364
and sediment formation, 83-85	sites of, 12
Pilot Ocean Data Station Network, 37	studies of, 415
Pipelines, 141, 365, 463	and zooplankton, 281
exposure of, 105	Polychaetes, 417, 419, 422, 427, 434
gas, 459, 460f	
oil, 461	distribution of, 429f, 430f
Plaice, 337, 339, 343f	Polychlorinated biphenyls (PCBs), 13, 142,
	143. 476 Polynuclear aromatic hydrocarbons (PAHs)
eggs, 281, 345 juvenile, 366, 369f, 370f	Polynuclear aromatic hydrocarbons (PAHs),
	142, 143 Papulation models 46
landings of, 338, 359f, 360f	Population models, 46
larvae, 281	Protio's man 76
nursery grounds for, 376, 379.	Pratje's map, 76 Precipitation 108 100 220
spawning of, 256, 282f, 364	Precipitation, 198–199, 239
Plankton, 276f, 362	frequency of, 184, 200f, 230n–235n
colour month units, 258t	for southwestern Norway, 80
and hydrography, 271–277	Primary production 263 229 321
inflow of, 272	Primary production, 263, 328–331
models of, 46	estimating, 301
and radioactivity, 285	measurement of, 331
red bloom of, 333. See also Red tide	in North Sea, 8, 326
Plankton Identification Sheets, 269	and oxygen content, 332
Plankton recorder surveys, 469	of surface waters, 330f
Plant production, 300	in Wadden Sea, 371
Plastic wrappings, disposal of, 468	Production cycles, in North Sea, 252–259
Platforms, drilling, 456	Productivity, biological, 476
gas-drilling, 6	of kelp, 383
gas production, 458	marine, 293
jack-up, 456	of North Sea, 249–266
moveable exploration, 459	primary, 299
oil-rig, 6	Protozoa, 9
unmanned, 458	Puffins, 397, 398
Pollen, "damp-air," 243	
Pollutants, categories of, 59–60	De l'es atre le com 000
chemical, 5–6	Radioactive decay, 239
daily discharge of, 388f	isotopes, 283–284
gaseous, 60	material, in atmosphere, 241
liquid, 60	Radiocarbon, measurements of, 249
organic, 11	Radionuclides, in sediment, 141
solubility of, 61	Rainout, 239
transport of, 58, 66	Reactions, chemical, 238–239
Pollution, 482	photo-chemical, 238–239
China clay, 418	Recommendations, 3–14
in coastal areas, 365	Recreation, 291, 482, 485m

Recruitment, of fish, 48. See also specific fish	Salts, nutrient, 363
Recycling, 473	Samarium, in estuaries, 318
Red tides, 283, 333. See also Plankton	immobility of, 321
Remineralization, 302	Sampling, grab, 441
Residence time, of water, 83	of zooplankton, 268, 277
Resource map, 481	Sand, 131, 464
Resources, avian, 400-412	coarse, 366
biologic, 383–385	demand for, 437-449
educational, 391	deposits of, 441
gravel, 441	dredging of, 440f, 445
living, 383, 481, 483m	dumping of, 145
non-living, 383, 481, 484m	export of, 439t
of North Sea, 383-399	extraction of, 14
sand, 441	fine, 366
sociologic, 383, 391–397	iron-coated, 142
RHENO, 64f, 69	prices of, 444
Rhine Delta region, 77	production of, 438t
Rhine estuary, lead in, 324	shell, 448
mercury in, 316	in suspension, 75. See also Mud
metals in, 318-319	Sand banks, 106
movement of sediments in, 312f	East Anglian, 118, 119f
Rhine river, heavy metals in, 310	migration of, 103f
mud in, 309, 314–315	Sandeels, 281, 337, 357
nitrogen content of, 328	landings of, 338, 357t, 359f, 360
phosphate in, 332	Sand hills, 116
phosphorous content of, 328	Sand ribbons, 106
pollution of, 308	Sand ridges, 137
Rhodamine B, 4, 63	Sand transport, directions of, 117, 119f
Rigs, offshore drilling, 455	estimates of, 121f
and pollution, 463. See also Platforms	in vicinity of sand banks, 118
Ringed plover, 401	Sand traps, in Dover Straits, 101
Rivers, China clay in, 418	Sand waves, absence of, 113
gravel in, 136	in English Channel, 117
metals in, 315	horizontal movements of, 105
as mud supply, 77	migration of, 103f, 104
mud transport of, 80, 139	ripple marks on, 111
pollution from, 141	after storm surges, 109
of Scandinavia, 81	and tidal currents, 108, 109, 116, 120-121,
as source of nutrients, 328	137
Ruthenium, 141	Sand wave zone, 106–111
Rutile, 448	around British Isles, 110f
C to I one	deposition in, 116
Sagitta elegans, 270f	sand transport directions in, 111–113
Sagitta setosa, 270f	of Southern Bight, 114
Salinity, 59, 60	Santa Barbara spill, 457
changes in, 20	Sardines, 281
and diffusion rates, 61	Scandium, 318, 321
long-term trends of, 20–21	Scavengers, 363
in nursery grounds, 371	Scheldt River, 85
stratification of, 117	Scotland, fishing effort of, 358
Salpa fusiformis, 272, 274f-275f	Scottish Coastal water mass, 17
Salt content, of drained marine aggregate,	Sea, temperature of, 189–190. See also
445	Temperatures

Seabed, pollution of, 141-145. See also Sewage sludge, 144. See also Sludge Benthos Sewers, pollution from, 141 Seabirds, 391, 400, 405-407, 408t Shear, vertical current, 66 Sea-duck, 403 Shear effect, 62 Seasons, in North Sea, 184 Shelducks, 403 and wind forces, 187 Shell content, of drained marine aggregate, Seaweed meal, 384 Shell Exploration and Production, Ltd., 34 Seaweeds, 383. See also Macrophytes Shellfish, 371-379 Sediment, aeolian supply of, 85, 139 bottom, 143, 294, 323, 366 area for, 379 Caenozoic, 133f distribution of, 364 carboniferous, 453 metals in, 291. See also specific shellfish China clay, 420f Shell sand, 448 distribution of, 5 Shetland Isles, 106 Ems, heavy metals in, 310-314 Shipping, 141, 465 Holocene, 131, 136 Shorebirds, 401-403 iron content of, 320 biomass of, 408t Mn-content of, 309 prey of, 402-403 and molluscs, 372 and shellfish, 400 organic content of, 428 Shoreline, and dissolved nutrients, 304t organic production of, 83-85 dumps along, 415, 417 Rhine, 310-314, 322 and enrichment, 304 river transport of, 81, 324 Shrimp, 376, 378f and sludge, 421-427 in estuaries, 365 transport of, 5-6, 101, 102t, 103f Silica, biogenic, 84 Sedimentation, 76-77 production of, 84 in atmosphere, 239 in river water, 333 deposition rates of, 106 Silica budget, 84, 85t history of, 6 Silicates, 293, 295, 301 rate of, 139. See also Mud distribution of, 305 Sediment transport, inferred, 106-120 excess of, 302-303 predicted, 120-124 measurement of, 299 rate of, 122 soluble, 298f sedimentary evidence of, 114-117 winter abundance of, 300 Sediment traps, fjords as, 87 Silican, 293, 301 near-bed, 101 Silt, 114, 283 Seismic reflection, and fish kill, 454-455 Silver, 141 Serial Atlas of the Marine Environment, Simulations, of North Sea, 51. See also 295, 305 Mathematical models Seven Stones (lightvessel), 20, 124 Skagerrak water mass, 17 Sewage, and algae, 387 Sludge, 423-433, 465 off beaches, 391 BOD of, 423 in coastal zone, 390 chlorinated hydrocarbons in, 423 discharge of, 464, 470f, 474 tomato seeds in, 425-427 in estuaries, 387, 472 toxic effects of, 431-433 kelp filtration of, 387 Slurry, gypsum, 472 liquid, 303 Smith's Knoll (lightvessel), 20, 122, 249 London works, 424 Snowout, 239 and oyster beds, 374 Soil, clayey, 366 and shoreline, 305 Solar radiation, 61 treated, 303 Sole, 281, 337, 339, 345-347 untreated, 469 and beam trawling, 345 and zooplankton, 283 and cold temperatures, 347

Sole (continued)	Sunshine, 300
international fishing for, 347	Surface pressure, anomalies of, 159, 60f
juvenile, 366, 367f, 368f	Surges, 55. See also Storm surges
landings of, 338, 359f, 360	Suspended matter, 322–324, 415, 477
nursery grounds for, 376, 379	Suspension feeders, 385
spawning of, 364	Suspension transport, 118–120
Solenette, 422	estimation of, 123
Solid waste, disposal of, 416f. See also	
Organic matter; Wastes	Tankers, movements of, 461-463. See also
Solubility, 59	Oil
Southern Bight, 106, 251	Teal, 404
gravels in, 136	Temperature, 60
organic matter in, 331	air, 189
primary production in, 328	anomalies of, 169
sand waves in, 109, 137	annual course of, 190f
sand transport in, 120, 123	average, 207m-210m;
Spawning, 362. See also Nursery grounds	and sea temperature, 192–193, 194f
Spectophotometry, 310	and diffusion rates, 61
Spionids, 427	long-term trends of, 20
Spores, airborne, 241, 242f, 243	in nursery grounds, 371
Sport, 391	sea. 155f. 156f. 189–190
Sprat, 337, 339, 357-359	anomalies of, 160, 161, 167, 169, 177
in China clay zones, 422	and atmospheric temperature, 192-193,
landings of, 338, 358t, 359t, 360	194f
STAFLO, 22f, 34, 36	average, 215m-222m
Starfish, 374, 417	average variation in, 192
Steamships, 75	high, 183
Steele's model, 48	history of, 173-177
Storage, 459	subnormal, 165
Storms, frequency of, 184	sea surface, 153, 154, 173, 177, 189-192
Storm surges, calculation of, 47	anomalies in, 155, 156, 158f, 159f, 163,
currents associated with, 108	175, 178
mathematical models for, 50-55	Atlantic Ocean, 155-168
Storm waves, 105	average, 211m-214m
height of, 124, 125f	history of, 171-173
oscillatory water movement produced by,	and wind circulation, 173
122	Terns, 405
and sedimentation transport, 123	Texel (lightship), 117
and sand, 136	Thames estuary, 105
Straits of Dover, 3	principal deeps of, 425f
herring off of, 350	sediment transport in, 101
mud concentration in, 82	sewage sludge in, 423-433
Stratification, 20	Thames river, dredging in, 88
haline, 20	mud of, 309
thermal, 39	sprat fishery in, 358
Student's t test, 158	Thermocline, 66
Sugars, 302	disappearance of, 164
Sulfur, deposition rates for, 7t	Thermohaline effects, 3
concentrations of, 244f	Tidal current, 111
emission rates for, 243	and gravel transport, 131–136
Sulfides, 294	maximum velocity of, 135f
Sulfur dioxide, 239, 245	near-surface, 124
Sulfuric acid, in estuaries, 388, 472	off Pentland Firth, 113

Tidal current (continued) Wangeroog Fairway, 104 Washout, 239 and plankton, 271 and sand deposition, 116, 137 Waste acids, 144, 145 Waste disposal, 389, 464, 465 and sand transport, 114-115, 118 and sand waves, 106, 120, 137 recommendations on, 13 and sand wave zone, 108 Waste-dumping operations, 89 in Southern Bight, 136 Wastes, 306 weak, 124 biodegradable, 473, 474 Tidal flats, erosion of, 138 chemical, 415 mud entrapment in, 87–88 China clay, 418-423 Tidal forces, 61, 62 coal, 415-418 Tides, calculation of, 47 discharges of, 473 mathematical models for, 50-55 distillery, 469 Titanium, 448 industrial, 310, 464, 472, 474 Titanium dioxide, 144 mercury, 145 Tomato seeds, as index, 424, 426f mineral, 433 Toxicity, acute, 474 non-biodegradable, 473, 476, 477 chronic, 475 recycling of, 473 Toxicology, 11 toxic, 465 Toxins, 302 trade, 385, 387, 388, 471t, 481 and plankton, 285 Water budget, of North Sea, 3 Trace elements, in estuaries, 10 Water masses, of North Sea, 17-20, 39, 273f Trace materials, bioaccumulation of, 10-11 Water Resources Board, 473 Trace metals, 293, 306 Wave action, wind-induced, 60 Tracers, 63, 104 Wave data, 93 Trawlers, Dutch otter, 346 Waves, height of, 124, 125f Grimsby, 339, 340f, 342f relative disturbance of, 123f and sand deposition, 137 Lowestoft, 341, 344, 345 North Shields, 348f storm, 136 Trawling, 422-423. See also Fishery Weather, long-term anomalies in, 155. See Turbidity, 60, 300 also Climate and algae production, 254 Weather Reporting Organization for Oil below thermocline, 82 Companies (WROCS), 456 Turbulence, 237-238 Weather ships, of Atlantic Ocean Weeds, 304 Unit of Coastal Sedimentation, 441 Well Bank, 121 Upwelling, rates of, 153 Westerlies, 153, 160, 161, 183 Uranium, 142 West Sole Gas Field, 457 Urea, dissolved, 11 Whelks, 376 estimates of, 305 Whitebait, in China clay zones, 422, 434 USSR, fishing effort of, 349 Whiting, 337, 339, 347-349 haddock landings of, 341 landings of, 338, 349t, 359f, 360 ocean studies of, 165 international fishing for, 348 Wildfowl, 400, 403-405 Variables, state, 44 biomass of, 408 Varne (lightvessel), 20 estimates of, 405 Vertical mixing, 300 Wind directions, 185, 193, 195 Visibility, over North Sea, 184 Wind forces, 184, 186, 195 Vitamins, 302 Wind roses, surface, 204m-206m, 223m-

Winds, over British Isles, 176f

circulation of, 153

at Kilnsea, 32

Wadden Sea, and fish life cycles, 365

mud in, 87, 139

as nursery ground, 371

Winds (continued)
over North Sca
observation of, 193
scalar average of, 187
surface, and stability, 193–195
vectoral average of, 187, 188f
warm, 189
Winkler titration, 424
Worms, nematode, 304, 305

Zinc, 141, 142, 293, 294 airborne, 11 in bioaccumulation, 476 contamination with, 313 in estuaries, 318, 319 in Rhine estuary, 324 in Rhine river, 312 in sludge, 431 in tropical rivers, 320 Zirconium, 141 Zooplankton, 267-289 distribution of, 271-272 dry weight of, 280, 281 fat content of, 278 in northern North Sea, 279f patchiness of, 278 pollution and, 281 production of, 271-272 quantity of, 262, 278 sampling of, 268, 277