

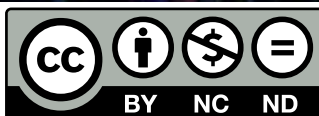
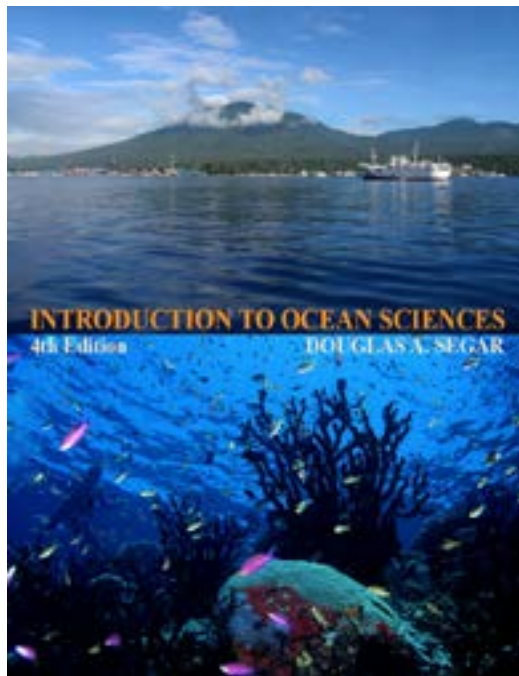
Introduction to Ocean Sciences

Fourth Edition, Second digital edition ver 4.0

DOUGLAS A. SEGAR

Contributing author Elaine Stamman Segar

© 2018 by Douglas A. Segar



This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivs 3.0 Unported License. To view a copy of this license, visit <http://creativecommons.org/licenses/by-nc-nd/3.0/> or send a letter to Creative Commons, 444 Castro Street, Suite 900, Mountain View, California, 94041, USA.

What does this Creative Commons Licence mean? You are free to use the book except that you can not use the book or any part of it for any commercial purpose including personal financial gain without written permission from the author. Uses that require written permission include, but may not be limited to, sale for profit, advertising use, or use as an incentive to purchase any other product. If you transmit or transfer the book to anyone by any means, you must attribute the book by at minimum citing the author, title, and ISBN number. Also, you can not alter, transform, or build on the work.

Most images and artwork contained in the book are copyrighted to the author (or others) and you may not use any of these in any way, except in your use of the book itself, without written permission from the copyright holder.

Library of Congress Cataloging-in-Publication Data

Segar, Douglas A.

Introduction to ocean sciences / Douglas A. Segar with contributions from Elaine Stamman Segar

p. cm.

ISBN: 978-0-9857859-1-8

1.Oceanography. I. Title

INDEX

Page ranges for each chapter in the book are listed here as an aid for those who are reading from individual chapter downloads. For these readers, the easiest way to use the index may be to print just this page and use it as a reference when navigating from an index entry to the listed pages in the book.

CHAPTER 1 The Ocean Planet.....	Pages 1 - 14
CHAPTER 2 History and Importance of Ocean Studies.....	Pages 15 - 34
CHAPTER 3 Studying the Oceans.....	Pages 35 - 58
CHAPTER 4 Plate Tectonics: Evolution of the Ocean Floor.....	Pages 59 - 88
CHAPTER 5 Water and Seawater.....	Pages 89 - 114
CHAPTER 6 Ocean Sediments.....	Pages 115 - 140
CHAPTER 7 Ocean-Atmosphere Interactions.....	Pages 141 - 174
CHAPTER 8 Ocean Circulation.....	Pages 175 - 204
CHAPTER 9 Waves.....	Pages 205 - 230
CHAPTER 10 Tides.....	Pages 231 - 252
CHAPTER 11 Coasts.....	Pages 253 - 282
CHAPTER 12 Foundations of Life in the Oceans.....	Pages 283 - 318
CHAPTER 13 Coastal Oceans and Estuaries.....	Pages 319 - 350
CHAPTER 14 Marine Ecology.....	Pages 351 - 398
CHAPTER 15 Ocean Ecosystems.....	Pages 399 - 422
CHAPTER 16 Impacts of Humans on the Oceans.....	Pages 423 - 450
CRITICAL CONCEPTS.....	Pages 451 - 500

- absorption: 56, 106-109, 112, 146, 427, 441, 467-470, 490-491
of light in water: 107
spectrum: 469
- Abudefduf* sp. (sergeant fish): 375, 384
- abyssal fan: 85, 129
- abyssal hill: 61, 80
- abyssal plain: 61, 85, 128-129, 138-139, 300
- abyssal zone: 300, 315, 415
- abyssopelagic zone: 300-301, 315, 421
- Acanthurus pyroferus* (mimic surgeonfish): 368
- accumulation rates, of sediment: 126, 129-130, 132, 138
- acidification: 2-5, 13, 25, 124, 136-137, 260, 423, 440-443, 445, 447
- acidity, of water: 3, 136, 336, 423, 443-445, 447
- acid rain: 99, 116, 137
- Acorn barnacles: 412
- acoustic: 21, 27, 49-50, 57, 111
- acoustic current meter: 49-50
- Acoustic Thermometry: 111
- Acoustic Thermometry of Ocean Climate (ATOC): 111
- acoustic tomography: 50
- Acreichthys tomentosus* (seagrass filefish): 362
- Acropora palmata* (elkhorn coral): 403-404
- Acropora* sp. (staghorn coral): 359
- acyclovir: 27
- Adaptations of Fins: 376
- adiabatic expansion: 144-145, 173
- Adriatic Sea: 334-335
- adsorption: 125, 289
- Aegean Sea: 17
- aerobic: 298, 444
- aesthetics: 25, 31, 33-34
- Afghanistan: 72
- Africa: 14, 16-19, 63, 65, 71-73, 83, 85, 133, 152, 158, 170, 182, 189, 197, 211, 224, 244, 301, 323-324, 348, 471
- African Plate: 63
- age
of Earth: 5
of sediments: 134
- agriculture: 3, 26, 152, 277-278, 334, 432
- Agulhas Current: 189, 211-212
- air masses: 142-144, 148-149, 151, 155, 160-161, 164-165, 168, 170-173, 204, 226, 230, 472, 486, 488
Coriolis effect and: 164, 487-488
vertical movement of: 143
- Alaska, Gulf of: 158, 160
- Albemarle Sound (NC): 338
- Alcatraz Island, San Francisco Bay, CA: 343, 345, 434-435
- Aleutian Islands: 12, 70, 194, 256, 333
- Aleutian Trench: 223
- Alexandria, Egypt: 17
- algae: 322, 366, 392, 402, 412
benthic: 315, 322, 352, 361, 402, 426
blooms, see blooms, algal: 332-334, 346, 348, 425
blue-green (cyanobacteria): 287, 305, 332-333, 408, 489-492
calcareous: 266, 276, 366, 402, 404, 419
encrusting: 352, 411-412, 420
green: 305, 408, 410
Halimeda sp.: 266, 392
ice: 413, 415, 420
- algal ridge: 404
- alligators: 314
- Allopatonia* sp. (shrimp): 366, 392
- Alpheus bellulus* (tiger pistol shrimp): 393
- Alps: 72
- aluminum: 61, 90, 116
- Alvin submersible: 21, 54, 416
- Amazon River: 133, 323
- Amblyrhynchus cristatus* (marine iguana): 312
- Amchitka Island, AK: 407
- American Samoa: 24
- amino acids: 6, 97, 290
- ammonia: 6, 33, 100, 102, 285, 289, 472, 491
- amnesic shellfish poisoning (ASP): 332-333
- amphidromic systems: 242-244, 250-251
- amphipods: 304, 306, 387, 415, 417
- Amphiprion*
A. clarkii (Clark's anemonefish): 373
A. frenatus (tomato anemonefish): 373
A. percula (clown anemonefish): 373
A. perideraion (pink anemonefish): 359, 373
- amplitude, of waves: 206, 225, 248
- anadromous fishes: 345-347, 380, 386, 394-395, 427, 439-440, 445
- anal fins: 368, 376-378
- Anchorage: 231, 235, 275
- anchovy: 25, 156, 158, 336
- Andes Mountains: 20, 69, 155, 170
- Andrew, Hurricane: 166-167
- anemone crab (*Dardanus* sp.): 392
- anemonefishes: 372-373, 381, 388-389
Clark's (*Amphiprion clarkii*): 373
clown (*Amphiprion percula*): 373
pink (*Amphiprion perideraion*): 359, 373
spinecheek (*Premnas biaculeatus*): 373
tomato (*Amphiprion frenatus*): 373
- anemones: 307, 355-356, 359, 364, 372-373, 381, 388-389, 392-393, 406-407, 412, 417
Haddon's sea (*Stichodactyla haddoni*): 373
rose (*Tealia lineata*): 406
sand: 356, 364
- angelfishes
black-spot (*Genicanthus melanospilos*): 377
blue-girdled (*Pomacanthus navarchus*): 377
pearlscale (*Centropyge vrolikii*): 368
- Angelfishes: 368
- angle of incidence: 146-147, 288-289
- anglerfishes: 377
deep-sea (*Chaunax pictus*): 366
- Anguilla: 386
- Anguilla* sp. (Atlantic eel): 386
- angular velocity: 477, 479-480, 483-484
- animals: 13, 109, 120, 286, 292, 295, 300, 314, 352-353, 360-361, 394, 407, 412, 414, 416, 431, 435
- anions: 93, 97
- annelid worms: 363
- anoxia: 298, 315, 333-335, 342, 346-348, 361, 395, 419, 425-426, 431-432, 444-447
- Antarctica: 3, 19, 23, 32, 62, 65, 84-85, 118, 121, 132-133, 142-143, 148-149, 153, 172, 177, 182, 185-186, 192, 194-197, 201-202, 210-211, 217, 243-244, 250, 293, 295, 306, 314-317,

- 329, 413-414, 421, 441-442, 463
- Antarctic Bottom Water: 194-195, 199, 202
- Antarctic Circumpolar Current: 177, 182, 185-186
- Antarctic Communities: 414
- Antarctic Convergence: 195, 202, 413
- Antarctic Divergence: 196, 295
- Antarctic Peninsula: 85, 414, 441
- Antennarius* sp. (Lembeh frogfish): 384
- Antennarius striatus* (striated frogfish): 365
- Anthozoa (polypoids): 359
- anthropogenic, inputs: 3, 5, 124, 136-137, 145, 197, 298, 336, 423-424, 429, 437, 439-442, 444, 447, 472, 496-499
- antinodes, of standing waves: 226-228, 242, 245, 247-248
- Antioch, CA (San Francisco Bay): 426
- aphotic zone: 108, 286, 288-289, 292, 306, 352, 415, 420
- Appalachian Mountains: 72, 84
- Aquarius: 52
- Arabian Gulf, see Persian Gulf: 31, 126, 155
- Arabian Peninsula: 159
- Arabian Sea: 85, 117, 133
- Arabs: 18
- aragonite: 123, 138
- Arceichthys tomentosus* (seagrass filefish): 362
- archaea: 6, 51, 97, 121, 283-288, 291, 295, 298-299, 301-302, 315-316, 354, 418-420, 490-491
- arches, sea: 262
- Archimedes' principle: 454-455
- arcs
- island: 67, 70-71, 85, 163, 416, 420
 - magmatic: 70-71, 85-86, 256
 - sedimentary: 70, 84, 86, 93, 256
- Arctic Ocean: 24, 28, 73, 84-85, 133, 153, 156, 160-161, 194-195, 197, 200-203, 301, 328-329, 413, 415-416, 421, 437, 441, 446, 463
- Arctic Oscillation: 160
- Arenicola brasiliensis* (lugworm): 363
- Argentina: 24, 170
- Argo floats: 22, 54
- Argo ROV: 29, 53-55, 74
- Aristotle: 17
- Armenia: 72
- armor: 371-372, 395
- arrowhead crab (*Huenia heraldica*): 392
- Aruba: 263, 362
- Asia: 17-18, 35, 65, 67, 71-72, 85, 117-119, 150, 152, 155, 159-160, 182, 256, 314, 386
- aspect ratio: 376
- assimilative capacity: 424-428, 437, 445, 447, 497
- associations, of species: 27, 336, 368, 372, 387-389, 392, 395
- Asthenosoma*
- A. intermedium* (fire urchin): 370
 - A. varium* (fire urchin): 392
- asthenosphere: 60-61, 63, 65, 67, 71-73, 80, 84-87, 139, 280, 451, 454-457, 459
- Astropyga radiata* (sea urchin): 393, 403
- Atlantic eel (*Anguilla* sp.): 386
- Atlantic Ocean: 18, 20, 58, 65, 72, 75, 78, 83-87, 108, 111, 118-120, 123-126, 129, 132-133, 153-156, 163, 167, 173, 180, 185, 188-189, 192-200, 202, 212, 236, 243-244, 251, 259, 270, 277, 293, 301, 309, 345, 401, 412, 442, 466
- Atlantis: 58
- atmosphere: 3-6, 13-14, 35, 90, 97-98, 102, 119, 124, 136-137, 142-147, 156, 161, 164, 171-173, 199, 203, 297, 408, 411-412, 440, 443, 458, 462-463, 467-472, 487
- convection cells in: 145, 147-152, 154, 158, 171-173
 - Coriolis effect in: 148
 - density of: 142-143, 173
 - greenhouse effect in: 3, 14, 35, 84, 114, 140, 161, 173, 203, 212, 258, 280, 421, 440-442, 467-468, 470-471
 - interactions of oceans and: 56, 141, 173, 203
 - land-ocean interactions with: 149, 161, 164, 167, 169, 171-173, 322
 - stratification of: 142
 - stratosphere of: 142-143
 - troposphere of: 142-143, 145, 147-149, 159, 171
 - water vapor and: 35, 90, 99, 101-103, 114, 135, 141-148, 163-164, 168, 170-173, 454, 458, 462-463, 469, 472, 487
- atmospheric: 145, 147-152, 154, 158, 171-173
- atolls: 20, 24, 32-33, 79-81, 84, 86, 225, 229, 275-276, 278-279
- atom: 91-92
- atoms: 90-92, 285, 465, 491
- Aurelia* sp. (moon jellyfish): 305, 307
- Australia: 16, 19, 43, 62, 65, 85, 111, 133, 138, 152, 158, 167, 182, 276, 323, 347, 372, 441
- autonomous floats: 41, 48, 55, 159, 181
- autonomous underwater vehicles (AUVs): 35, 45, 52, 55-57, 244
- autotrophs: 285-286, 288-290, 292, 295, 301, 304, 315, 353, 408
- AUVs (autonomous underwater vehicles): 35, 45, 52, 55-57, 244
- avalanches: 128-129, 138, 257
- Azerbaijan: 72
- azidothymidine (AZT): 27
- Azores: 18, 160
- back-arc basins: 71, 85-86
- backscattering: 107
- of light in water: 107-108, 146, 188
 - of solar energy: 146
- backshore: 263, 265, 267, 269, 274, 278
- backwash: 266-267, 270
- bacteria: 16, 51, 93, 97, 105, 121, 123, 175, 185, 283-288, 290-292, 295, 298, 300-302, 304-306, 315-316, 333, 352-354, 360-362, 372, 394, 416, 418-421, 424, 431, 435, 442, 446, 472, 490
- Baffin Bay: 42, 85
- baguios: 167
- Bahamas: 119, 126, 167, 201, 439
- Baikal, Lake, Russia: 421
- Baja California, Mexico: 248, 324, 384, 387
- Balanus glandula* (barnacle): 357, 410
- baleen: 295, 306, 310, 313, 387, 414, 493
- baleen whales: 295, 306, 310, 313, 387, 414, 493
- Balistoides conspicillum* (clown triggerfish): 378
- Balkan Peninsula: 72
- Baltic Sea: 85, 155, 190, 298, 321, 333
- Banggi cardinalfish, *Pterapogon kauderni*: 384
- Bangladesh: 167, 277, 279
- Banzai Pipeline: 221
- bar-built estuaries: 337-338, 346
- bar charts: 6-8
- barnacles: 37, 306, 356-357, 380-381, 399, 410-412, 420, 436, 440
- acorn: 381, 412

- Balanus glandula*: 357, 410
 buckshot: 410-411
Chthamalus sp.: 357, 410
 coral (Pyrgomatidae): 357
 barracuda, chevron (*Sphyraena putnamiae*): 375
 barred filefish (*Cantherhines dumerilii*): 376
 barrier beaches: 265, 271-274
 barrier islands: 2, 255-256, 258, 261, 265, 270-274, 278-280, 337-338, 346
 barrier reefs: 80-81, 260, 276, 278-279, 404
 bars
 baymouth: 270-271
 longshore: 221, 263, 265, 268-269, 271, 273, 278
 basalt: 61, 72-73
 basket star (Gorgonocephalidae): 359-360
 bass, striped: 26, 345, 439
 bathyal zone: 300, 315, 415
 bathymetry: 37, 42, 56
 bathypelagic zone: 300
 bathyscaphes: 54
 bathysphere: 54
 baymouth bars: 270-271
 Bay of Bengal: 85, 117, 133, 321
 Bay of Fundy, Canada: 246, 250, 255, 280
 bays: 30, 85, 117, 218-219, 228, 245-250, 255, 260, 263, 277, 279, 335, 338, 341, 345, 425-426, 432-435, 439-440, 467
 beaches: 1, 116, 205, 220, 248-249, 256, 260-269, 271-275, 278-279, 300, 314, 335, 355, 384, 387, 408, 424, 428, 431-432, 436, 439, 446
 barrier: 265, 271-274
 closures of: 428, 432, 436
 grain size in: 266-267
 human structures and: 272, 278
 lagoons and: 270, 278
 litter on: 28, 34, 46, 116, 424-425, 430, 435-436, 440, 446
 longshore drift and: 33, 130, 266-267, 269-275, 278, 337-338
 seasonal changes in: 269
 slope of: 266, 269-270, 278
 sources of materials in: 265
 wave sorting of: 267
 zones of: 263-265, 268, 278
 Beagle, HMS: 19-20, 22, 34, 81
 Beaufort Sea: 255, 270
 behavior, of marine organisms: 52
 Behm, Alexander: 40
 Beihai, China: 237
 Beijing, China: 476
 bends: 53, 75
 Bengal, Bay of: 85, 117, 133, 321
 Benguela Current: 183
 Bennett's butterflyfish (*Chaetodon bennetti*): 365
 benthic environment: 299-300, 314-315, 427
 abyssal zone of: 300, 315, 415
 bathyal zone of: 300, 315, 415
 hadal zone of: 300, 315
 intertidal (littoral) zone of: 231, 248, 264-265, 268, 278, 300, 315, 352-353, 394, 399, 408, 410, 419
 sublittoral zone of: 300, 315
 supralittoral zone of, see also rocky intertidal communities: 33, 300, 408, 411, 420
 benthic organisms: 51-52, 299, 315-316, 352, 392
 benthos: 27, 50, 295, 300-301, 307, 309, 314-316, 320, 346, 352, 355, 434-435, 446
 Bering Sea: 3, 19, 25-26, 28, 70, 73, 86, 133, 163, 194-195, 348, 387, 443
 Bering Strait: 84, 194
 berms: 263-265, 269, 278
 Bermuda: 111, 126
 Bermuda Rise: 126
 Big Sur, CA (near Monterey): 262
 binary fission: 381
 Bioaccumulation: 429, 448, 496, 498
 bioassays: 429, 446, 498
 bioavailable: 434, 436, 446
 biochemical cycles: 489, 492
 biodegradable chemicals and materials: 430
 Biodiversity: 15, 36, 351, 396, 399, 421, 423, 449, 451, 495-496
 biogenous sediment: 121, 130
 biogeochemical cycles: 93-94, 97, 112, 114-116, 297, 437, 466
 biological age dating: 43, 59, 68, 88-89, 114-115, 134, 140, 175, 203, 451, 464-465
 biological niche: 400
 Biological Oceanography: 34, 50
 bioluminescence: 302, 307
 Biomagnification: 429, 448, 496, 498
 biota: 31, 33, 301, 317, 325, 334, 345, 352, 415, 425, 427, 429, 434-435, 437, 439, 466-467, 471
 bioturbation: 134-135, 361
 black coral (*Cirrhopathes* sp.): 392, 404
 black-headed parrotfish (*Scarus gibbus*): 371
 black-saddled mimic filefish (*Paraluteres prionurus*): 368
 black-saddled toby (*Canthigaster valentini*): 368
 black-spot angelfish (*Genicanthus melanospilos*): 377
 black turban snails (*Tegula funebris*): 410
 blooms: 326, 328, 330-334, 346, 384, 426
 algal: 332-334, 346, 425
 diatom: 325, 331-332
 dinoflagellate: 332-333, 346, 348
 blubber: 314, 387
 blue-girdled angelfish (*Pomacanthus navarchus*): 377
 blue-green algae (cyanobacteria): 287, 305, 332-333, 408, 489-492
 blue-ringed octopus (*Hapalochlaena* sp.): 283
 boiling point: 74, 99-102, 143, 463
 bonds
 chemical: 91
 covalent: 91-92
 hydrogen: 91-92, 99-103, 106, 112
 ionic: 91-93
 bony fishes: 310-311, 364, 379, 395
 Bores, tidal: 246, 250-251
 boron: 96
 Bosnia: 72
 Boston: 163, 235
Bothus: 307, 375
 B. mancus (flowery flounder): 307
 B. sp. (flounder): 375
Botryllus sp. (tunicate): 359
 boundary currents, eastern: 182-184, 186-187, 201-202, 324, 386
 boundary currents, western: 169, 182-186, 188-189, 194, 201-202,

- 204, 323, 400
 box corers: 42-43, 52, 57
 boxfishes: 371-372
 spotted (*Ostracion meleagris*): 371
 brackish. water: 349, 362, 440
 Brahmaputra: 85, 117, 277, 321
 brain coral (*Diploria sp.*): 359
 Brazil: 133, 167, 183, 217, 323
 breakwaters: 221, 275, 278
 breezes, land and sea.: 169-170, 172
 brine: 31, 194-195
 British Columbia (BC), Canada: 130, 133, 160
 brittle stars: 389, 399, 416
 bromine: 96, 100
 brown cup coral (*Paracyathus stearnsii*): 406
Bryaninops yongei (whip goby): 388
 buckshot barnacles: 410-411
 budding: 381
 budget
 heat: 145-146, 171
 water: 144-146
 buffering
 of heat: 102, 153, 161
 of pH: 99
 bulkheads: 428
 buoyancy: 112, 288, 309, 311, 316, 352-353, 355, 375, 380, 394-396, 415, 454
 burrfishes: 372
 burrowing sponge (*Oceanapia sagittaria*): 384
 butterflyfishes: 364, 376, 381, 389
 Bennett's (*Chaetodon bennetti*): 365
 Klein's (*Chaetodon kleinii*): 374
 Meyer's (*Chaetodon meyeri*): 375
 buttress zone: 404, 419
 bycatch: 26
 byssal threads: 411
 cables, undersea: 129
 calcareous organisms: 121, 133, 136
 calcite: 123, 138
 calcium: 3, 13, 95, 99, 121, 123-124, 126, 130-131, 135-136, 138-139, 266, 300, 306, 310, 313, 372, 402, 417, 420, 447
 calcium carbonate: 3, 95, 99, 121, 123-124, 126, 130-131, 135-136, 138-139, 266, 300, 306, 310, 313, 372, 402, 447
 California (CA): 13, 22, 24-26, 28, 30, 41, 67, 69, 75, 87, 117, 120, 126, 129, 159-160, 168, 170-171, 175, 183, 187, 203, 224, 235, 248, 253, 255-257, 261-264, 267, 275, 287-288, 311, 313-314, 318-319, 322-325, 333, 342, 357, 384-385, 387, 405-408, 410-411, 419, 421, 426, 429, 434, 443, 446
 California Current: 187, 443
 California gray whale: 314, 387
 California, Gulf of: 175
 California mussel (*Mytilus californianus*): 311, 357, 385, 410
 calorie (cal): 100, 102
 Camille, Hurricane: 166
 camouflage, in hunting and defense: 364, 366, 368, 392, 395
 Canada: 25, 43-44, 58, 69, 84-85, 119, 130, 140, 160-161, 170, 195, 236-237, 253, 255, 258-259, 277, 280, 333, 338, 443
 Canary Islands: 18, 120
 Cannery Row, Monterey, CA: 25
Cantherhines dumerilii (barred filefish): 376
Canthigaster valentini (black-saddled toby): 368
 canyons, submarine: 41, 84, 120, 129, 256, 267, 278
 Cape Cod, MA: 255, 320
 Cape Hatteras, NC: 187-188, 320
 Cape Mendocino: 69
 capillary waves: 208-209, 212-213, 228
Carangoides sp. (trevally): 375, 377
Caranx melampygus (bluefin trevally): 368
 carbonate compensation depth (CCD): 123-124, 131-133, 135, 138, 203, 300
 carbon dioxide: 3-4, 14, 97-99, 112, 123-124, 126, 136, 199, 203, 285-286, 289, 297-298, 315, 423, 440-441, 445, 447, 469-470, 490, 492
 carbon organic, ; see also organic matter: 289, 298-299, 315-316, 335
 carcasses: 415-416, 419-420
Carcharhinus amblyrhynchus (gray reef shark): 308, 377
Carcharodon carcharias (great white shark): 308
 carcinogens: 414, 429, 446, 497-499
 Cardiidae (cockles): 355
 cardinalfish
 Banggi cardinalfish, *Pterapogon kauderni*: 384
 cardinalfish, weed (*Foa brachygramma*): 392
 Caribbean Sea: 23, 85, 127, 141, 237, 244, 260, 303, 362, 404, 473
 Carmel, CA (near Monterey): 253
 carnivores: 286, 295, 301, 305, 308, 315, 336, 352, 354, 381, 411-412
 carotenoids: 490-491
 cartilaginous fishes: 311, 316
 Cassiopeia andromeda (upside-down jellyfish): 305
 Cassiterite: 29
 catadromous fishes.: 345, 347, 380, 395, 427
 Catarina, Hurricane.: 167
 cations: 93
 caudal fins: 376-377, 379, 392, 395
Caulerpa racemosa (grapeweed): 322
 caves, sea: 262
 Cayman Islands: 85, 141, 260
 CCD (carbonate compensation depth): 123-124, 131-133, 135, 138, 203, 300
 Celebes sweetlips (*Plectorhinchus celebicus*): 368
 celerity: 206, 218
 cell division: 303
 Central America: 155, 158
 central rift valleys: 73, 76
 centripetal force: 232-234, 250-251, 477, 479-486
Centropyge vrolikii (pearlscale angelfish): 368
 cephalopods: 309, 313
 cercaria: 389
 cetaceans: 310, 313, 394
 CFCs (chlorofluorocarbons): 143
Chaetodon
 C. bennetti (Bennett's butterflyfish): 365
 C. kleinii (Klein's butterflyfish): 374
 C. meyeri (Meyer's butterflyfish): 375
 Challenger, HMS: 36
 Chang (Yangtze) River: 117
 chaos, chaotic systems: 1, 14-15, 27, 36, 59, 63, 88, 141, 159-161, 164, 171, 173, 175, 197, 203, 277, 319, 336, 348, 451, 471, 473-476, 499

- charts, see maps, mapping: 6-7, 9, 13-14, 19, 38, 41, 164
Chaunax pictus (deep-sea anglerfish): 366
 cheeklined wrasse (*Oxycheilinus digramma*): 375
Cheilinus fasciatus (redbreasted Maori wrasse): 377
 chelation: 326
Chelonia mydas (green sea turtle): 312, 362
 chemical bonds: 91
 Chemical Oceanography: 96, 140
 chemical sensing, in marine organisms: 384, 393-394, 416
 chemosynthesis: 14, 21, 58, 88, 140, 285-286, 300, 315, 317, 353, 396, 416, 421, 492
 chemotaxis: 380
 Chernobyl, Ukraine: 437-438
 Chesapeake Bay, VA: 5, 138, 247-248, 335, 338, 425, 432
 chevron barracuda (*Sphyraena putnamiae*): 375
 Chicxulub, Mexico: 136-138, 225
 Chikyu: 43
 Chile: 159, 170
 China: 24-25, 27, 29, 33, 72, 86, 117-118, 246
 Chiso Chemical Corporation: 433
 chitons: 410-411
 lined (*Tonicella lineata*): 410
 chlorine: 13, 91, 95, 100, 143
 chlorofluorocarbons (CFCs): 143
 chlorophylls: 52, 56, 108, 161, 285, 292, 295, 297, 323-324, 327, 489-492
 chloroplasts: 489-492
 chordates: 307
 Christmas tree worm (*Spirobranchus giganteus*): 360
 chromatophores: 366, 368
 chronometers: 11, 17-18
Chthamalus sp. (barnacle): 357, 410
 Chukchi Sea: 387
 circulation
 eddies in: 31, 48, 56, 175, 188-189, 202, 303, 322, 325, 327-328, 346, 401, 413, 418
 Ekman spiral: 177-178, 201, 203
 Ekman transport: 178-187, 190, 201-203, 265, 323-324, 339, 346, 436
 Langmuir: 190-191, 202, 303, 322, 327, 339
 circulation, estuarine: 338, 341-342, 344-345, 347, 432, 435, 446
 circulation, thermohaline: 176, 190, 201-203, 225, 440-442
Cirrhipathes sp. (black coral): 392, 404
Cirrhitichthys falco (Falco hawkfish): 365
 clams
 giant (*Tridacna gigas*): 393
 Tellina sp.: 362
 Clark's anemonefish (*Amphiprion clarkii*): 373
Clavelina sp. (lightbulb tunicate): 359
 clays: 116, 119, 123, 132-133, 138, 225, 461
 deep-sea (red): 132-133
 cleaner wrasse (*Labroides phthirophagus*): 368
 Clean Water Act: 428
 climate
 deep-ocean circulation and: 196, 202
 interannual variations of: 156, 160, 171
 ocean surface currents and: 169, 182-189, 194, 201-202, 204, 323-324, 386, 400
 zones of: 161-163, 171
 climate change: 3, 5, 13, 136, 197, 440-442, 444-445, 447, 468, 470
 climatic winds: 147-150, 163-164, 169, 171, 177, 181-182, 188, 325
 cycles of: 83
 MOC and: 189, 196-197, 202, 226, 231, 335, 442
 sedimentary (stratigraphic) record of: 133, 135, 138
 susceptibility of ecosystems to: 413
 wave heights and: 212
 climatic:; see climatic winds
 clingfish, crinoid (*Discotrema crinophila*): 392
 clinker: 116
 clones: 381
 clouds: 146, 166, 170-171, 176, 363, 380, 442, 470
 clown anemonefish (*Amphiprion percula*): 373
 clownfishes: see anemonefishes
 clown triggerfish (*Balistoides conspicillum*): 378
 Clypeaster (sand dollars): 403
 cnidarians: 307, 374
 cnidocysts: 307
 coastal plains: 83, 86, 117, 256, 259, 271, 277, 336-337, 343, 442
 Coastal Zone Color Scanner: 108, 188
 coastal zones: 2, 48, 108, 156, 188, 253, 314, 319, 322, 324, 334-336, 426, 428, 434-435, 439, 447
 characteristics of: 319, 346
 currents and: 186-187, 202-203, 320, 322-325, 346
 food webs in: 325
 human structures and: 272, 278
 nutrients in: 322, 327, 346
 salinity in: 320
 seasonal variation in: 328, 346-347
 temperature in: 321
 turbidity of: 322
 upwelling in: 122, 156-157, 169-170, 186, 202, 289, 294-295, 323-327, 330, 335, 345-347
 waves and: 175, 205, 263, 321, 327
 coastline/: 24, 84, 119, 257, 279
 coasts: 2, 22, 25, 33, 69, 83, 87, 117, 133, 156, 166, 169-170, 182, 186-187, 223, 225, 236-237, 244, 253, 256-257, 259-267, 270-271, 276, 278, 323, 325, 333, 338, 346, 387, 408, 428, 454, 456-457
 barrier islands on: 2, 255-256, 258, 261, 265, 270-274, 278-280, 337-338, 346
 classification depositional or erosional: 253, 278
 classification primary or secondary: 256
 deltas on: 5, 130, 259, 277-279, 338, 425-426
 formation of: 256
 human structures and: 272, 278
 lagoons on: 31, 79-81, 130, 229, 256, 270-272, 276, 278, 280, 314, 319-321, 338, 387, 402-403, 419
 modification of: 260
 reefs and atolls on: 20, 24, 32-33, 79-81, 84, 86, 221, 225, 229, 260, 275-276, 278-280, 404
 sea-level change and: 83-84, 86-87, 131, 231, 256-258, 278, 457
 subduction zones near: 68
 wetlands on: 2, 34, 127, 130, 263, 276-279, 338, 343-345, 347, 362, 425-428, 439, 442, 445-447
 coasts?/: beaches on, see beaches
 cobalt: 29, 124-125, 289
 coccolithophores: 121-122, 302, 304-305, 316
 cockles (Cardiidae): 355

- Cocos Plate: 69
cod, Atlantic (*Gadus morrhua*): 307
coelenterates,: see cnidarians
cohesive: 127, 140, 280, 460-461
Coleman's shrimp (*Periclimenes colemani*): 392
collisions, of continents: 71-72, 79, 86
colloidal matter: 125
colonial organisms: 305, 307, 354, 359-360, 374, 381, 395
Colorado (CO): 280
Columbia River, WA: 161
Columbus, Christopher: 17-18, 35, 88, 230, 397
common mussel (*Mytilus edulis*): 385
common reef squid (*Sepioteuthis lessoniana*): 309, 384
communication, in marine organisms: 392, 395
communities
 Antarctic: 414
 Arctic: 414
 at hydrothermal vents: 417
 chemosynthetic: 6-7, 13, 285, 288, 295, 315, 352, 418-421, 490
 marine: 125, 299, 303, 314-315, 329, 396, 400, 407-408, 412, 415-421, 427, 446, 495-496
 rocky intertidal: 408, 419, 421
compensation depth: 123-124, 133, 138, 203, 288-289, 300, 315
complexed ions: 436, 498
complex systems: 57, 476
computer modeling: 1, 14-15, 35, 47, 56-58, 141, 159-160, 173, 175, 190, 197, 200, 203, 283, 317, 451, 471-472
computer tomography: 63
concealment: 368, 370, 372, 395
condensation: 99, 144-145, 147, 173, 463
conduction: 63, 73, 105, 146-147, 454, 458, 462, 472, 475
conductivity,: electrical, see electrical conductivity
cone shell (*Conus geographicus*): 371
Congo River: 85
congregations, spawning: 380
conservative properties, of seawater: 199, 202
constituents, dissolved, in seawater: 47, 95, 103, 112, 114, 199, 421, 449
contaminants: 426, 432-433, 435, 445, 466-467, 498
contamination: 35, 45-46, 57, 97, 346, 414, 424, 426-428, 433, 435, 440, 446-448, 467, 499
 fat-soluble: 414, 433-434
 in dredged material: 446
 nonpoint sources: 432
 vs. pollution: 424
continental collisions: 71-72, 79, 86
continental crust: 60-61, 65, 67, 69-72, 74, 76, 83-87, 454-458
continental drift see also plate tectonics: 20, 22, 43, 65
continental margins: 67, 81, 84, 93, 117, 130-131, 138
continental rises: 61, 139
continental shelves: 22-24, 28, 30, 61, 83-86, 130-131, 138-139, 184, 186, 225-226, 258, 300, 315, 319, 323, 327, 334-335, 401
continental slopes: 28-29, 34, 61, 84, 126-129, 133, 137-139, 196, 419, 435
contour plots: 7-9, 13-14
contours: 7-9, 13-14, 164, 172, 178-179, 201, 243, 421, 487-488
Conus geographicus (cone shell): 371
convection: 62-63, 105, 114, 148-150, 152, 171-173, 175, 203, 458-460, 475
convection cells: 145, 148-152, 171-173, 458-460
convergent plate boundaries: 67-68, 70, 76, 80, 86-87, 124, 256
 continental: 71-72, 79, 86
 oceanic: 85
conversion tables: 12
conveyor belt circulation: 196-197, 298
Cook Inlet: 19, 28, 246
Cook, James: 18
Cook Strait, New Zealand: 19
cooperation, in hunting and defense: 23, 372, 374, 395, 498
Copenhagen, Denmark: 95
copepods: 295, 304, 306, 316-317, 354, 388, 412, 415
copper: 29, 58, 97, 124-125, 135, 277, 332, 406, 417, 424, 427, 430, 436-437, 497-498
Copper River, AK: 277
copper rockfish (*Sebastes caurinus*): 406
coral crabs (*Cancer sp.*): 370
coral reefs: 80-81, 260, 276, 278-279, 329, 399-402, 419, 421, 496
corals
 black (*Cirrhopathes sp.*): 392, 404
 brain (*Diploria sp.*): 359
 brown cup (*Paracyathus stearnsii*): 406
 elkhorn (*Acropora palmata*): 403-404
 hard: 322, 329, 357, 359-360, 384, 392, 399, 403, 496
 reef building (hermatypic): 400-401, 404
 soft,: 357, 359, 366, 368, 392, 399, 404, 419
 staghorn (*Acropora sp.*): 359
 symbiosis in: 275-276, 278, 322, 329, 346, 392, 400-401, 404, 418-419, 442
 Tubastrea sp.: 359
 whip: 366, 388, 392
 Xenia sp. (soft coral): 359
coral shrimp (*Dasycaris zanzibarica*): 366
coral shrimp (*Vir philippinensis*): 392
core, Earth's: 42-43, 60, 62-63, 77, 127, 189, 458
corers: 42-43, 45, 52, 57
Coriolis effect
 climatic winds and: 148
 Critical Concept: 477
 in estuaries: 338, 341-342, 344-345, 347, 432, 435, 446
 oceanic currents and: 177-178, 201, 203
 tides and: 242
 waves and: 208, 226, 228
 weather systems and: 1-2, 56, 141, 145, 147-148, 157, 160, 162, 164-169, 172-173, 212, 223, 228, 272, 279-280, 296, 463, 471, 473
cormorant, double-crested (*Phalacrocorax auritus*): 313
cormorants: 313-314
cornetfish (*Fistularia commersonii*): 374
Corpus Christi, TX C (south of Galveston): 272
corrosion, as factor in ocean studies: 36-37, 46
cosmogenous sediment: 116, 126, 130, 138
countershading: 368
covalent bonds: 91-92
cowries: 361, 392
 allied (*Primovula sp.*): 361
 egg (*Pseudosimnia sp.*): 392
Crabeater seal, *Lobodon carcinophagus*: 414
crabs: 306, 366, 368, 370, 372, 384, 392-393, 412

- anemone (*Dardanus* sp.): 393
 arrowhead (*Huenia heraldica*): 392
 coral (*Cancer* sp.): 370
 decorator: 366, 368, 392
Dorippe frasco: 393
 hermit: 392-393, 410, 412
 horseshoe (*Limulus polyphemus*): 248, 384
 king: 3, 25-26, 306
 Majidae: 366
 northern kelp (*Pugettia producta*): 406
Pagurus sp.: 410
 porcelain (*Porcellanella triloba*): 392
 spider (*Xenocarcinus* sp.): 366, 392
Crassostrea virginica (eastern oyster): 381, 439
 crests
 of oceanic ridges: 76
 of waves: 206-208, 212, 215, 218-223, 228, 242, 267-268
 Crete: 17, 68
 crinoid clingfish (*Discotrema crinophila*): 392
 crinoid cuttlefish: 309
 crinoids: 309, 366, 368, 389, 392-393, 399
 crinoid shrimp (*Periclimenes amboinensis*): 366
 Croatia (Balkans): 72, 335
 crocodiles: 314
 cross-sectional profiles: 9
 crust
 continental: 60-61, 65, 67, 69-72, 74, 76, 83-87, 454-458
 density of: 59
 Earth's: 6, 9, 13, 35, 59, 65, 67, 87, 93-94, 124, 139, 280, 337, 419
 formation of: 59
 oceanic: 60-61, 63, 65, 67-73, 76, 80, 83, 85-87, 123, 130, 134, 139, 276, 280, 285, 454-457
 crustaceans: 112, 295, 306, 313, 316, 332, 352-356, 372, 377, 387-388, 412, 415-416
 crusts, phosphorite: 29-30, 45, 124, 126, 138
Cryptocentrus cinctus (yellow shrimp goby): 393
 CTD samplers: 47, 95
 ctenophores: 305, 307, 316, 354-355
Cucumaria sp. (creeping sea cucumber): 360
 cum sole motion: 164, 177-179, 201, 242, 477, 484, 487
 currents
 Agulhas: 183, 189, 211-212
 Antarctic Circumpolar: 177, 182, 185-186
 Benguela: 183
 California: 187, 443
 climate affected by: 196, 202
 coastal: 186-187, 202-203, 320, 322-325, 346, 428
 Davidson: 187
 deep-ocean: 176, 190, 201-203, 225, 440-442
 East Australian: 183
 ebb: 231, 245, 250
 eddies in: 48, 56, 175, 188-189, 202, 303, 322, 325, 327, 346, 401, 413, 418
 Equatorial: 182, 185-186, 201-202
 flood: 231, 245
 Florida: 180
 generation of: 176
 geostrophic: 179-185, 190, 201, 203, 230, 488
 Gulf Stream: 19, 31, 153, 163, 169, 180, 183, 185-189, 195, 197, 202-203, 226, 345, 386, 462
 gyre: 181-182, 203
 horizontal pressure gradients in: 180-182
 inertial: 190, 202
 Kuroshio (Japan): 153, 163, 183, 189, 345
 latitudinal heat transfer by: 147
 measuring: 47-48, 50
 open-ocean: 182
 residual: 341-343, 345
 restoring forces in: 176
 rip: 2, 222, 228-229, 268
 steering forces in: 176
 subpolar (high-latitude): 185
 surface slope and: 180-182
 surface (wind-driven): 175-178, 180, 182, 190, 201-203, 225, 319
 tidal: 31, 190, 196, 202, 231, 244-251, 322, 328, 338-339, 341, 343, 345-346, 418, 435
 turbidity: 34, 120, 128-129, 133, 137-138, 209, 256-257, 416, 460, 462
 wave heights and: 211
 currents, soundings affected by: 38
 cuttlefish: 309, 313, 351, 366, 384
 broadclub (*Sepia latimanus*): 309
 crinoid: 309
 flamboyant (*Metasepia pfefferi*): 351, 384
Cyanea sp. (jellyfish): 307
 cyanobacteria (blue-green algae): 287, 305, 332-333, 408, 489-492
 cycles: 65, 94, 328, 466
 biogeochemical: 93-94, 97, 112, 114-116, 124, 291, 297, 430, 437, 466
 diurnal: 235-239, 242-244, 250-251, 292, 306
 hydrologic: 90, 437
Cyclichthys orbicularis (orbicular burrfish): 371
 cyclones
 extratropical: 148, 162, 164, 168-169, 172, 223, 296
 cyclones, see also hurricanes: 148, 162, 164, 167-169, 172, 223, 296
 cyclonic storms: 168
 Cymothoidae (fish doctor, isopod): 388
 cysts: 327
 damselfishes, lemon (*Pomacentrus moluccensis*): 388
Dardanus sp. (anemone crab): 393
 Dark Ages: 17-18, 35
 darkspotted moray eel (*Gymnothorax fimbriatus*): 378
 dartfish (*Nemateleotris magnifica*): 365
 Darwin, Charles: 19-20, 22, 34-35, 69, 81
Dasyzaris zanzibarica (coral shrimp): 366
 dating (age estimation): 134
 dating, by radioactivity: 134
 Davidson Current: 187
 DDT: 97, 425, 427, 429-430, 434, 437, 446, 448
 Deacon's Reef, Papua New Guinea: 89, 399
 Dead Sea: 126
 dead zones: 5, 298, 333-335, 346, 425, 432, 444-445, 447
 decay, radioactive: 63, 200, 458, 464-465
 declination, lunar: 238, 240, 250
 decomposers: 286, 290, 292-293, 298-299, 360-361
 decomposition: 29, 97, 121, 126, 285, 291-292, 294, 298, 315, 416
 decorator crabs: 366, 368, 392

- deep-ocean water masses: 181, 190, 193
 deep-sea anglerfish (*Chaunax pictus*): 364, 366, 380
 Deep Sea Drilling Program (DSDP): 22, 43
 deep-sea mud: 131-133
 Deepwater Horizon: 334, 430-431
 deep-water wave: 209, 213-214, 216, 218, 228-229
 defense,: see hunting and defense
 deforestation: 13, 116
 Delaware: 255, 338
 Delaware Bay: 338
 deltas, river: 5, 117, 130, 256, 259, 277-280, 337-338, 425-426
Dendrochirus zebra (zebra lionfish): 378
 Dendronephthya: 359, 392, 399
 Denmark: 95
 density
 - absolute: 207, 452
 - atmospheric: 143
 - of Earth's crust: 60
 - of lithospheric plates: 61
 - of marine organisms: 416
 - relative: 105, 452, 464
 - stratification by: 179, 441, 452
 - water: 35, 46, 58, 89, 95, 102-105, 112, 114-115, 140-141, 175, 180-181, 186, 190-191, 193, 201-203, 207, 293, 451, 453-454, 458, 463-464
 deoxygenation: 2-5, 13, 25, 136-137, 423, 432, 440-443, 445, 447
 deposit feeders: 360-363, 395-396, 402, 416, 419
 deposition
 - glacial: 118
 - of sediment: 84-85, 119, 121-122, 124-126, 129-130, 132-135, 138, 361, 402, 427
 depth of no motion, in waves: 180-181
 depth of seafloor: see bathymetry
 detritus: 4, 93, 120-121, 276, 278, 286, 291-292, 295, 298, 300, 315, 327, 345, 352-354, 360-362, 366, 394, 402, 407, 411-412, 416, 419, 443, 460
Diadema savignyi (long-spined sea urchin): 361
 diagenesis: 135, 138
 diarrhetic shellfish poisoning (DSP): 332-333
 diatom ooze: 130
 diatoms: 117, 121-122, 130, 132-133, 135, 138, 288, 291-292, 295, 302-306, 315-316, 325-326, 328, 331-333, 335, 345-347, 354, 360, 381
Didemnum molle (tunicate): 359
 diffusion: 135, 143, 196, 289-290, 353-354, 362, 452-453, 472
 dikes: 72
 dinoflagellates: 275, 288, 302, 304-305, 316, 329, 331-333, 335, 346, 348, 372, 400
 dip angle: 78-79
Diploastrea heliopora (hard coral): 329
Diploria sp. (brain coral): 359
Discotrema crinophila (crinoid clingfish): 392
 dispersion: 209, 215-217, 228, 419
 - of waves: 209, 216-217, 228
 disposal: waste, see waste disposal
 dissipation, of waves: 212
 dissolution: 116, 121-123, 132, 138, 140, 262-263
 diurnal cycles
 - in temperature: 161, 169
 - of tides: 235-239, 244, 250
 - of zooplankton: 292
 divergence: 67, 72-73, 75, 148-149, 152-154, 162, 176-177, 179-182, 185-186, 191, 194, 196, 202, 295, 303, 458-460
 - in atmospheric convection cells: 148
 divergent plate boundaries: 67, 72-73, 75, 78, 80, 86-87, 256
 diversity: 36, 396, 399, 421, 449, 495-496
 - ecosystem: 36, 396, 421, 449, 495-496
 - genetic: 27, 36, 380-381, 387, 395-396, 421, 449, 495-496
 - physiological: 36, 396, 421, 449, 495-496
 - species: 15, 27, 31, 36, 351, 396, 399, 421, 423, 427, 449, 451, 495-496
 DNA: 22, 284, 429, 498
 doldrums (intertropical convergence zone): 148, 177, 185
 dolphins, bottlenose: 333
 domoic acid: 332-333
 Doppler shift: 50
Dorippe frascione (crab): 393
 dorsal fins: 365, 368, 376-377, 379
 Dover, England: 121-122, 140
 downwelling: 63, 72, 86, 88, 148-149, 152-153, 155, 171-172, 180, 182, 185-186, 190, 201-203, 292, 296, 328, 413, 458-460
 drag: 38, 48, 63, 106, 374-377, 395
 Drebbel, Cornelius: 53
 dredges: 20, 25, 44-45, 52, 57, 274
 dredging, pollution from: 27, 34-35, 345, 430, 434-435, 440, 446
 drifters: 48, 57
 drift nets: 26, 51, 314
 drilling: 22, 28-29, 34, 43, 57, 62, 68, 127, 134, 139, 226, 448
 drogues: 48, 57
 drowned river valleys: 337-338, 346
 drugs: 27-28, 34-35, 372, 424
 dynamic height: 180-182
 Earth
 - age of: 5
 - structure of: 59, 87
 - uniqueness of: 90
 earthquakes: 41, 63, 65, 72, 75, 128-129, 137, 205, 208, 223-225, 228, 256, 277, 439
 - epicenters of: 128, 277
 - turbidity currents and: 34, 120, 128-129, 133, 137-138, 209, 256-257, 416, 460, 462
 Earth sciences: 159
 East African Rift Zone: 67, 72
 East Australian current: 183
 East China Sea: 117
 Easter Island: 17, 67, 78
 eastern boundary currents: 182-184, 186-187, 201-202, 324, 386
 eastern oyster (*Crassostrea virginica*): 381, 439
 East Pacific Rise: 67, 73-74, 84, 139
 East Wind Drift: 185, 201
 ebb currents: 231, 245, 250
Echeneis naucrates (remora): 308, 378
Echinocardium sp. (heart urchin): 363
 echinoderms: 266, 443
 echolocation: 394-395
 echo sounders: 39-41, 57, 306
 echo sounders, wide area: 41
 ecological requirements, of species: 351, 394
 ecology: 160, 250-251, 351, 421, 439, 441, 446
 - adaptation in: 290, 302-303, 317, 351, 354, 360, 372, 374-

- 380, 393, 395, 412, 415, 496
communication in: 392, 395
feeding in: 295, 308, 330, 353-356, 359-363, 387, 394-396, 402, 411-412, 416-420
habitats in: see habitats
hunting and defense in: see hunting and defense
marine: 351
navigation in, reproduction in: see reproduction
species associations in: 336, 387, 395
- ecosystems
assimilative capacity of: 424-428, 437, 445, 447, 497
diversity in: 15, 27, 31, 36, 351, 396, 399, 421, 423, 427, 449, 451, 495-496
- ecosystems, marine
aphotic zone as: 108, 286, 288-289, 292, 306, 352, 415, 420
classification by: 283, 400, 419
communities in: 400, 419
coral reefs as: 80-81, 260, 276, 278-279, 329, 399-402, 419, 421, 496
hydrothermal vents as: 6, 21, 29, 52, 54, 93, 97, 104, 124-125, 133, 138-140, 199, 285, 288, 295, 300, 315, 352-353, 394, 416-421
kelp forests as: 287-288, 301, 315, 319, 322, 352, 405-408, 412, 419, 421
nutrient-limited: 289, 294, 317, 326, 328-330
polar regions as: 4, 98, 102, 105, 143, 146-147, 171-172, 182, 185, 194, 200, 315, 328, 347, 396, 413-415, 420, 441, 443, 462-463
rocky intertidal communities as: 300, 315, 399, 408-412, 419-421
Sargasso Sea as: 188-189, 296, 303, 345, 386, 412-413, 420-421
- ecosystem, terrestrial: 161, 287, 353, 364, 428
- Ecuador: 23
- eddies: 31, 48, 56, 175, 188-189, 202, 303, 322, 325, 327-328, 346, 401, 413, 418
- eels, freshwater: 345
Atlantic (*Anguilla* sp.): 386
- eels, moray: 377-378, 380
darkspotted (*Gymnothorax fimbriatus*): 378
- EEZs (exclusive economic zones): 23-25, 28, 34, 440
- effluents: 99, 338, 344, 420, 425-427, 432-434, 446, 498
- egg cowrie (*Pseudosimnia* sp.): 392
- egg laying: 314, 327, 381, 384, 386, 395
- eggs: 248, 309, 311, 314, 327, 374, 380-381, 384-385, 387, 389, 392, 395
mortality of: 342, 381, 385, 387, 395, 442, 445
pelagic: 248, 331, 345, 374-375, 380, 384-387, 395-396, 440
- Egyptians, ancient: 17, 68, 172, 277
- Ekman Motion: 177, 201
- Ekman spiral: 177-178, 201, 203
- Ekman transport: 178-187, 190, 201-203, 265, 323-324, 339, 346, 436
- Elagatis bipinnulata* (trevally): 368
- electrical charge: 90
- electrical conductivity: 47, 95, 112
- electrical fields: 393-394, 396
- electromagnetic radiation, spectrum of, see also light: 36, 56, 90, 106-107, 109, 112-113, 468-469
- electrons: 90-92, 100, 116, 176, 285, 491-492
- electrostatic charge or attraction: 91, 93, 127, 461
- elephant seal (*Mirounga angustirostris*): 26, 311, 314, 429
- elkhorn coral (*Acropora palmata*): 403-404
- El Niño/Southern Oscillation (ENSO): 25, 149, 156-160, 171, 185-186, 226, 295, 442
- embryos: 429, 498
- emission spectrum: 469
- Emperor Seamount chain: 77-79, 81
- emperor shrimp (*Periclimenes imperator*): 392
- encrust, encrustation, encrusting organisms: 322, 352, 359, 361, 381, 401-402, 404, 407-408, 411-412, 419-420
- endangered: 25, 31, 34
- Endangered Species: 25, 31, 34
- energy
as oceanic resource: 31, 385
from tides: 35, 249-250
kinetic: 176, 178, 201, 207-208, 219
of waves: 31-33, 56, 127, 137, 206-210, 212-213, 215, 217-221, 224-228, 250, 255, 260, 262-263, 267-269, 273, 275, 278-279, 402-404
potential: 179, 182, 207-208, 219
- energy, solar: 3, 119, 146-147, 162, 169, 171, 401, 415, 462, 467-470
- English Channel: 244
- Enhydra lutris* (sea otter): 314, 407-408, 419
- ENSO (El Niño/Southern Oscillation): 25, 149, 156-160, 171, 185-186, 226, 295, 442
- environment
benthic: 299-300, 314-317, 354, 427
pelagic: 299-300, 314-316, 352
- Environmental Protection Agency, U.S. (EPA): 397
- enzymes: 290, 418
- Ephesus, Turkey: 336-337
- epicenters, of earthquakes: 128, 277
- epifauna: 300, 352, 363, 366, 394
- epipelagic zone: 300, 315
- Epitonium billeeanum* (snail): 384
- equator: 9, 11, 146-149, 152, 154, 156, 167, 171-172, 182, 184-185, 238, 241, 477, 483-485
- Equatorial Countercurrent: 203
- Equatorial Undercurrent: 203
- equatorial zone, currents in: 182, 185-186, 201-202
- equinoxes: 146-147, 149
- Eratosthenes: 17, 35
- Eretmochelys imbricata* (hawksbill sea turtle): 312, 314
- erosion: 81, 84-85, 116, 118-119, 253, 256, 260-267, 271-275, 277-278
by extratropical cyclones: 148, 162, 164, 168-169, 172, 223, 296
by glaciers: 118
by rivers: 116
by waves: 25, 84, 119, 168, 221, 261-263, 273-274, 278
human activity and: 277, 440
in coastal formation and modification: 84, 253, 256, 260, 263, 273-274, 278
lithogenous sediment and: 84, 116, 118-119, 221
- estuaries: 117, 246, 251, 319, 336-339, 341-348, 425-428, 431-432, 434-435, 439-440, 446, 467
as marine habitats: 345
bar-built: 337-338, 346

- circulation in: 338, 341-342, 344-345, 347, 432, 435, 446
 coastal-plain: 337-338
 contaminants in: 342
 Coriolis effect in: 338, 341-342, 344-345, 347, 432, 435, 446
 fjords as: 84, 118, 127, 255, 258-259, 285, 298, 321, 328, 333, 337-339, 341-342, 346-347
 geological origins of: 337
 partially mixed: 194, 339, 341-346, 348, 453
 pollution in: 30, 342, 467
 salinity in: 338, 341-342, 344-345, 347, 432, 435, 446
 salt wedge: 338-339, 341-344, 346
 sediment transport in: 342
 tectonic: 337-338, 346
 tidal currents in: 246
 well-mixed: 339, 341, 343-344, 346
 wetlands and: 345
 eukaryotes (eukarya): 284, 287, 295, 302, 489, 491
 euphausiids: 304, 306, 316, 353-354
 Eurasia/: (see Europe and Asia)
 Eurasian Plate: 63, 86
 Europe: 18-19, 78, 81, 85, 133, 158, 160, 163, 171, 182, 185, 197, 202-203, 244, 275, 386, 434, 462, 471
 Europeans voyages of discovery by: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
 eustasy: 59, 83-84, 86-87, 115, 139, 253, 257-259, 280, 451, 454, 456-457
 eutrophication: 290, 334, 426, 432, 445
 evaporation: 30-31, 96, 102, 126, 144, 146-148, 153-155, 162, 164, 171, 192-193, 196, 202, 320-321, 342, 408, 412, 441, 463-464, 466, 470
 evaporites: 81, 124, 126, 138
 Everest, Mount: 36, 77
 evolution, theory of: 20, 284
 exclusive economic zones (EEZs): 23, 35
 excretion: 379, 429
 excurrent openings: 309, 354, 359, 362
 exotic terranes: 69-70, 85, 93
 expansion, adiabatic: 144-145, 173
 exponential (scientific) notation: 2
 extinctions, threats of: 2, 4, 136-137, 314, 441, 444-445, 447, 495-496
 extratropical cyclones: 148, 162, 164, 168-169, 172, 223, 296
 Exxon Valdez: 430
 Fairbanks, AK: 88
 Falco hawkfish (*Cirrhichthys falco*): 365
 Falkland Islands: 24
 false cleaner wrasse: 368
 fans, abyssal: 85, 129
 fan worms: 360, 364, 372
 farmers: 473
 farming: 27, 470
 fathom: 38
 faults, transform: 69, 75-76, 81, 86-87, 256, 338
 fauna: 301, 317, 334, 361, 394, 408-409, 417-418
 fecal pellets: 120, 122, 127, 286, 290, 292, 298, 315, 317, 326, 346, 363
 feedback: 5, 136, 414, 440, 468, 470-471
 feeding: 353-356, 386, 394
 deposit: 360-363, 395-396, 402, 416, 419
 filter: 353-354, 387, 394, 412, 417-418, 420
 grazers: 292, 295, 303, 314, 326, 332, 353, 360-362, 394, 407-408, 411-412, 420, 426
 suspension: 353-356, 359-360, 394, 396, 402, 411, 416
 Ferrel cells: 148-149, 152, 154-155, 162, 171, 182
 Fessender, Reginald: 39
 fetch, of winds: 32, 164, 210, 217, 228, 328
 Fiji: 260, 308, 312, 359, 370-371, 374-375, 378, 404
 filefish: 362, 368, 376
 barred (*Cantherhines dumerilii*): 376
 black-saddle mimic (*Paraluteres prionurus*): 368
 seagrass (*Acreichthys tomentosus*): 362
 filter feeders: 353-354, 387, 394, 412, 417-418, 420
 fins: 376-379, 395
 adaptations of: 376
 aspect ratio of: 376
 fire goby (*Nemateleotris magnifica*): 365
 fire urchin: 370, 392
 (*Asthenosoma intermedium*): 370
 (*Asthenosoma varium*): 392
 fish doctor parasites: 388
 fisheries: 22, 25-27, 34, 250, 316, 326, 328, 333, 336, 346, 348, 428, 440, 494-495
 fishes: 26-27, 52, 109, 294, 307, 310-312, 314, 316-317, 345, 364, 368, 372, 374-377, 379-380, 388, 394-395, 407, 412, 414-416, 433, 493-495
 anadromous: 345-347, 380, 386, 394-395, 427, 439-440, 445
 bony: 310-311, 364, 379, 394-395
 cartilaginous: 311, 316
 catadromous: 345-347, 380, 386, 394-395, 427, 445
 collection of: 26, 34, 49, 51-52, 57, 301, 314, 435, 440, 495
 fish fluke: 389
 Fistularia commersonii (cornetfish): 374
 fjords: 118, 258-259, 321, 337-338, 341-342
 Flabellina rubrolineata (nudibranch): 361
 flagella: 288, 304
 flagellates: 304, 325-326, 331-332, 346-347, 354
 flamboyant cuttlefish (*Metasepia pfefferi*): 351, 384
 flasher scorpionfish (*Scorpaenopsis macrochir*): 388
 floats: 48-49, 55, 105, 181, 454-455
 flood currents: 231, 245
 floods: 152, 158-159, 231, 277-278, 337, 341-342
 flora: 301, 317, 408-409
 Flores, Indonesia: 16
 Florida: 33, 52, 113, 119, 126, 160, 163, 166-167, 175, 180, 187, 189, 235, 255, 258, 272, 310, 333, 419, 442, 471
 Florida Current: 180
 Florida, Straits of: 126
 flounder, *Bothus sp.*: 375
 flounder, flowery (*Bothus mancus*): 307
 fluids, mixing of: 35, 58-59, 87, 89, 114-115, 139, 141, 173, 175, 203, 451
 fluke, fish: 389
 fluorine: 96
 flyingfishes: 379
 Foa brachygramma (weed cardinalfish): 392
 focus, of earthquakes: 28, 33, 36, 288, 394, 423, 470, 473
 fog: 147, 169-170, 324
 Folger, Timothy: 19
 food chains: 3, 294-295, 301, 317, 330, 345, 348, 492-493

- food webs: 26, 295, 300, 302, 315, 326, 335, 427, 429
 foreshore: 262-263, 265, 268-269, 278
 forked caudal fins: 376, 395
 fossil fuels: 3, 14, 29, 31, 35, 200, 229, 421, 470
 fossil record: 6, 137
 fossils: 20, 65, 69, 126, 130, 135-137, 225, 465
 fouling: 36-37, 57, 298, 335, 436-437, 440
 fracture zones: 41, 73, 75-76, 84, 87
 fragmentation: 381
 France: 31, 43, 159, 249, 252
 Franklin, Benjamin: 19
 Fraser River, BC, Canada: 130
 freezing point: 99-100, 102-105, 144, 321, 348, 463-464
 frequency: 50, 167, 206, 332-333, 346, 348
 freshwater, also see runoff: 31, 34, 90, 104-106, 113, 155, 186, 197, 246, 319-320, 328, 333, 337-339, 341-342, 344-346, 379, 386, 395, 413, 428, 439-440
 friction: 164, 176, 178, 201, 217, 238, 339, 460, 477
 fringing reefs: 80-81, 221, 260, 276, 279-280, 404
 frogfishes: 364-366, 375, 377, 384, 412
 Lembbeh (*Antennarius sp.*): 384
 sargassumfish (*Histrio histrio*): 412
 striated (*Antennarius striatus*): 365
 fronts
 between water masses: 187
 cold: 168-169
 fronts between: 187
 frustules: 121-122, 133, 138, 292, 303-304, 316, 331
 Fukushima, Japan: 437-438
 fundamental niches: 400, 411-412, 419
 Fundy, Bay of: 246, 250, 255, 280
 fungi: 121, 284, 286, 292, 298, 352, 361-362
 fur seal: 26, 348, 435
 fur seals: 348, 414
 fusion, latent heat of: 35, 100-102, 105, 112, 114, 173, 348, 462-463
Gadus morrhua (Atlantic cod): 307, 494
 Gakkel Ridge: 73, 416
 Galápagos Islands: 19, 312
 Galápagos Ridge: 416
 Galveston, TX: 28, 166, 235, 255, 272-273, 279, 440
 Ganges River: 85, 117, 277, 321
 gas, gases:
 dissolved: 95, 97-98, 112, 190, 193, 443
 greenhouse: 3, 34, 114, 160-161, 173, 203, 212, 280, 424, 440-442, 468-471, 473
 natural: 25, 28-29, 34-35, 43, 83, 85, 139, 277, 298, 300, 419, 439
 transfer between oceans and atmosphere: 97
Gastrolepidia clavigera (scale worm): 392
 gastropods: 354, 361, 372, 393, 410
 gelatinous holoplankton: 305, 307
 gelbstoff: 97
 generators, wave energy: 32-33
 genetic diversity: 27, 36, 380-381, 387, 395-396, 421, 449, 495-496
 genetics: 27, 36, 52, 284-285, 309, 380-381, 385, 387, 395-396, 419, 421, 429, 449, 493, 495-496, 498
Genicanthus melanospilos (black-spot angelfish): 377
 genus, in taxonomy: 284, 287, 303, 408, 412, 417
 Geographic Information Systems (GIS): 56
 geological record: 71
 geologists: 24
 geology: 2, 13, 20, 88, 140, 416, 460
 Georges Bank: 327-328
 Georgia, GA: 72, 187, 235, 313, 414
 geostrophic flow: 141, 164, 173, 175, 180, 182, 184, 187, 204-205, 226, 230, 451, 487-488
 Germany: 17, 23, 43
 ghost pipefish (*Solenostomus paradoxus*): 366
 giant clam (*Tridacna gigas*): 392-394
 Gibraltar: 126, 193, 195, 466
 Gibraltar, Straits of: 126, 193, 195, 466
 gills: 313, 379, 435
 glacial flour: 118-119
 glacial maxima: 83
 glaciation: 116, 456
 glaciers: 83-84, 87, 116, 118-119, 133, 138, 140, 197, 256, 258-259, 337-338, 441-442, 456
 Global Positioning System (GPS): 35-36, 48-49, 56
 global warming: 5, 83, 160, 173, 203, 440-441, 457, 468, 470
 Glomar Challenger: 43
Gnathophylloides mineri (urchin shrimp): 392
 goatfishes, blackstriped (*Upeneus tragula*): 363
 Gobi Desert: 119
 gobies: 363-365, 368, 377-378, 388, 392-393
 fire (*Nemateleotris magnifica*): 365
 Old Glory (*Amblygobius rainfordi*): 378
 whip (*Bryaninops yongei*): 388
 yellow shrimp (*Cryptocentrus cinctus*): 393
 GoFlo bottle: 45-46
 gold: 26, 29-30, 417
 Goldman's sweetlips (*Plectorhinchus goldmanni*): 379
 Gondwanaland: 65, 85
 Goode's interrupted projection: 10, 12, 14
 Gorda Plate: 69
 gorgonian seahorse: see pygmy seahorse
 Gorgonocephalidae (basket stars): 359-360
 GPS (Global Positioning System): 35-36, 48-49, 56
 grab samplers: 42-43, 52, 57-58
 graded beds: 128, 138
 grain size: 33, 116, 127-130, 138-140, 266, 268-269, 272, 278, 280, 400, 427, 440, 461-462
 Grand Cayman Island: 141
 granite: 61, 265
 grapeweed (*Caulerpa racemosa*): 322
 graphs, interpretation of: 7, 13, 474
 grasses: 264, 270, 276, 278, 301, 314, 362
 gravel: 29-30, 116, 128, 138, 278-279, 319, 356, 386
 gravity: 42-43, 57, 62-63, 120, 207-208, 228, 232, 234, 380, 451-452, 477, 480-481, 483-484, 486
 buoyancy of fishes and: 380
 in longshore drift: 266
 Newton's law of: 232
 sedimentation and: 120
 surface tension and: 106
 tides and: 250
 vertical mixing of water inhibited by: 194
 waves and: 176, 207-208
 gravity corers: 42-43
 gray reef shark (*Carcharhinus amblyrhynchos*): 308, 377
 grazers, grazing: 292, 295, 303, 314, 326, 332, 353, 360-361, 394,

- 407-408, 411-412, 420, 426
 Great Barrier Reef: 276
 Great Britain, see United Kingdom: 23-24, 43, 217, 437
 great circle: 12
 Great Lakes of North America: 227
 great white shark (*Carcharodon carcharias*): 26, 308
 Greece: 72, 334
 Greeks, Ancient: 17, 83, 336-337
 greenhouse effect: 14, 114, 140, 173, 203, 212, 258, 467-468, 470-471
 greenhouse gases: 161, 173, 280, 440-442, 468, 470
 Greenland: 3, 12, 18, 73, 78, 84-85, 118, 194-197, 201-202, 293, 437, 441-442
 Greenland Sea: 194
 Greenwich, England (near London): 11, 13
 groins: 273-275, 278, 428
 groundwater: 90, 146, 285, 428-430, 442, 458
 grunion (*Leuresthes tenuis*): 248-249, 384
 Guam: 24, 255
 Gulf Stream: 19, 31, 153, 163, 169, 180, 183, 185-189, 195, 197, 202-203, 226, 345, 386, 462
 guyots: 81
Gymnosarda unicolor (dogtooth tuna): 307
Gymnothorax fimbriatus (darkspotted moray eel): 378
 gyres: 153, 177, 181-187, 189, 194, 201-204, 291, 296, 315, 320, 323-324, 328, 345-346, 386, 412, 420, 436
 subpolar (high-latitude): 185, 201
 subtropical: 153, 177, 182-185, 187, 189, 203, 291, 296, 315, 386, 412, 436
 habitats: 53, 352, 394, 427, 439-440, 447
 hadal zone: 300, 315
 Haddon's sea anemone (*Stichodactyla haddoni*): 373
 Hadley cells: 148, 152, 154-155, 162, 171, 182
 hadopelagic zone: 300
 half-life: 200, 464-465
Halimeda sp. (algae): 266, 392
 haloclines: 179, 192, 194-195, 320-321, 324, 328-329, 339, 341, 344-346, 413, 420
Hapalochlaena sp. (blue-ringed octopus): 283, 372
 harbors: 27, 209-210, 221, 223, 229, 231, 235, 245-246, 272, 274-275, 278, 311, 334, 337-338, 345, 407, 425, 434, 436-437
 harbor seal (*Phoca vitulina*): 311
 hard parts: 3, 93, 95, 116-117, 120-123, 138, 291-292, 299, 306, 315-316, 329, 356, 402, 404, 419
 harmonics: 228
Harpa major (harp shell): 354
 harp shell (*Harpa major*): 354
 hatchetfish: 415
 Hawaii: 2-3, 17-18, 23-24, 32-33, 36, 59, 62-63, 76-79, 115, 126, 129, 160, 170-171, 221, 223, 225, 255-257, 262, 265-266, 279, 312, 322, 362, 368, 371, 375-376, 384, 387, 425
 Hawaiian Island-Emperor Seamount chain: 77-78, 81
 hawkfishes: 364-365, 404
 Falco (*Cirrhichthys falco*): 365
 longnose (*Oxycirrhites typus*): 404
 headlands: 218-219, 224, 228, 260-262, 265, 267-268, 271, 279
 Heard Island: 111
 heat: 35, 99-102, 105, 112, 114, 142, 144-147, 152, 169, 171-173, 189, 213, 229, 348, 441, 458-459, 462-463, 468, 470, 472
 Earth's budget of: 145-146
 latent: 35, 100-102, 105, 112-114, 144-147, 166, 171-173, 348, 462-463
 sensible: 100, 102, 146, 168
 heat capacity: 35, 89, 100-102, 112-114, 142, 150-151, 162, 169, 171, 173, 213, 229, 348, 440, 462-463
 heat transfer: 143, 146-147, 171, 458, 462, 471-473
 Heezen, Bruce: 21, 40, 56, 58, 140
 helium: 35, 62, 90, 436, 454
 herbicides: 427
 herbivores: 286, 292, 295, 298, 301, 305, 315, 326, 330, 332, 354, 360, 411
 hermaphroditism: 381
 hermatypic (reef-building) corals: 81, 259, 275, 278, 329, 356, 400-401, 404, 419, 425
Hermisenda crassicornis (horned nudibranch): 406
 hermit crabs: 392-393, 410, 412
 Herodotus: 16-17, 36, 68
 herring gull (*Larus argentatus*): 313
 herrings: 295, 310-311
Heteractis magnifica (anemone): 359
 heterocercal caudal fins: 377, 395
 heterotrophs: 285-286, 292, 315
 high-latitude gyres: 177, 182
 high-pressure zones: 147-148, 150, 152, 157-158, 160, 164, 487-489
 high seas: 22, 26, 34, 440
 high-tide line: 231, 262-263, 265, 269, 300, 314, 384, 408, 411
 high-tide zone: 408, 411-412, 420
 hills, abyssal: 61, 80
 Hilo, Hawaii: 170-171
 Himalaya Mountains: 67, 72, 85-86, 152
Hippocampus bargibanti (pygmy seahorse): 366
Hippocampus kuda (spotted seahorse): 366
Hippolyte commensalis (humpbacked shrimp): 392
Histrion histrio (sargassumfish): 412
 HIV/AIDS: 27, 428
 HIV/AIDS virus: 27, 428
 Hokule'a: 36
 holoplankton: 304-307, 316
 Homer, AK: 270
 hominids: 7
 Homo erectus: 16
 Homo sapiens: 5, 284
 Honolulu, Hawaii: 171
 horned nudibranch (*Hermisenda crassicornis*): 406
 horned sea star (*Protoreaster nodosus*): 403
 horse latitudes: 148, 154
 horseshoe crab (*Limulus polyphemus*): 384
 hot spots: 62-63, 66, 76-81, 84-86, 124, 256-257, 276, 280, 456
 Huang (Yellow) River: 118
 Hudson Bay, Canada: 85
 Hudson River: 246, 338
Huenia heraldica (arrowhead crab): 392
 Hugo, Hurricane: 166
 humidity: 408, 411, 441, 476
 humpbacked shrimp (*Hippolyte commensalis*): 392
 humpback whale (*Megaptera novaenglia*): 310
 hunting and defense: 313-314, 352, 363-364, 368, 372, 395
 camouflage in: 364, 366, 368, 392, 395
 concealment in: 368, 370, 372, 395

- group cooperation in: 305, 310, 372, 374-375, 394-395
 lures in: 52, 364-366, 377, 395, 415
 poisons in: 332, 352, 372, 395-396
 speed in: 364
 spines and armor in: 106, 288, 352, 368, 371-372, 377-378, 392-393, 395
 hurricanes: 1-2, 56, 117, 141, 145, 147, 157, 160, 164-168, 172-173, 211-212, 223, 228, 272, 277, 279-280, 463, 471, 473, 496
 Hydration: 93
 hydrocarbons: 97, 300, 419-420, 430, 432, 448
 hydrogen: 6, 13, 33, 62, 90-93, 99-103, 105-106, 112, 135, 199-200, 285, 289, 298, 315, 342, 347, 352, 417-420, 424-425, 437, 490-492
 hydrogen bonds: 91-92, 99-103, 106, 112
 hydrogenous sediment: 116, 124, 126, 128, 130, 138
 hydrogen sulfide: 6, 285, 298, 315, 342, 347, 352, 417-420, 425
 hydrographic surveys: 19
 hydrographic wire: 46
 hydroids: 361, 372, 392, 399, 412, 417
 hydrologic cycles: 90, 437
 hydrophones: 43, 111
 hydrosphere: 60-61
 hydrostatic pressure: 277
 hydrothermal minerals: 29, 124, 133
 hydrothermal vents: 6, 21, 124-125, 199, 288, 300, 352, 416-421
 black-smoker: 417
Hymenocera elegans (harlequin shrimp): 353
 hypoxia: 333-335, 346, 426, 444, 447
Hypselodoris bullocki (nudibranch): 384
 ice
 density of: 103, 105
 formation of: 104, 464
 heat-buffering effect of: 102
 ice ages: 83-84, 87, 118, 124, 197, 277, 337, 442, 454, 458, 468, 471
 ice algae: 413, 415, 420
 ice exclusion: 161, 193-194, 202, 328, 413, 420
 Iceland: 17-18, 25, 73, 77-78, 160, 197, 202
 Icelandic Ridge: 78
 ice-rafted sediment: 133
 ice sheets: 3, 83-84, 90, 135, 149, 194, 197, 329, 415, 441-442, 457, 463, 471
 iguana, marine (*Amblyrhynchus cristatus*): 312
 incidence, angle of: 146-147, 288-289
 incubation: 381
 incurrent openings: 309, 354, 359
 India: 65, 72, 85, 152, 224, 256
 Indian Ocean: 19-20, 25, 33, 85-86, 111, 117, 133, 150, 152-153, 156, 160, 167, 182, 189, 194, 197, 211, 222-225, 243, 301, 323
 Indo-Australian Plate: 72, 85
 Indonesia: 16, 29, 62, 70-71, 137, 156-159, 171, 223-224, 256, 283, 305, 309, 312, 323, 354, 357, 359-361, 363, 365-366, 368, 370, 373, 384, 388, 392-393, 403
 Indonesian Arc: 85-86
 Indus River: 85, 117
 Industrial Revolution: 3, 13, 200, 297, 423, 440
 industrial waste: 25, 332, 423, 428
 inertial currents: 190, 202
 inertial period: 477, 485-486
 infauna: 300, 352, 362, 394, 446
 innkeeper worm (*Urechis caupo*): 362-363
 in osmosis: 345-347, 379-380, 386, 394-395, 427, 439-440, 445
 in situ measurements: 57, 200
 interference, in waves: 206, 215-216, 228
 intermediate waves: 218
 internal waves: 56, 196, 225-226, 228-229, 231, 322, 327, 339, 341, 346
 International Ocean Drilling Program (IODP): 43, 68, 140
 International Seabed Authority (ISA): 24
 International System of Units (SI): 12, 14, 100
 interstitial (pore) water: 29, 69, 135, 139, 298, 362, 395, 419, 442
 intertidal (littoral) zone: 231, 248, 264-265, 268, 278, 300, 315, 352-353, 394, 399, 408, 410, 419
 intertropical convergence zone (ITCZ, doldrums): 148, 177, 185
 inverse estuaries: 339, 342, 347
 invertebrates: 331-332, 363, 366, 368, 372, 380-381, 394-395, 420
 iodine: 100, 437
 ionic bonds: 91-93
 ions: 13, 91, 93, 95, 99, 112, 289, 291, 379, 491
 complexed: 436, 498
 Iran: 72
 iridium: 137
 Iron: 124-125, 133, 135, 285, 289, 292, 315, 413, 417
 iron oxide: 125, 133
 ironshore: 260
 Irrawaddy River: 117
 island (mountain) effect: 161, 170-171
 islands, barrier: 2, 255-256, 258, 261, 265, 270-274, 278-280, 337-338, 346
 islands, sedimentary and magmatic arc: 70-71, 84-86, 93, 256
 islands, volcanic: 70-71, 78, 80, 84-86, 225, 256-257, 276, 280
 isobars: 8, 487-489
 isopods: 408, 411, 420
 isopycnals: 8
 Isostasy: 59, 61, 87, 115, 139, 253, 280, 451, 454-455
 isostatic leveling: 77, 83-84, 86-87, 257-260, 273, 280, 454, 456-458
 isotherms: 8, 152-153
 isotopes: 88, 97, 135-136, 140, 199, 203, 437, 464-465
 Israel: 17, 172
 Italy: 17, 335
 Ivan, Hurricane: 211
 Jamaica: 338
 Jamaica Bay: 338
 Japan: 24-25, 29, 33, 38, 43, 67-68, 70, 137, 153, 160, 163, 195, 203, 205, 222, 224-225, 334, 345, 428, 433, 437-438, 446
 Japan (Kuroshio) Current: 153, 163, 183, 189, 345
 Japan, Sea of: 334, 437, 446
 Jason II ROV: 53-55
 Jason Jr. ROV: 54
 Java: 71, 86, 223
 Java Sea: 86
 jellyfish: 7, 26, 305, 307, 314, 316, 354-355, 435
 jet streams: 119, 148, 160, 226, 230
 jetties: 274-275, 278, 280
 Johnson Sea Link: 52
 JOIDES Resolution: 43
 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP): 424
 joule (J): 100

- juveniles, of marine organisms: 276, 303, 309, 330-331, 336, 345, 368, 381, 495, 497
 Kahoolawe, Hawaii: 171
 Kailua-Kona: 170-171
 Katrina, Hurricane: 166-167, 277
 Kauai, Hawaii: 255, 279
 Kealakekua Bay, Hawaii: 18
 Keeling Atoll: 81
 kelp: 287-288, 301, 315, 319, 322, 352, 405-408, 412, 419, 421
 kelp forests: 315, 352, 405-408, 419, 421
 Kelvin waves: 226, 228
Kentrodoris rubescens (nudibranch): 384
 Kilauea volcano: 59, 76, 78, 256-257, 266
 killer whale (*Orcinus orca*): 295, 310, 313, 407
 kinetic energy: 176, 178, 201, 207-208, 219
 king crab: 3, 25-26, 306
 Klein's butterflyfish (*Chaetodon kleinii*): 374
 Kona, Hawaii: 32
 Krakatau (Krakatoa): 70-71, 120, 136, 223, 225
 krill: 295-296, 306, 348, 353, 396, 414
 Kuril Islands: 24
 Kuroshio (Japan) Current: 153, 163, 183, 189, 345
Labroides phthiophagus (cleaner wrasse): 368
 lagoons: 31, 79-81, 130, 229, 256, 270-272, 276, 278, 280, 314, 319-321, 338, 387, 402-403, 419
 Laguna Madre, TX (south of Galveston): 342
 Lanai, Hawaii: 225
 landfills: 428, 430, 433
 land-ocean-atmosphere interactions: 171
 Landsat satellite: 343, 349
 landslides: 75, 116, 120, 208, 223, 256-257, 278, 280
 Langmuir circulation: 190-191, 202, 303, 322, 327, 339
 La Niña: 156-159, 171
 lanternfish: 415
 La Rance, France (English Channel, French coast): 31, 249, 252
Larus argentatus (herring gull): 313
 larvae: 3, 106, 121, 248, 305-306, 309, 316, 325, 327, 331, 336, 345-347, 352-353, 372, 374, 381, 384-389, 395, 411, 418-419, 443, 445, 492, 495, 497-498
 lasers: 56, 107
 Lassen, Mount, CA (near CA-OR border): 69
 latent heat of fusion: 35, 100-102, 105, 112, 114, 173, 348, 462-463
 latent heat of vaporization: 35, 100-102, 112-114, 144, 146-147, 171, 173, 462-463
 lateral line: 394
Laticauda colubrine (banded sea snake): 312
 latitude: 9, 11, 13-14, 17, 78-79, 147, 149-150, 152, 154, 162-163, 171, 238, 241, 301, 463, 472, 477, 485-486
 latitudinal imbalance, of Earth's heat energy: 145, 171
 latitudinal transfer, of heat: 1, 14-15, 35, 89, 114, 141, 173, 196, 205, 229, 319, 348, 451, 462
 latitudinal variation, of marine environments: 300
 lava: 45, 59, 72, 74, 76-77, 93, 171, 255-257, 266, 411
 Law of the Sea conferences: 22-25, 31, 34-35
 law of the Sea Treaty (LOS): 23-25, 31, 34-35, 434
 leaching: 113, 116, 125
 leatherjacket: see black-saddled mimic filefish
 Lebanon: 17
 leeward: 80, 170-172, 209, 404
 Lembeh frogfish (*Antennarius sp.*): 384
 lemon damselfish (*Pomacentrus moluccensis*): 388
 Leopard seal: 414
Leuresthes tenuis (grunion): 248-249, 384
 levees: 30, 259, 277-279, 338, 425, 427
 lichens: 408, 420
 light
 infrared: 36, 106-108, 145-146, 188, 442, 467-470
 primary production and: 4, 14, 58, 88-89, 112, 114, 140, 285, 288-289, 300, 315, 317, 352, 396, 421, 426, 443, 449, 489-492
 ultraviolet: 6, 36, 106-108, 143, 146, 289, 467-469, 491
 underwater transmission of: 106, 112, 114
 light-limited productivity: 1, 14, 35, 58-59, 88-89, 114-115, 140, 283, 317, 351, 396, 399, 421, 423, 449, 451, 489
 limestone: 16, 126, 402, 419
 limiting nutrients: 289-292, 298, 315-316, 426
 limpets: 408, 410-411, 417, 420
Limulus polyphemus (horseshoe crab): 384
Linckia laevigata (sea star): 388
 lined chiton (*Tonicella lineata*): 410
 lionfishes: 377-378
 zebra (*Dendrochirus zebra*): 378
 lipids: 97
 lithogenous (terrigenous) sediment: 81, 116-120, 123-124, 126-127, 129-133, 138, 289, 299, 331
 lithosphere: 60-63, 67, 69-75, 77, 80, 86, 455
 lithospheric plates: 43, 60-63, 65, 67, 73, 75, 78, 81, 86-87, 93, 256-257, 439, 454-456, 476
 lithospheric upwelling: 63, 66-67, 72-74, 76, 80-81, 85-87, 123-125, 129, 133, 135, 196, 416-417, 420, 457
 litter: 125, 276, 353, 436
 littoral (intertidal) zone: 231, 248, 264-265, 268, 278, 300, 315, 352-353, 394, 399, 408, 410, 419
 littoral (longshore) drift: 33, 130, 266-267, 269-275, 278, 337-338
Littorina sp. (periwinkles): 408, 411, 420
 lizardfishes: 364-365
 twospot (*Synodus binotatus*): 365
Lobodon carcinophagus, Crabeater seal: 414
 lobster pots: 51-52, 309
 lobsters: 51-52, 112, 306, 309, 372
 logarithmic scales: 6, 99, 303
 log plots: 6, 8
 Loihi Seamount, Hawaii: 78, 256
 Loma Prieta earthquake: 41, 76, 129, 137, 256, 277
 Long Island, NY: 247-248, 274, 327
 Long Island Sound: 247-248
 longitude: 9, 11, 13-14, 16-18, 239, 472
 longnose hawkfish (*Oxycirrhites typus*): 404
 longshore bars: 221, 263, 265, 268-269, 271, 273, 278
 longshore currents: 190, 213, 267
 longshore (littoral) drift: 33, 130, 266-267, 269-275, 278, 337-338
 Long Valley, CA (east of San Francisco near C-NV border): 120
 Long Valley caldera: 120
 Lorenz, Edward: 474, 476
 Lorenzian waterwheel: 474-475
 Los Angeles, CA: 434
 Louisiana (LA): 139, 166-167, 278, 419
 low-pressure zones: 147-148, 150, 152, 157-158, 164-166, 168, 172, 187, 189, 226, 487-488
 low-tide lines: 231, 248, 261-263, 265, 269, 276, 278, 300, 402, 408

- low-tide terrace: 265
 low-tide zone: 408, 412, 420
 lugworm (*Arenicola brasiliensis*): 362
 lunar month: 237-238, 240, 250
 lunate caudal fins: 376-377, 395
 lures, in hunting and defense: 52, 364-366, 377, 395, 415
 Macdonald Seamount chain: 78, 422
 Macedonia (Balkans): 72
 Mackenzie delta, Yukon, Canada: 277
 mackerel: 295, 380, 493
 macroalgae: 287, 301, 303, 322, 345, 360-361, 381, 394, 401, 405, 411-412, 419-420
Macrocystis sp. (kelp): 287, 322
 Madagascar: 85, 152
 Madden-Julian Oscillation (MJO): 159-160
 Magellan, Ferdinand: 18
 magma: 61, 63, 67, 69-75, 77, 79, 86, 416-417, 420
 magmatic arcs: 70-71, 85-86, 256
 magmatic rocks: 75, 79, 420
 magnesium: 95, 126, 285, 289, 417, 420, 491
 magnetic fields: 62, 79, 134, 140, 393-394, 396
 magnetism: 65
 Maine, Gulf of: 328
 maine (ME): 170, 328, 411
 Majidae (crabs): 366
 major constituents, of seawater: 95-96
 malaria: 434, 448
 Malaysia: 24
 Malibu Beach, CA (north of Los Angeles): 267
 mammals, marine: 3, 20, 33, 52, 112, 158, 310, 312-314, 316, 333, 336, 364, 368, 374, 387, 407, 414, 435, 439, 446-447
 manatee (*Trichechus manatus*): 361
 mandarin fish (*Synchiropus splendidus*): 384
 manganese: 22, 24, 29-30, 45, 124-126, 135, 138, 140, 285, 417
 manganese nodules: 22, 24, 29-30, 45, 124-126, 138
 mangroves, mangrove swamps: 2, 97, 255-256, 264, 270, 276, 345, 399, 427, 445
Manta birostris (manta ray): 308, 313, 379, 392, 404
 mantle, Earth's: 60-63, 67, 69-70, 72-78, 83, 86-88, 93, 124, 392, 451, 455-456, 458-460
 maps, mapping: 1, 7-9, 11-14, 16-19, 36, 39-42, 56-58, 181, 488
 marginal seas: 29, 75, 83, 85-86, 96, 117-118, 126, 130, 155, 171, 320-321, 333-334, 413
Marginopora vertebralis (foraminifera): 122
 margins, continental: 67, 81, 84, 93, 117, 130-131, 138
 Mariana Arc: 124, 416
 Mariana Islands: 70
 Mariana Trench: 20, 54, 71
 Mariculture: 27
 marine mammals: 3, 20, 26, 33, 52, 112, 158, 310, 312-314, 316, 325, 333, 336, 364, 368, 374, 387, 407, 414, 435, 439, 446-447, 449
 marine organisms
 behavior of, //347-391: 52
 benthic: 299-300, 314-316, 322, 352, 355, 381, 394, 446
 chemical sensing in: 384, 393-394
 classification of: 284
 colonial: 305, 307, 354, 359-360, 374, 381, 395
 communication in: 392, 395
 density of: 416
 detritus of: 4, 93, 121, 276, 278, 295, 298, 300, 345, 353-354, 360-362, 394, 419
 distribution of: 300
 diversity of: 27, 36, 396, 399, 421, 449, 495-496
 effects of toxins on: 429, 446, 448, 496, 498
 excretions from: 97, 286, 291, 315, 317, 348, 379, 428-429
 eyes in: 394, 415, 420
 fouling by: 36-37, 57, 436-437, 440
 hard parts of: 3, 93, 95, 116-117, 120-123, 138, 291-292, 299, 306, 315-316, 329, 356, 402, 404, 419
 magnetic fields sensed by: 394
 navigation in: 392, 395
 oviparous: 381
 ovoviviparous: 381
 pelagic: 51, 57, 296, 299-300, 310, 314-317, 352, 354, 374, 380-381, 384-386, 394, 396, 427
 siliceous: 116, 121-123, 131-133, 135, 138, 292, 303
 tides and: 248
 viviparous: 384, 408
 wetlands and: 2, 34, 127, 130, 263, 276-279, 338, 343-345, 347, 362, 427-428, 439, 442, 445-447
 marlin: 376
 marshes, salt: 83, 97, 256, 276, 285, 345
 marsh grass, *Spartina* sp.: 361
 Maryland (MD): 129, 270, 333
 Massachusetts (MA): 40, 163, 235, 255, 320
 mass extinction: 2, 13, 136-137, 441, 444-445
 mass wasting: 120
 mathematical modeling: 56, 159, 182, 203, 239-240, 317, 440, 470-474, 476
 Maui, Hawaii: 265
 Mauna Loa, Hawaii: 2, 78
 Maury, Matthew Fontaine: 19
 maximum sustainable yield: 15, 25, 27, 36, 319, 336, 346, 348, 399, 421, 451, 493-495
 meanders: 148, 188-189, 202, 226, 230
 of Gulf Stream: 188-189, 202
 of jet streams: 148-149, 168, 172, 226, 413
 mechanical current meters: 49
 Medea ROV: 53-55
 Mediterranean Sea: 16-17, 34, 68, 85-86, 126, 129-130, 155, 160, 192-196, 202-203, 320, 342, 386, 466
Megaptera novaengliae (humpback whale): 310
 Mekong River, Delta: 118
Melithaea sp. (gorgonian sea fan): 359
 menhaden: 25, 310, 333
 Mercator projection: 10-12, 14, 16, 39
 mercury: 46, 90, 97, 106, 332, 424, 429, 433, 452
 Meridional Overturning Circulation (MOC): 196-197, 202, 442
 meroplankton: 305-307, 309, 316, 381, 385, 395
 mesopelagic zone: 300
 mesoscale eddies: 188-189, 202, 303, 325
 mesosphere: 143
 metacercaria: 389
 metamorphosis: 299
Metasepia pfefferi (flamboyant cuttlefish): 351, 384
 meteorites: 6, 62, 116, 126-128, 136-138, 208, 223, 225
 meters, current: 48-51, 57, 244
 methane: 3, 6, 25, 29, 34, 90, 99, 114, 128, 285, 300, 419-420, 442, 467, 470

- methane hydrates: 25, 29, 34, 128, 442
methylmercury: 429, 433, 446
Mexico: 2, 5, 22, 24, 28-29, 69, 84-85, 118, 127, 133, 137, 160, 166, 173, 175, 180, 197, 211, 225, 236-237, 244, 251, 258, 270, 314, 334-335, 419, 430-432
Mexico, Gulf of
 dead zone in: 335
 oil rigs in: 25, 28, 34, 439
Mexico, Gulf of CA: 175
Meyer's butterflyfish (*Chaetodon meyeri*): 375
Miami Beach, FL: 272, 279
Miami, FL: 272, 279
microalgae: 345, 360, 394, 401, 426, 437
Micronesia: 17, 34
Micronesians: 16, 18, 35
micronutrients: 326, 413
microorganisms: 6, 13, 51-52, 106, 129, 285-287, 299, 352, 403, 428, 448
Mid-Atlantic Ridge: 15, 67, 72-73, 83, 85-86, 126
Middle East: 83
middle-tide zone: 408, 411-412, 420
mid latitudes: 168, 178, 191-192, 323, 331, 409, 441
migration, and reproduction: 16, 52, 78, 150, 152, 258, 270, 273, 278, 292, 298, 306, 345, 379, 385-387, 397, 414
mimicry: 366, 368
mimic surgeonfish (*Acanthurus pyroferus*): 368
Minamata, Japan: 428, 433, 446, 449
mining, seafloor: 23-24, 29-31, 34, 116, 124, 319, 417
Minoan civilization: 17, 225
minor constituents, of seawater: 96-97
miracidium: 389
Mirounga angustirostris (elephant seal): 26, 311, 314, 429
Mississippi (MS): 5, 118, 166-167, 197, 259, 277-279, 335, 338, 432, 440
Mississippi River: 259, 279, 335, 338, 432
Mississippi Sound: 440
mixed (surface) layer, of ocean water: 3-4, 105, 157, 176, 179-180, 185-186, 191-193, 197, 200, 202-203, 293, 317, 320-321, 324-333, 339, 341, 344-346, 443, 453, 462
mixed tides: 235-239, 244-245, 250-251, 384
mixing, of water masses: 4, 175, 185, 191, 193, 196-199, 226, 292-293, 320-322, 326-327, 330-331, 333, 337-339, 341, 346, 412-413, 420, 425, 443, 453-454
Mnemiopsis leidyi (ctenophore): 305
MOC (Meridional Overturning Circulation): 189, 196-197, 202, 226, 231, 298, 335, 441-442, 444
modeling, mathematical: 14, 16, 35-36, 47, 56-58, 149, 157, 159-160, 167, 173, 182, 185, 190, 200, 203, 224, 239-241, 248, 286, 297-298, 317, 414, 440-441, 466, 468, 470-474, 476, 494, 497
molecules
 clustering of: 104-105, 374, 463
 friction between: 176
 polar: 92, 100
 water: 6, 90-93, 99-100, 102-107, 112-113, 135-136, 143-144, 176, 193, 199, 207-208, 212-213, 215, 217, 219, 379, 437, 460, 463, 487, 491
mollusks: 116, 266, 306, 309, 313-314, 354-356, 361, 370, 372, 389, 392-393, 399, 402, 412, 437, 439, 443
 bivalve: 355-356, 372, 389, 402
 gastropod: 354, 361, 372, 393, 410
Molokai, Hawaii: 262
molybdenum: 29
monsoons: 18, 152-153, 155, 161, 279, 321
Montenegro (Balkans): 72
Monterey: 25, 41, 129, 253, 255, 261-263, 287, 311, 313, 322, 357, 405-406, 410, 426
month, lunar: 237-238, 240, 250
Montrose Chemical Corporation: 434
moon
 declination of: 238, 240, 250
 gravitational attraction of: 208-209, 232, 250
moon wrasse (*Thalassoma lunare*): 378
moraines (deposition sites): 258-259
moray eels: 377-378, 380
mosquitoes: 106, 434
Moss Landing Power Plant, CA (near Monterey): 426
mountain (island) effect: 161, 170-171
mountain ranges: 37, 59, 61, 63, 69, 75, 117, 155, 162, 170-171, 259
mud: 116
mud snail (*Nassarius papillosus*): 371
multibeam sonar: 40-41
mussels: 332, 345, 356-357, 385, 410-412, 416, 418, 420
 California (*Mytilus californianus*): 311, 357, 385, 410
 common (*Mytilus edulis*): 385
mutagens: 429, 446, 497, 499
Mytilus californianus (California mussel): 311, 357, 385, 410
Mytilus edulis (common mussel): 385
NADW (North Atlantic Deep Water): 194, 196-197, 199-200, 202-203, 293
Nansen bottles: 46
Nansen Fracture Zone: 84
Nansen, Fridtjof: 177
narcosis: 53, 380
Nassarius papillosus (mud snail): 371
National Academy of Sciences: 426
Nautilus pompilius (chambered nautilus): 309, 313, 415
navigation, in marine organisms: 392, 395
Navy, U.S.: 19, 27, 211, 230, 439
neap tides: 237-240, 250-251, 385
nearshore: 29, 33, 127, 130, 138, 169, 187, 192, 260, 263, 332, 343, 425, 432, 439
Nebrius concolor (nurse shark): 308, 313
nekton: 305, 309-310, 316-317, 326-327, 334, 354-355
Nemanthus annamensis (colonial anemone): 359
Nemateleotris magnifica (fire goby): 365
Nembrotha rutilans (nudibranch): 384
neritic province: 299-300, 315
nets, collection: 26, 34, 49, 51-52, 57, 301, 314, 435, 440, 495
neurotoxic shellfish poisoning (NSP): 332
neutrons: 90
Nevada (NV): 117, 155, 170, 173
New Brunswick, Bay of Fundy, Canada: 255
New England coast: 327
Newfoundland: 18
New Jersey (NJ): 226, 261, 273, 327, 333-334, 428
New Orleans, LA: 166, 277
Newton, Isaac: 231-232
Newton's law of gravitation: 232

- New York Harbor: 245-246, 338, 425
 New York (NY): 36, 87, 140, 204, 226, 235, 237, 245-246, 252, 274, 334, 338, 397, 421, 425, 428, 449, 476, 499
 New Zealand: 19, 29, 258-259, 264, 338
 niches
 ecological: 36, 396, 400, 409, 421, 449, 496
 fundamental: 400, 411-412, 419
 survival: 400, 419
 nickel: 29, 60, 62, 90, 124-125
 Niger delta: 277
 Nigeria: 277
 Nile delta: 277
 Ninety East Ridge: 85
 nitrates: 95, 135, 285, 289, 291, 293, 298, 332, 417, 472, 491
 nitrogen: 291, 332, 472, 491
 as nutrient, in photosynthesis: 135, 185, 285-287, 289-296, 298, 303, 315, 317, 322-323, 325-332, 334, 345-346, 401-402, 405, 412-413, 419, 426, 432, 444, 447, 497
 biogeochemical cycle of: 291
 in seawater: 95, 97-98, 112, 190, 193
 nitrogen narcosis: 53, 380
 noble gases: 90
 nodes, of standing waves: 226-228, 242, 245, 247-248, 318
 nodules
 manganese: 22, 24, 29-30, 45, 124-126, 138
 phosphorite: 29-30, 45, 124, 126, 138
 noise, ocean: 112
 nonconservative properties of seawater: 199, 202
 nonindigenous species: 423, 427, 439, 447
 nonlinear relationships: 6, 8, 13-14, 36, 88, 173, 203, 336, 348, 471, 473-476
 nonpoint sources of pollution: 432, 446
 North American Plate: 65, 67, 69-70, 75
 North Atlantic Deep Water: 194, 196-197, 199-200, 202-203, 293
 North Atlantic Deep Water (NADW): 194, 196-197, 199-200, 202-203, 293
 North Atlantic Gyre: 386, 420
 North Atlantic Oscillation (NAO): 160
 North Carolina (NC): 58, 320, 338
 North Equatorial Current: 182
 northern kelp crab (*Pugettia producta*): 406
 North Pacific Gyre: 345, 386, 436
 North Pole: 9, 11, 13, 72, 85, 134, 238, 477-478, 480
 North Sea: 39, 85, 244, 385-386
 North Star: 11, 17
 Norway: 17, 33, 84, 129, 385-386
 Norwegian Sea: 194
 Nova Scotia, Canada: 44, 58, 129, 237, 246, 250
 nucleus, of atoms: 90-92
 nudibranchs: 35, 361, 372, 381, 384, 392, 396, 406-407, 412
 Flabellina rubrolineata: 361
 horned (*Hermisenda crassicornis*): 406
 Hypselodoris bullocki: 384
 Kentrodorid rubescens: 384
 Nembrotha rutilans: 384
 nurse shark (*Nebrius concolor*): 308, 313
 nutrient-limited: 289-292, 294, 298, 315-317, 326, 328-330, 426
 nutrients: 135, 185, 285-287, 289-296, 298, 303, 315, 317, 322-323, 325-332, 334, 345-346, 401-402, 405, 412-413, 419, 426, 432, 444, 447, 497
 anthropogenic: 5, 298, 333-335, 346, 348, 423, 425-426, 431-432, 444-447
 in coastal zones: 289, 322, 325-327, 346
 in estuaries: 345
 limiting: 289-292, 298, 315-316, 329, 426, 491
 primary production and: 289-290, 292, 315, 331, 346
 recycling of: 290, 331, 346
 transport of: 292
 uptake of: 289
 vertical distribution of: 292, 294
 Oahu, Hawaii: 78, 171, 221, 257, 279
 Oakland, CA (on San Francisco Bay): 277
Oceanapia sagittaria (burrowing sponge): 384
 Ocean Drilling Program (ODP): 43, 68
 oceanic crust: 60-61, 63, 65, 67-73, 76, 80, 83, 85-87, 123, 130, 134, 139, 276, 280, 285, 454-457
 oceanic plateaus: 69-70, 130, 133
 oceanic province: 299-300, 315
 oceanic ridges: 63, 67, 72-74, 76, 80-81, 85-86, 124-125, 133, 135, 196, 416-417, 457
 crests of: 63, 76, 170
 earthquakes on: 61, 65, 72
 sedimentation on: 29, 124
 transform faults in: 69, 75-76, 81, 86-87, 256, 338
 types of: 73
 volcanism in: 73-74
 oceanic upwelling: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
 oceanography: see also ocean sciences: 15-16, 19, 21, 34-35, 140, 204
 oceans
 aesthetic aspects of: 25, 27, 31, 33-34, 424, 426, 428, 435-436, 446
 assimilative capacity of: 424-428, 437, 445, 447, 497
 benthic environments in: 299-300, 314-317, 354, 427
 climate zones of: 161-163, 171
 color of: 107
 exploration of: 16-18, 21, 24, 28, 34, 54-55, 88, 124, 319, 419, 448
 formation of: 6
 foundations of life in: 283
 interactions of atmosphere and: 6, 56, 141, 173, 203, 472
 land-atmosphere interactions with: 161-163, 171
 noise in: 112
 origin of life in: 6
 pelagic environments in: 51, 299-300, 315, 317, 352, 354, 380, 384-385, 394
 pycnocline zone of: 4, 179, 191-193, 202, 443, 453
 recreational uses of: 1, 15, 25, 27, 31, 34, 253, 266, 428
 residence times in: 94, 114, 140, 173, 280, 298, 317, 320, 333-334, 348, 425-426, 440, 449, 465-467
 surface height of: 36, 39, 56-57, 179-181, 183-184, 215, 226-227, 235, 242, 250
 surface microlayer of: 46, 106, 352-353
 surface (mixed) zone of: 4, 105, 157, 185-186, 191-193, 200, 202, 317, 320-321, 327-328, 330-331, 341, 346, 443, 462
 ocean sciences: 2, 7, 9, 12-13, 15-16, 22, 54, 56-57, 90, 302, 451
 ocean thermal energy conversion (OTEC): 32-33, 35
 octopi: 283, 366, 370, 372, 381

- blue-ringed (*Hapalochlaena sp.*): 283, 372
Octopus luteus: 370
- Odobenus rosmarus* (walrus): 311, 314, 414
- of tidal currents: 31, 190, 196, 202, 231, 244-251, 322, 328, 338-339, 341, 343, 345-346, 418, 435
- of waves: 206-207, 214-215, 217-218, 228, 241
- oil (petroleum): 22, 25, 28-29, 34-35, 43, 83, 85, 97, 139, 277, 298, 300, 419, 430-431, 439, 446, 448
- oil spills: 2, 25, 334, 423, 430-431, 445-446
- Okhotsk, Sea of K: 195
- Old Glory goby: 378
- Old Glory goby (*Amblygobius rainfordi*): 378
- omnivores: 286, 292, 301, 305-306, 315, 352, 354, 384
- onshore-offshore transport: 325
- ooliths: 126
- oozes: 21, 123, 130-133, 135, 137-138
 diatomaceous: 133
 radiolarian: 130-132, 138
- operculum: 372, 411
- optimum concentration range, of toxins: 496-498
- orange-fin filefish: see barred filefish
- orbicular burrfish (*Cyclichthys orbicularis*): 371
- orbicular (*Cyclichthys orbicularis*): 371
- orbital motion: 213-214, 221-222, 228, 232, 267, 482
- orbital velocity: 127, 138, 240-241, 244, 250, 267-268, 477-481, 485-486
- Orcinus orca* (killer whale): 295, 310, 313, 407
- Oregon (OR): 69, 160, 163, 225, 298, 333, 335, 421, 444, 447
- organic matter: 4, 29, 83, 97, 135, 277, 285-286, 294-295, 298-299, 315, 362, 426, 431, 446, 490
- organisms: 52, 57, 106, 122, 284-285, 287, 295, 299-300, 315, 352, 429, 442, 492, 496-498
 classification of: 283
- Origin of Species (Darwin): 20
- Orinoco River, Venezuela: 155, 323
- orthogonals (wave rays): 218-219, 229
- oscillation(s): 156, 160, 171
 in standing waves: 206, 208, 226-229, 242-245, 247-248, 250-251
 ocean-atmosphere: 25, 149, 156-161, 171, 185-186, 226, 295, 442
 tuned: 188, 227-228, 242, 244-245
- Osmoregulation: 379
- osmosis: 379, 395
- osmotic pressure: 375, 379
- Ostracion meleagris* (spotted boxfish): 371
- OTEC (ocean thermal energy conversion): 32-33, 35
- otter trawls: 51
- outfalls: 33, 425, 428, 430, 433, 446
- overfishing: 25-27, 307, 328, 336, 348, 424, 440, 447
- Overturning: 105, 196, 202, 441, 444
- oviparous species: 381
- ovoviviparous species: 381
- oxidation: 133, 135, 285, 299, 424, 490
- Oxycheilinus digramma* (cheeklined wrasse): 375
- Oxycirrhites typus* (longnose hawkfish): 404
- oxygen: 4, 91-92, 97-98, 135, 285, 293, 296, 298, 333, 427, 443-444
 demand: 333
 depletion of: 298, 333-335, 346, 348, 425-427, 431-432, 444, 446-447
 in seawater: 47, 95, 97-98, 112, 124, 126, 135, 190, 193, 293, 296, 298, 315-317, 352, 417, 425, 427, 442-444, 447
- oysters: 3, 5, 130, 278, 306, 309, 332, 345, 356-357, 381, 427, 437, 439, 443, 445, 447
 eastern (*Crassostrea virginica*), spiny: 381, 439
- ozone: 120, 142-143, 172-173, 200, 289, 317, 467, 470
- ozone layer, depletion of: 120, 143, 172-173, 289
- Pacific Decadal Oscillation (PDO): 160-161, 171
- Pacific Ocean: 16, 18, 20, 24-25, 27, 29, 62-63, 65-70, 78, 84-87, 111, 118-119, 123-126, 129, 132-133, 139, 152-153, 155-161, 163, 167, 171, 186-187, 192, 194, 203, 210, 223, 225-226, 229, 236, 244, 262, 267, 292-294, 298, 301, 304, 335, 386-387, 404, 429-430
- Pacific Plate: 67-68, 70-71, 75, 77-79, 85
- Pacific salmon: 386
- Pagurus sp.* (crab): 410
- paints, antifouling: 34-35, 436-437, 446, 448
- Palau: 260, 262, 305, 366, 377, 404
- Palm Beach, FL (north of Miami): 272
- Pamlico Sound, NC: 338
- Panama: 223, 251
- Pangaea: 65, 71, 81, 83-85, 256, 457
- Papua New Guinea: 17, 35, 89, 122, 305, 307-309, 322, 329, 353-354, 356-357, 359-362, 365-366, 368, 370-371, 373-378, 384, 388, 392-393, 399, 403-404
- parachute drogues: 48, 460
- Paracyathus stearnsii* (brown cup coral): 406
- Paraluteres prionurus* (black-saddled mimic filefish): 368
- paralytic shellfish poisoning (PSP): 332-333, 346
- Parapercis hexophthalma* (speckled sandperch): 378
- parasites: 27, 368, 372, 388-389, 392, 395
- parasitism: 336, 387, 395
- Pardachirus pavoninus* (peacock sole): 366
- Pardo, Arvid: 22
- parrotfish, black-headed (*Scarus gibbus*): 371
- partially mixed estuaries: 194, 339, 341-346, 348, 453
- partial tides: 240, 244
- particulate matter: 93, 256, 298-299, 344, 427
- passive margins: 81, 83-87, 259, 319, 338, 346
- Patagonia: 19
- pathogens, see also toxins, toxicity: 428, 432, 446
- PCBs: 97, 425, 427, 429-430
- PDO (Pacific Decadal Oscillation): 160-161, 171
- PDRs (precision depth recorders): 39-41
- peacock sole (*Pardachirus pavoninus*): 366
- pearlscale angelfish (*Centropyge vrolikii*): 368
- pectoral fins: 376-379, 395
- pelicans, brown (*Pelecanus occidentalis*): 313
- pelvic fins: 376, 379
- penguins: 143, 158, 301, 313-314, 348, 414-415, 499
- Pennatulacea (sea pens): 355-356, 370, 392, 402, 406
- Pennsylvania (PA): 438
- Pensacola, Fla.: 235
- Periclimenes: 366, 392
 P. amboinensis (crinoid shrimp): 366
 P. cf. tosaensis: 392
 P. cf. venustus: 392
 P. colemani (Coleman's shrimp): 392
 P. imperator (emperor shrimp): 392
 P. soror (sea star shrimp): 392

- periods, of waves: 205-206, 214, 218, 220, 228, 235, 265, 327
 periwinkles, *Littorina sp.*: 408, 411
 Persian Gulf: 31, 126
 Peru: 19, 23, 25, 156-159, 171, 183, 323
 petroleum: 22, 25, 28-29, 34-35, 43, 83, 85, 97, 139, 277, 298, 300, 419, 430-431, 439, 446, 448
 petroleum hydrocarbons,: 97, 430, 448
Pfiesteria piscicida: 372
 pH: 3, 47, 99, 123-124, 126, 408, 412, 417, 420, 443
Phalacrocorax auritus (double-crested cormorant): 313
 pharmaceutical products, from marine organisms: 27-28, 34-35, 372, 424
 phase changes, of water: 99-101, 112-113
 Philadelphia, PA: 397
 Philippine Plate: 71
 Philippines: 18, 20, 23-24, 27, 29, 68, 71, 86, 120, 167, 308, 322, 359-360, 368, 371, 378
Phoca vitulina (harbor seal): 311
 Phoenicians: 17
 phosphates: 95, 126, 135, 199, 289-290, 293, 310, 331-332, 492
 phosphorite nodules and crusts: 29-30, 45, 124, 126, 138
 phosphorus: 3-4, 29, 95, 100, 126, 185, 226, 285, 289-292, 315, 317, 326, 330-332, 413, 421, 432, 449, 472, 490-492
 photic zone: 108, 286, 288-289, 291-292, 295, 298, 300, 315-317, 322-323, 327-332, 346, 352, 401, 415, 419, 427, 443
 photophores: 415-416
 photosynthesis: 4, 14, 58, 88-89, 97, 112, 114, 140, 285-289, 292, 296, 298, 300, 302, 315, 317, 352, 396, 401, 421, 426, 443, 449, 489-492
Physalia physalis (Portuguese man-of-war): 305, 307, 354, 374, 381
 Physical Oceanography: 45, 57, 204, 338
 phytoplankton: 51, 55-57, 107-108, 116, 122, 132, 143, 156, 185-187, 202, 226, 288-290, 292, 294-299, 301-306, 315-317, 322, 325-328, 330-334, 336, 344-347, 352-354, 374, 381, 384, 394, 396, 401-402, 413, 415, 420, 426, 428, 445, 493, 495, 498
 piers: 205, 229, 253, 275, 338, 428
 Pinatubo, Mount, Philippines: 68, 120
 pinnipeds: 311, 314
 pipefish, ghost (*Solenostomus paradoxus*): 366
 pistol shrimp (*Synalpheus sp.*): 393
 piston corers: 42-43
 plains, abyssal: 61, 85, 128-129, 138-139, 300
 plankton: 51-52, 56, 107, 122, 276, 289, 301, 305, 307-308, 312-313, 315-317, 325-330, 332, 336, 346, 355, 359, 376, 384, 386, 392, 407, 411-412, 431, 435
 plankton nets: 51
 plastics, pollution from: 28, 46, 116, 425, 435-436, 440, 446
 plateaus, oceanic: 69-70, 130, 133
 plate boundaries: 63, 65, 67, 70-72, 75-76, 80, 86-87, 256
 convergent: 67-73, 83, 85-86, 93, 118, 223, 256, 338, 419
 divergent: 24, 67, 71-76, 79-81, 83, 85-87, 123-125, 129, 133, 135, 139, 276, 416-418, 420, 456-457
 transform: 69, 75-76, 81, 86-87, 256, 338
 plates, lithospheric (tectonic): 60, 63, 65, 75, 78, 86, 454-456
 plate tectonics: 59, 62-63, 80, 86-87, 134
 platinum: 29
Plectorhinchus celebicus (Celebes sweetlips): 368
Plectorhinchus goldmani (Goldman's sweetlips): 379
 plume worms: 417
 plutonium: 437
Pocillopora sp. (hard coral): 329
 Point Lobos State Park, CA (near Monterey): 253
 polar bears: 301, 414-415
 polar cells: 148-149, 155, 171
 Polaris: 11
 polarity, of molecules: 92, 100
 polar regions: 147, 171, 413-415, 420, 441
 Pole Star: 11
 pollution: 423-424, 426, 431-433, 445, 447-448
 Polynesia: 17-18, 34, 80
 Polynesians: 16-19, 35
 polypoids (Anthozoa): 359
 polyps: 329, 356-357, 359, 361, 366, 368, 374, 377, 404, 442
Pomacanthus navarchus (blue-girdled angelfish): 377
Pomacentrus moluccensis (lemon damselfish): 388
 porcelain crab (*Porcellanella triloba*): 392
Porcellanella triloba (porcelain crab): 392
 pore (interstitial) water: 29, 69, 135, 139, 298, 362, 395, 419, 442
 porpoises: 222, 313, 316
 Portland, OR: 163
 Portuguese man-of-war (*Physalia physalis*): 305, 307, 354, 374, 381
 Poseidonius: 17, 35
 potassium: 13, 95, 113
 potential energy: 179, 182, 207-208, 219
 practical salinity units (PSU): 95, 104, 464
 precipitation
 atmospheric: 80, 99, 121, 145-149, 155, 161-162, 170-171
 of salts: 29, 96, 124, 126, 133, 466
 precision depth recorders (PDRs): 39-41
 predation: see hunting and defense
 predators: 248, 276, 345, 352, 364, 366, 368, 371-372, 374-375, 377, 381, 384, 389, 392-396, 407, 411, 494
Premnas biaculeatus (spinecheek anemonefish): 373
 pressure
 atmospheric: 8, 36-37, 103, 143, 148, 151-152, 157, 164-165, 168-169, 209, 223, 226
 gradient balanced by centripetal force: 141, 164, 166, 173, 175, 179-185, 187, 190, 201, 203-205, 226, 230, 451, 487-488
 high: 83, 148, 177, 187, 300, 416-417
 hydrostatic: 277
 low: 149, 158, 164, 166, 173, 177, 204, 309, 415
 pressure gradients: 147-148, 164, 166, 169, 172-173, 177, 179-186, 190, 201, 204, 207-208, 215, 230, 233-234, 242, 483-484, 486-489
 vapor: 142, 144, 458, 487
 water density and: 35, 47, 58, 89, 102-103, 112, 114-115, 124, 140, 175-176, 191-193, 199, 203, 451, 453-454, 463
Priacanthus hamrur (crescent-tailed bigeye): 370
 primary production: 285-289, 292, 295, 315, 317, 328, 331, 335, 352, 419-420, 426, 444, 447, 491-493
 primary productivity: 83, 122, 138, 292, 294-295, 297-298, 315, 323-324, 335, 346, 405, 440
 prime meridian: 11, 13
Primovula sp. (allied cowrie): 361
 Prince Edward Island, Canada: 333
 Prince William Sound, AK: 256, 430

- Prochlorococcus sp. (photosynthetic cyanobacteria): 301
 production
 nutrient limited: 289, 294, 317, 326, 328-330, 491
 primary: 8, 83, 114, 122, 126, 138, 156, 186, 188, 285-292, 294-298, 304, 315, 317, 323-331, 334-335, 344-348, 352-353, 360, 401, 405, 412-413, 416, 419-421, 426, 432, 440-441, 444-445, 447, 490-493, 497
 secondary: 286
 profile, cross sectional: 60, 157, 165, 168, 195, 372, 375
 profiling, seismic: 43-44
 progressive waves: 206-208, 226-229, 235, 244-245, 247, 250
 projections, map: 9-12, 14, 16, 39, 304, 306, 364, 495
 prokaryotes: 284, 352, 489
 protein: 25, 285, 348, 491, 493-494
 protists: 284, 352
 protons: 90, 92
Protopalpythoa sp. (zooanthid): 359
Protoreaster nodosus (rhinoceros sea star): 403
 protozoa: 295, 306
Protula magnifica (spiral fan worm): 360
Pseudanthias huchtii (threadfin anthias): 376
Pseudosimnia sp. (egg cowrie): 392
 PSU (practical salinity units): 95, 104, 464
Pterapogon kauderni, Banggai cardinalfish: 384
Pterocaesio lativittata (yellowstreak fusilier): 375
 pteropods: 3, 122-123, 130, 138, 306-307, 316, 354, 443, 445, 447
 Ptolemy: 17
 Puerto Rico: 24, 85, 167, 403
 pufferfish: 368
 Puget Sound, WA: 29, 249, 338
Pugettia producta (northern kelp crab): 406
 purse seines: 51
 Pu'u O'o, Hawaii: 76
 pycnoclines, see also haloclines, thermoclines: 4-5, 158, 178-179, 181, 184-186, 190-194, 201-203, 225-226, 228, 298, 317, 321-322, 346, 443-444, 451, 453-454
 pygmy seahorse (*Hippocampus bargibanti*): 366
 Pyrgomatidae (barnacle): 357
 Pythagoras: 17
 Pytheas: 17
 quill-backed rockfish (*Sebastes maliger*): 406
 radiation
 electromagnetic: 36, 49, 56, 90, 106-109, 112-113, 467-469
 of heat: 145-147, 173, 454, 467
 solar: 146-147, 151-152, 169, 171, 176, 193, 239-240, 462, 468, 470
 radioactivity
 dating by decay of radioactive isotopes: 134
 in tracing water masses: 47-48, 199-200, 202-203, 437
 parent and daughter atoms: 88, 140, 203, 464-465
 Radioactivity: 59, 88-89, 97, 114-115, 140, 175, 203, 317, 429, 437-439, 451, 464
 radioisotopes (radionuclides): 60, 78, 95, 97, 112, 114, 140, 199, 202, 437, 446, 464-465
 radiolaria: 122-123, 131-132, 135, 138, 306, 316
 radiolarian oozes: 130-132, 138
 radionuclides: see radioisotopes
 radio waves: 36, 106-107
 raggy scorpionfish (*Scorpaenopsis venosa*): 366
 rainbow runner (*Elagatis bipinnulata*): 368
 Rainbow trout (*Oncorhynchus mykiss*): 379
 rain, rainfall, see also precipitation, atmospheric: 99, 121, 146-149, 155, 161-162, 170-171
 Raritan Bay, NJ: 338
 rays
 blue-spotted (*Taeniura lymma*): 308
 manta (*Manta birostris*): 308, 313, 379, 392, 404
 torpedo (*Torpedinidae*): 308
 rebreather device, scuba: 35
 recreation, oceans and: 1, 15, 25, 27, 31, 34, 253, 266, 428
 recycling
 nutrients: 290-292, 315, 331, 346
 of human products: 428
 redbreasted Maori wrasse (*Cheilinus fasciatus*): 377
 red-cheeked fairy basslet, see threadfin: 376
 red (deep-sea) clays: 123, 133, 138
 Red Sea: 17, 21, 74-75, 85-86, 124, 126, 133, 155, 308, 320, 342, 371, 374, 392, 466
 red tides: 332
 red urchin (*Strongylocentrotus* sp.): 407
 reef flats (terraces): 402-404, 419
 reefs
 atolls: 20, 24, 32-33, 79-81, 84, 86, 225, 229, 275-276, 278-279
 barrier: 80-81, 260, 276, 278-279, 404
 fringing: 80-81, 221, 260, 276, 279-280, 404
 reef whitetip shark (*Triaenodon obesus*): 308, 312
 reflection
 of light in water: 107
 refraction
 of light in water: 109
 of sound in water: 109-111
 of waves: 218-219, 225, 262
 refuse, trash and garbage: 34, 116, 424, 430, 435-436, 446
 relationships, nonlinear: 6, 8, 13-14, 36, 88, 173, 203, 336, 348, 471, 473-476
 relict sediments: 130-131, 138-139, 257
 remora (*Echeneis naucrates*): 308, 378-379, 392
 remotely operated vehicles (ROVs): 29, 53-55, 74
 reproduction
 asexual: 381, 395
 hermaphroditic: 381, 395
 migration and: 16, 52, 78, 150, 152, 258, 270, 273, 278, 292, 298, 306, 345, 379, 385-387, 397, 414
 separate-sex: 380
 timing in: 384
 vegetative: 381
 reservoirs, oil and gas: 81, 85
 residence time: 94, 114, 140, 173, 280, 298, 317, 320, 333-334, 346, 348, 425-426, 440, 448-449, 465-467
 residual currents: 341, 343, 345
 resources: 1, 13, 16, 22-27, 29-31, 34-35, 173, 295, 317, 336, 364, 372, 385, 423-424, 427-428, 440, 442
 respiration: 4, 98, 285, 288-289, 315, 443, 492-493
 restoring forces, currents and, waves and: 176, 207-208, 228-229
 resuspension, of sediments: 115, 127, 140-141, 173, 253, 276, 280, 283, 317, 322, 451, 460-461
 reversing thermometers: 46-47
Rhincodon typus (whale shark): 308
 rhinoceros sea star (*Protoreaster nodosus*): 403

- Rhodophyta: 322
Rhopalaea sp. (tunicate): 359
ridges: oceanic, see oceanic ridges
rift zones, see also specific zones: 67, 72, 74-75, 81, 83, 85
rings, Gulf Stream: 188-189, 202
Rio de Janeiro, Brazil: 244
Rio Grande Rise: 78
rip currents: 2, 222, 228-229, 268
rivers
 deltas of: 5, 117, 130, 256, 259, 277-280, 337-338, 425-426
 erosion by: 116
 oxygen depletion in: 334, 427
 sediments transported by: 116
 tidal currents in: 246, 250-251
roaring forties: 149
Robinson projection: 10, 12
rockfishes
 copper (*Sebastes caurinus*): 406
 quill-backed (*Sebastes maliger*): 406
rocky intertidal communities: 300, 315, 399, 408-412, 419-421
Rocky Mountains: 84, 155
Romania (Balkans): 72
rose anemone (*Tealia lineata*): 406
Rossby waves: 148, 226, 228, 230
Ross, John: 42
rounded caudal fins: 376
ROVs (remotely operated vehicles): 29, 53-55, 74
Royal Society: 20
runoff, freshwater: 31, 34, 90, 105, 246, 320, 328, 337-339, 341-342, 345, 379, 428, 439-440
Russia: 24, 72, 195, 386, 421, 437
Ryukyu Trench: 67
Sabellidae (tube worms): 356
saccopharyx fish: 415
Sacramento River, CA: 341
Sahara Desert: 119-120
Saint Lawrence River, Canada: 197
Sakhalin Island, Russia: 448
salinity: 47, 95, 104-105, 109, 112, 153-155, 161, 171, 192-194, 199, 300, 320, 341-342, 379, 400, 440, 463-464
 and solubility of gases: 97-98
 as conservative property: 199
 electrical conductivity and, in estuaries: 47, 95, 112
 ice formation and: 105, 161, 193-194, 202, 328, 413, 420
 in coastal oceans: 320-321
 in rocky intertidal communities: 300, 315, 399, 408-412, 419-421
 ocean surface: 153, 161
 of marginal seas: 118, 155, 320-321
salmon: 3, 161, 345, 385-387, 427, 439
 Pacific: 386
salps: 305, 307, 309, 316, 354-355, 359
salt marshes: 83, 97, 256, 276, 285, 345
salts, dissolved, see also salinity: 83, 94-95, 102-106, 112-113, 161, 193, 379, 463, 487
salt wedge estuaries: 338-339, 341-344, 346
Samoa: 24
samplers, sampling
 bottles for: 45-47, 51
 contamination of: 46
 core: 42-43
 CTD: 47, 95
 grab: 42-43, 52, 57-58
 of marine organisms: 51
 of seafloor: 20, 25, 42-45, 52, 57, 257, 274
 of seawater chemistry: 45-47, 51, 95
 rosette: 47
San Andreas Fault, CA: 69, 75, 87
sand anemones: 356, 364
sand burrow: 392
sand dollars (*Clypeaster* sp.): 402-403
sand dunes: 255-256, 263-265, 269, 271
San Diego Bay, CA: 342
Sand, oolite: 126
sandperches, speckled (*Parapercis hexophtalma*): 378
Sandy Hook Bay, NJ: 338
San Francisco Bay: 30, 117, 245, 277-279, 338, 341, 343, 345, 425-426, 434-435, 439-440, 467
San Francisco, CA: 12, 30, 76, 117, 137, 170, 235, 245, 264, 277-279, 318, 322, 338, 341, 343, 345, 410, 425-426, 434-435, 439-440, 467
San Joaquin River, CA (near San Francisco): 341
Santa Barbara harbor: 274-275
Santa Cruz, CA (between San Francisco and Monterey): 76, 256
Santa Cruz Mountains: 76
Santa Monica: 275, 434
sardines: 294-295, 307, 310, 492
Sargasso Sea: 188-189, 296, 303, 345, 386, 412-413, 420-421
sargassumfish (*Histrio histrio*): 412
Sargassum sp.: 296, 303, 412-413, 420-421
Saronikos Gulf, Greece (central Aegean Sea): 334
satellites: 21-22, 36, 39, 41, 55-57, 90, 159, 166, 181, 188, 202, 211, 226, 275, 297, 324
saturation pressure: 143-144, 171
saturation solubility: 97-98, 296, 427
Saudi Arabia (see Arabian Peninsula): 31
saw blade shrimp (*Tozeuma armatum*): 392
scale worms: 389, 392, 417
scallops: 356, 372
Scandinavia: 84, 163, 259
scarps: 264-265, 278
Scarus gibbus (black-headed parrotfish): 371
scattering, of light in water: 107
scavengers: 308, 411-412, 416, 420
scavenging: 354
schooling: 305, 310, 374-375, 394-395
scientific (exponential) notation: 7, 12, 14
Scorpaenopsis macrochir (flasher scorpionfish): 388
Scorpaenopsis venosa (raggy scorpionfish): 366
scorpionfishes: 366, 372, 377, 380
 flasher (*Scorpaenopsis macrochir*): 388
 raggy (*Scorpaenopsis venosa*): 366
Scotch Cap, AK: 223
Scotland: 194
scuba divers: 1, 21, 26, 31, 35, 52-53, 57, 107, 109, 112, 205, 213-214, 312, 378-380, 388, 394, 404
Sea Beam multibeam sonar: 40
seabirds: 18, 158, 313-314, 325, 336, 379, 407, 446
sea cucumbers: 309, 355, 359-360, 372, 384, 392, 402-403, 412, 416, 494

- creeping (*Cucumaria* sp.): 360
Thelenota rubralineata: 384
 sea fans gorginians
 Melithaea sp.: 359
 sea fans (gorgonians): 359, 361, 366, 374, 389, 400, 404
 seafloor: 29, 36, 38-39, 42-44, 54-55, 57-58, 73, 133, 139, 217, 220, 223, 300, 315, 322, 352, 360, 368, 405, 416, 457, 461
 as habitat: 299-300, 314-316, 322, 346, 352, 355, 381, 394, 434, 446
 depth of, see bathymetry: 37, 42, 56
 mining of: 24, 34, 124
 spreading of: 24, 43, 60, 63, 66-67, 70-76, 79-81, 83, 85-87, 93, 123-125, 129, 133, 135, 138-139, 195-196, 241, 256, 276, 285, 416-421, 456-457
 /seafloor
 drilling of: 22, 28-29, 34, 43, 57, 62, 68, 127, 134, 139, 226, 448
 interaction of waves and,: 207, 222-223, 275
 sampling of,: 20, 25, 42-45, 52, 57, 257, 274
 slope of: 28-29, 34, 61, 84, 126-129, 133, 137-139, 196, 419, 435
 topography of: 37, 39-41, 57, 196, 202
 sea grasses, turtle grass (*Thalassia* sp.): 361-362, 366
 seagrass filefish (*Acreichthys tomentosus*): 362
 seagulls: 313-314
 seahorses: 366, 379, 381
 pygmy (*Hippocampus bargibanti*): 366
 spotted (*Hippocampus kuda*): 366
 sea-level change: 8, 25, 36, 61, 82-84, 86-87, 131, 148, 223, 257-260, 271, 276-280, 337, 441-442, 454, 456-458
 eustatic: 83-84, 86-87, 257-259, 280, 454, 456-457
 isostatic: 77, 83-84, 86-87, 257-260, 273, 280, 454, 456-458
 sea lion, California (*Zalophus californianus*): 26, 311, 313-314, 316, 333, 407, 429, 434
 seals: 26, 52, 143, 277, 294, 311, 313-314, 316, 348, 407, 411, 414-415, 429, 435
 Crabeater, *Lobodon carcinophagus*: 414
 elephant (*Mirounga angustirostris*): 26, 311, 314, 429
 harbor (*Phoca vitulina*): 311
 seamounts: 41, 77-81, 85-86, 126, 130, 133, 196, 300, 327
 Sea of Japan: 334, 437, 446
 Sea of Okhotsk: 195
 sea otter (*Enhydra lutris*): 314, 407-408, 419
 sea pens (*Pennatulacea*): 355-356, 370, 392, 402, 406
 Seasat satellite: 41
 sea snakes
 banded (*Laticauda colubrine*): 312
 seasonal variation: 150-152, 162-163, 191, 195, 269, 321, 327-328, 330-331, 333, 346
 in beaches: 269
 in climate: 149, 156, 251, 291, 297, 326, 328, 331
 in coastal oceans,: 328, 346-347
 in primary production: 328, 330-331, 346-347
 sea stars: 306, 309, 353, 355, 359, 366, 381, 388-389, 392, 399, 402-403, 406-407, 411-412
 basket star: 359-360
 Linckia laevigata: 388
 rhinoceros (*Protoreaster nodosus*): 403
 sea star shrimp (*Periclimenes soror*): 392
 sea turtles: 248, 312, 314, 316, 361-362, 387, 394
 green (*Chelonia mydas*): 312, 361-362
 hawksbill (*Eretmochelys imbricata*): 312, 314
 sea urchin: 372, 407-408, 419
 sea urchins: 309, 361, 370, 372, 407, 412, 419, 443, 494
 Astropyga radiata: 393, 403
 fire (*Asthenosoma intermedium*): 370
 fire (*Asthenosoma varium*): 392
 heart (*Echinocardium* sp.): 363
 long-spined (*Diadema savignyi*): 361
 red (*Strongylocentrotus* sp.): 407
 seawalls: 220, 228, 272-273, 278-280
 seawater: 89, 98
 density of: 95, 102-104, 112, 141, 180, 190, 463-464
 dissolved organic matter in: 97, 286, 290, 298-299, 315, 326, 353, 446, 472
 oxygen in: 293, 296, 298, 333-335, 346, 348, 425-426, 432, 444, 447
 pH of: 3, 99
 trace elements in: 95, 97, 112, 289
 upwelling of: 122, 156-157, 169-170, 186, 202, 289, 294-295, 323-327, 330, 335, 345-347
Sebastes caurinus (copper rockfish): 406
Sebastes maliger (quill-backed rockfish): 406
 secondary production: 286
 sediment: 42-44, 57, 69, 83-86, 93, 116-117, 121-122, 124-135, 138-139, 259, 277-278, 300, 337, 352, 355, 361-363, 394-395, 400, 402, 427, 434, 461, 466
 accumulation rates of: 126, 129-130, 132, 138
 age dating of: 134
 as habitat: 299-300, 314-316, 352, 355, 381, 394, 446
 as historical (stratigraphic) record: 43, 59, 68, 88-89, 114-115, 134, 140, 175, 203, 451, 464-465
 biogenous: 116, 120-124, 126, 129-131, 133-135, 137-138
 biogeochemical cycles and: 93-94, 97, 112, 114-116, 124, 291, 297, 430, 437, 466
 classification of: 116, 138
 coastal formation by: 253, 256, 278
 cohesiveness of: 127, 140, 280, 460-461
 cosmogenous: 116, 126, 130, 138
 graded beds in: 123, 127-130, 137-139
 hydrogenous: 116, 124, 126, 128, 130, 138
 ice-rafted: 133
 in back-arc basins: 71, 85-86
 in continental margins: 81, 130-131, 138-139, 257
 in estuaries: 342
 lithogenous (terrigenous): 81, 116-120, 123-124, 126-127, 129-133, 138, 289, 299, 331
 relict: 130-131, 138-139, 257
 resuspension of: 115, 127, 140-141, 173, 253, 276, 280, 283, 317, 322, 451, 460-461
 sampling of: 42-45, 52, 57, 257
 sorting: 87, 116, 130, 139, 173, 216-217, 228, 267, 269, 278, 452, 462
 suspended: 117, 277, 434
 thickness of: 126, 129-130, 138
 topographic smoothing by: 80
 transport of: 33-34, 116, 119-120, 127-129, 133, 137-138, 209, 256-257, 269, 416, 424, 427-428, 460, 462
 sedimentary arcs: 70, 84, 86, 93, 256
 sedimentary mud: 20, 34, 36, 38, 41-42, 116-117, 129, 131-133,

- 276-277, 300, 314, 362, 368, 371, 427, 462
 sedimentary rocks: 5, 67, 69, 72, 93, 116, 119, 124, 134, 136, 139, 260
 sediments, relict: 130-131, 138-139, 257
 seiches: 226
 Seismic profiling: 43-44
 seismic tomography: 62
 selenium: 100
 Sellafield, Great Britain: 437
 semidiurnal tides: 235-240, 242-245, 247, 250-251
 sensible heat: 100, 102, 146, 168
Sepia latimanus (broadclub cuttlefish): 309
Sepioteuthis lessoniana (common reef squid): 309, 384
 Serbia (Balkans): 72
 sergeant fish (*Abudefduf sp.*): 375, 384
 setae: 353
 sewage: 3-4, 25, 33, 35, 98, 253, 276, 291, 298, 332, 334, 338, 342, 344, 346, 348, 423, 425-426, 428, 430-435, 440, 444, 446, 448, 498
 Seychelle Islands: 25
 shadow zone: 110-111
 shallow-water waves: 218, 220, 223, 228, 241-243, 246, 250-251
 sharks: 1, 26, 51-52, 116, 125, 127, 308, 310-313, 316, 364, 377, 379-381, 384, 392, 394-395, 404, 407, 416
 gray reef (*Carcharhinus amblyrhynchos*): 308, 312, 377
 great white (*Carcharodon carcharias*): 26, 308, 312
 nurse (*Nebrius concolor*): 308, 313
 reef whitetip (*Triaenodon obesus*): 308, 312
 whale (*Rhincodon typus*): 308, 313
 shear stress, see also friction: 209, 225
 shelf break: 61, 300, 315, 319
 shelf valleys: 84
 shellfish: 3, 15, 25, 31, 276, 311, 314, 330, 332-334, 345-346, 427-428, 433, 435, 440, 446
 Shemya Island: 407
 Sheridan, WY: 163
 ships, shipping: 50, 116, 211, 319
 shoals: 19, 328, 343
 shore: 205, 218-221, 228, 260, 408, 411-412
 shoreline: 131, 220, 253, 271-272, 409
 shrimp: 26, 353-354, 366, 368, 370, 392-394, 412, 417
 Alloponotia sp.: 366, 392
 banded coral (*Stenopus hispidus*): 353
 Coleman's (*Periclimenes colemani*): 392
 coral (*Dasycares zanzibarica*): 366
 coral (*Vir philippinensis*): 392
 crinoid (*Periclimenes amboinensis*): 366
 emperor (*Periclimenes imperator*): 392
 harlequin (*Hymenocera elegans*): 353
 humpbacked (*Hippolyte commensalis*): 392
 Periclimenes cf. tosaensis: 392
 Periclimenes cf. venustis: 392
 pistol (*Synalpheus*): 393
 saw blade (*Tozeuma armatum*), sea star (*Periclimenes soror*), tiger pistol (*Alpheus bellulus*): 392
 urchin (*Gnathophylloides mineri*): 392
 Siberia, Russia: 84
 Sierra Nevada mountains: 117, 155, 170
 silica, silicates: 69, 93, 121-122, 127, 135, 139, 265, 289-293, 303-306, 315-316, 326, 330-332, 346, 413, 417, 420
 siliceous organisms: 121-122, 131
 silicon: 61, 90, 96-97, 116, 289, 291, 331
 sills: 73, 126, 193-194, 258-259, 338, 341-342, 347
 silt: 38, 116, 133, 138, 262, 461
 silver: 29, 124, 135, 368, 386, 417
 sinks: 4, 63, 67, 80-81, 105, 173, 190, 193-194, 276-277, 280, 288, 317, 344, 452-454, 456, 460
 SI units: 12, 14, 100
 skates: 381
 slack water: 245-248, 250
 slope
 of beaches: 266, 269-270, 278
 of ocean surfaces: 180-182
 of seafloor: 28-29, 34, 61, 84, 126-129, 133, 137-139, 196, 419, 435
 Slovenia (Balkans): 72
 slumps: 120, 208, 223, 225, 257, 261-262
 slurp guns: 52
 slurries: 33, 35, 431
 snails: 306, 309, 354, 371, 384, 388, 396, 399, 407-408, 410-412, 417, 420, 443
 black turban (*Tegula funebris*): 410
 Epitonium billeeanum: 384
 mud (*Nassarius papillosus*): 371
 parasitic (*Thyca crystallina*): 388
 sodium: 13, 91, 93, 95, 113, 126, 466
 sodium chloride: 13, 93, 126
 soft corals: 357, 359, 366, 368, 392, 399, 404, 419
 solar energy: 119, 146-147, 162, 169, 171, 401, 462, 467-468, 470
Solenostomus paradoxus (ghost pipefish): 366
 sole, peacock (*Pardachirus pavoninus*): 366
 Solomon Islands: 307, 368, 375
 solstices: 146, 149, 151, 172
 solubility, see also saturation solubility: 97-98, 113, 123, 126, 135, 138, 296, 427, 429, 443-444, 447
 Somalia: 23, 224
 sonar: 39-43, 52, 74, 109-113, 257, 439, 447
 sorting, in sedimentation: 266-267
 sound channels: 109-111
 sounders: 39-41, 57, 306
 soundings, difficulties of, echo: 18, 20, 37-38, 40-42, 109
 sound, underwater transmission of: 50, 109-111, 113
 South Africa: 16, 189, 244
 South America: 12, 14, 19-20, 22, 65, 67, 69, 72, 85, 117, 133, 155, 158-159, 163, 170, 182, 195, 301, 323
 South Carolina: 166
 South China Sea: 24-25, 29, 86, 118
 South Equatorial Current: 182
 Southern Ocean: 133, 143, 194-195, 292, 296, 317, 329, 348, 414, 421, 441
 South Pole: 9, 11, 13, 134, 143, 148, 477-478, 483-484
 South Sandwich Trench: 85
 Soviet Union: 23, 43, 200, 437-438, 446
 Spain: 17
Spartina sp. (marsh grass): 361-362
 spawning: 248, 331, 345, 374-375, 380, 384-387, 395-396, 440
 species
 classification of: 283, 400, 419
 endangered: 25, 31, 34
 nonindigenous: 423, 427, 439, 447

- species succession: 330-331, 346
speckled sandperch (*Parapercis hexophthalma*): 378
spectrum
 absorption: 469
 emission: 469
speed
 in hunting and defense: 364
Sphyraena putnamiae (chevron barracuda): 375
spider crab (*Xenocarcinus sp.*): 366, 392
spinecheek anemonefish (*Premnas biaculeatus*): 373
spines: 106, 288, 352, 368, 371-372, 377-378, 392-393, 395
spiny oyster: 356-357
 Pacific (*Spondylus varians*): 357
spiral, Ekman: 177-178, 201, 203
Spirobranchus giganteus (Christmas tree worm): 360, 364, 372
spits: 261, 270-271, 274-275, 337-338
Spitsbergen: 84
Spondylus varians (Pacific spiny oyster): 357
sponges: 7, 13, 27, 314, 361, 366, 368, 372, 374, 381, 384, 392, 394, 396, 399, 412
 burrowing (*Oceanapia sagittaria*): 384
spores: 327, 346, 405, 407, 413, 419
spotted boxfish: 371
spotted seahorse (*Hippocampus kuda*): 366
Spratly Islands: 24
spreading cycles: 65, 71, 83-84, 87, 258, 301, 457
spreading, seafloor: 457
spring tides: 237, 239-240, 248, 250-251, 265, 380, 384-385, 402, 411
squid: 52, 309-310, 313, 316, 352, 364, 372, 374, 381, 384, 414-415, 493
 common reef (*Sepioteuthis lessoniana*): 309, 384
Sri Lanka: 224
stacks: 262
staghorn coral (*Acropora sp.*): 359
standing stock, CC see also biomass: 295, 330, 494
standing waves: 206, 208, 226-229, 242, 244-245, 247-248, 250
steady state: 7, 94, 112-113, 115, 466
steepness: 206-207, 209, 211, 213, 217-220, 228, 265, 487-489
steering forces, currents and: 176-177
Stenopus hispidus (banded coral shrimp): 353
St. Helens, Mount, OR: 68-69, 120
Stichodactyla haddoni (Haddon's sea anemone): 373
stonefishes: 372, 377
storm front: 212-213
storm(s): 168, 210, 269, 328
Stratigraphy: 134
stratosphere: 142-143
striated frogfish (*Antennarius striatus*): 365
striped bass: 26, 345, 439
Strongylocentrotus sp. (red urchin): 407
strontium: 96
sturgeon: 439
subduction: 63, 65-71, 76, 85-86
subduction zones: 63, 65-72, 76, 83, 85-86, 419
sublittoral zone: 300, 315
submarine canyons: 41, 84, 120, 129, 256, 267, 278
submarines: 21, 27, 34, 36, 39, 41, 53-54, 84, 107, 109-112, 120, 128-129, 226, 256, 267, 278, 374-375, 379, 401, 437-438, 446
submersibles: 21, 36, 41, 45, 52-55, 57-58, 74, 415-416
subpolar (high-latitude) gyres: 177, 182
subtropical gyres: 153, 177, 182-185, 187, 189, 203, 291, 296, 315, 386, 412, 436
Suez Canal, Egypt: 466
sulfides: 6, 124, 135, 285, 298, 352, 417-420
sulfur: 31, 95, 99-100, 136-137, 285, 289
Sumatra, Indonesia: 71, 223
superplumes: 63, 72, 75, 77
supersaturation: 123, 144, 171, 296, 315
supralittoral zone: 33, 300, 408, 411, 420
surface, ocean
 microlayer of: 46, 106, 352-353
 sloping of: 180-182
surface sediments: 42, 123, 131-133, 135, 138-139, 285, 394, 416
surface tension: 105-106, 112-113, 176, 207-208, 228-229, 352
surfers: 207, 216, 220-221, 246
surf, surf zone: 207, 222, 275
surgeonfish, mimic (*Acanthurus pyroferus*): 368
surges from: 166-168, 223, 228, 269, 276-277, 279, 300, 408, 442
survival niches: 400, 419
suspension feeder: 355
suspension feeders: 353-356, 359-360, 394, 396, 402, 411, 416
 benthic: 355
 pelagic: 354
suspension, of sediment: 107, 113, 299, 317, 355, 418, 460
swamps, mangrove: 2, 97, 255-256, 276, 399, 427, 445
swash: 266-267, 269
sweetlips: 368, 379
 Celebes (*Plectorhinchus celebicus*): 368
 Goldman's (*Plectorhinchus goldmani*): 379
swells: 63, 209, 213, 217, 228-229, 320, 372
swim bladders: 112, 311, 316, 377, 380, 394-395
swimming, adaptations in: 375-376
swordfish: 310, 376
Symbiosis: 387, 395
Synalpheus sp. (pistol shrimp): 393
Synchiropus splendidus (mandarinfish): 384
Synodus binotatus (twospot lizardfish): 365
synoptic observation: 55, 188
Syria: 17, 172
Taeniura lymma (blue-spotted ray): 308
Tahiti: 19
Taiwan: 17, 24
Tambora, Indonesia: 71, 120
Tampa Bay, FL: 440
Taxonomy: 284
Tealia lineata (rose anemone): 406
tectonic estuaries: 337-338, 346
tectonic plates, see plates, lithospheric: 43, 60-63, 65, 67, 75, 78, 81, 86-87, 256, 439, 454-456, 476
Tegula funebris (black turban snails): 410
tektites: 137-138
Tellina sp. (clam): 362
temperature
 and carbon dioxide solubility in seawater: 123
 and solubility of gases: 98, 444, 447
 as conservative property: 199, 202
 diurnal cycles in: 161, 169
 greenhouse effect and: 212, 470

- in coastal oceans: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
- in rocky intertidal communities: 33, 300, 315, 399, 408-412, 419-421
- land and sea breezes and: 161, 169-170, 172
- ocean surface: 56, 143, 152, 161-162, 164, 188, 212
- water density and: 58, 103-105, 114, 180, 203, 454, 463-464
- temporal variation: 45, 55, 97, 111, 113, 164, 245, 305, 468
- teratogens: 429, 446, 497, 499
- trevally
 - rainbow runner (*Elagatis bipinnulata*): 368
- terrace, low-tide: 265
- terranes, exotic: 69-70, 85, 93
- terrestrial climate zones: 162-163
- terrigenous (lithogenous) sediment: 81, 116-120, 123-124, 126-127, 129-133, 138, 289, 299, 331
- territorial seas: 22-24, 34
- Texas (TX): 28, 129, 167, 235, 255, 258, 272, 335, 342
- Thailand: 29, 159, 224
- Thalassia* sp. (turtle grass): 361-362, 366
- Thalassoma lunare* (moon wrasse): 378
- Tharp, Marie: 21, 40, 56, 58
- Thelenota rubralineata* (sea cucumber): 384
- thermoclines: 8, 33, 157, 179, 186, 191, 193, 203, 290-298, 315, 321, 323-331, 333-335, 346, 400, 412-413, 440
 - seasonal: 179, 191, 193, 321, 327-328, 330-331, 333, 346
- thermohaline circulation: 176, 190, 201-203, 225, 440-442
- thermometers: 46-47, 111
 - reversing: 46-47
- thermometry, acoustic: 111
- threadfin anthias (*Pseudanthias huchtii*): 376
- Three Mile Island, PA: 438
- Thresher USS: 226
- Thunnus* sp. (tuna): 374
- Thyca crystallina* (parasitic snail): 388
- tidal bores: 246, 250-251, 264, 314
- tidal curves: 235
- tidal ranges: 31, 231, 235, 237-240, 242-243, 245-246, 248-251, 255, 262-263, 265, 337, 339, 385, 411
- tide pools: 322, 372, 379, 408, 412, 420
- tides
 - amphidromic systems and: 242-244, 250-251
 - and gravity: 234, 250
 - as waves: 208-209, 235, 241-242, 245, 250
 - Coriolis effect and: 235
 - currents and: 31, 190, 196, 202, 231, 244-251, 322, 328, 338-339, 341, 343, 345-346, 418, 435
 - distribution of force in: 234, 250
 - diurnal: 235-239, 244, 250
 - ebb: 231, 245-247, 250-252, 322, 341
 - energy from, equilibrium: 35, 249-250
 - flood: 246, 251
 - high: 205, 231, 235, 238-240, 242, 244-246, 248-249, 263, 265, 278, 300, 384, 408, 420
 - landmasses and: 241
 - latitudinal variation in: 241
 - low: 205, 231, 235, 239-240, 242, 245-246, 250-251, 259, 264-265, 276, 352, 355, 402, 408, 412
 - marine organisms affected by: 248-249, 384
 - mixed: 235-239, 244-245, 250-251, 384
 - nutrient transport by: 237, 239-240, 250-251, 385
 - open-ocean: 244-245, 250
 - partial: 240, 244
 - predicting: 240
 - range of: 31, 231, 235, 237-240, 242-243, 245-246, 248-251, 255, 262-263, 265, 337, 339, 385, 411
 - tables for: 235, 246, 248, 251
 - wave speed of: 241
- Tierra del Fuego: 19
- tiger pistol shrimp (*Alpheus bellulus*): 393
- timing, in reproduction: 384
- Titanic: 39, 54-55
- Tokyo, Japan: 12, 203
- tomato anemonefish (*Amphiprion frenatus*): 373
- tomography: 50, 62-63
 - acoustic: 50
 - computer: 63
 - seismic: 62
- Tonicella lineata* (lined chiton): 410
- TOPEX/Poseidon satellite: 55, 211
- topographic maps: 7-8
- topography, dynamic: 180-182
- toxicity: 326, 429, 496-498
 - chronic: 496
 - dinoflagellate: 332-333, 346, 348
 - effects on marine organisms of: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
 - in estuaries: 345, 496
 - in hunting and defense: 372
 - in industrial waste: 99, 427, 432-434, 446
 - non point sources (urban and agricultural): 432, 446
 - of antifouling paints: 34-35, 436-437, 446, 448
 - synthetic vs. natural: 430, 496
- toxins: 283, 307, 332-333, 346, 372, 428, 430, 498
- Tozeuma armatum* (saw blade shrimp): 392
- trace elements
 - importance to life of: 37, 46, 58, 95, 97, 199, 289, 326, 427, 429-430, 432, 448, 498
 - in seawater: 95, 97, 112, 289
- tracers, in water masses: 47-48, 199-203, 437
- tracing: 47-48, 109, 114, 197, 199-203, 437
- trade winds: 148-150, 152, 155, 157-158, 162, 166, 170-173, 182-186, 201, 210, 325
- trains, wave: 214-216, 228-229
- transform faults: 69, 75-76, 81, 86-87, 256, 338
- transport
 - Ekman: 178-187, 190, 201-203, 265, 323-324, 339, 346, 436
 - of heat latitudinally by ocean currents: 147
 - of nutrients: 292
 - of sediment: 25, 84, 116, 119, 168, 221, 261-263, 273-274, 278
 - onshore-offshore: 325
- Transport by Winds: 119
- traps: 51-52, 57, 77, 83, 138, 267, 309, 372, 435
- trash, pollution from: 34, 116, 424, 430, 435-436, 446
- trawl nets: 20, 26, 29, 51-52, 57, 440
- trenches: 63, 65-67, 69, 75-76, 84-85, 118, 133, 138, 241, 300, 317
- trevally: 368, 375-377
 - bluefin (*Caranx melampygus*): 368
 - Carangoides* sp.: 375, 377

- Triaenodon obesus* (reef whitetip shark): 308
tributyltin: 429, 437, 446
Trichechus manatus (manatee): 361
Tridacna gigas (giant clam): 392-394
Trieste bathyscaphe: 54
triggerfishes: 372, 376-378
 clown (*Balistoides conspicillum*): 378
triple junctions: 67
Tristan da Cunha: 78
tritium: 199-200, 437
trochoidal shape, of waves: 206, 209
trophic efficiency: 294, 335, 346, 492
trophic levels: 294-296, 299, 307, 315, 335-336, 430, 446, 492-494, 498
tropical regions: 80, 104, 147, 158, 166, 171-172, 184, 202, 289, 307, 321, 328-329, 346-347, 355, 427, 430, 448, 462
Tropic of Cancer: 149
Tropic of Capricorn: 149
troposphere: 142-143, 145, 147-149, 159, 171
troughs, of waves: 29, 206-209, 213, 215, 220, 222-224, 226-227, 242, 245-246, 263, 265, 267-269
Trout, rainbow (*Oncorhynchus mykiss*): 379
Truman, Harry S.: 22, 34
Truman Proclamation: 22
truncate caudal fins: 376, 395
trunkfishes: see boxfishes
TS diagrams: 198-199
tsunamis: 1-2, 34, 70, 129, 137, 205, 208-209, 219, 222-225, 228-229, 257, 300, 437-439
Tubastrea sp. (hard coral): 359
tube worms
 Riftia pachyptila: 418
 Sabellidae: 356
tuna: 294-295, 493
 dogtooth (*Gymnosarda unicolor*): 307
 Thunnus sp.: 374
tuned oscillation: 227
tunicates: 120, 307, 309, 354-355, 359, 361, 372, 394, 399
 Didemnum molle: 359
 lightbulb, (*Clavelina sp.*): 359, 469
 Rhopalaea sp.: 359
/tunicates
 Botryllus sp.: 359
turbidites, turbidite layers: 123, 127-130, 137-139
turbidity: 128-129, 322
turbidity currents: 34, 120, 128-129, 133, 137-138, 209, 256-257, 416, 460, 462
turbulence: 116-118, 128, 183, 209, 213, 231, 245, 248, 288, 292, 300, 322, 327-328, 339, 341-342, 354, 374, 408, 411-413, 458-462
Turkey: 72, 336-337
Turnagain Arm, Cook Inlet, AK: 246, 255
turtle grass (*Thalassia*): 314, 361-362, 366
turtles: 26, 52, 248, 312, 314, 316, 361-362, 366, 387, 394, 404, 435
 green (*Chelonia mydas*): 312, 361-362
 hawksbill (*Eretmochelys imbricata*): 312, 314
Tuscarora, USS: 38
twospot lizardfish (*Synodus binotatus*): 365
typhoons: 167
United Kingdom: 43, 217, 437
United Nations: 22-23, 26, 34, 424
United States: 2, 22-29, 33-35, 38, 40-41, 43, 84, 87, 118, 130, 139, 148, 159-160, 167, 169-170, 172-173, 225, 230, 237, 253, 255, 258, 267, 270, 272, 276-277, 280, 287, 320, 333, 335, 338, 345, 372, 425, 428-434, 439-440, 444, 448, 458, 471, 473
units of measurement: 7, 12, 14, 22, 31, 94-95, 143, 235, 464
Upeneus tragula (blackstriped goatfish): 363
upwelling: 63, 67, 72, 74-75, 86, 88, 122, 126, 131-133, 138, 148-149, 153-158, 169-172, 182, 185-187, 190, 193, 196, 201-203, 289, 292, 294-295, 315, 317, 320, 323-331, 333, 335-336, 345-347, 384, 405, 412-413, 416, 419, 447, 458-460
 coastal: 122, 156-157, 169-170, 186, 202, 289, 294-295, 323-327, 330, 335, 345-347
Ural Mountains, Russia: 71
urchins: see sea urchins
urchin shrimp (*Gnathophyllodes mineri*): 392
Urechis caupo (innkeeper worm): 362-363
Valdez, AK: 430
valleys, in continental shelves: 84
van der Waals force: 92, 99, 102, 106
Vanuatu: 375, 379, 384, 392
vaporization, latent heat of: 35, 100-102, 112-114, 144, 146-147, 171, 173, 462-463
vapor, water: see water vapor
Vasco da Gama: 18
vectors: 477
vegetation: 8, 145, 162, 260, 263-264, 271, 276, 278, 314, 319, 404, 440, 470
vegetative reproduction: 381
velocity, of sound in water: 50, 109-111, 113
venom: 372, 377, 395
vents: hydrothermal, see hydrothermal vent
Venus: 42, 90, 107
vertebrates: 309, 332-333
vertical exaggeration: 8-9, 14
vertical movement of: 176, 190, 201-203, 225, 440-442
Vietnam: 24
Vikings: 18
viperfish: 415
Virginia (VA): 235, 255, 275
Virgin Islands, U.S.: 24, 33
Vir philippinensis (coral shrimp): 392
viruses: 51, 284, 287, 298-299, 301-302, 315-316, 333, 372, 428
viscosity: 105-106, 112, 203, 212-213, 228, 288, 353, 381, 460
viviparous species: 384, 408
volcanic islands: 70-71, 78, 80, 84-86, 225, 256-257, 265, 276, 280, 420
volcanic rocks: 43-44, 62, 78, 120, 129, 260, 266, 416
volcanoes, volcanism: 59, 69-71, 73-78, 81, 86-87, 119-120, 124-125, 223, 256-257, 276, 278, 416, 456
 as source of lithogenous particles: 119
 coastal formation by: 63, 65-73, 76, 83-86, 93, 117-118, 123, 129, 223, 225, 256, 285, 338, 416-417, 419
 extinctions and: 136-138, 225
 in hot spots: 62-63, 66, 76-81, 84-86, 124, 256-257, 276, 280, 456
 in magmatic arcs: 70-71, 85-86, 256
 in oceanic ridges: 24, 60, 63, 66-67, 70-76, 79-81, 83, 85-87, 93, 123-125, 129, 133, 135, 138-139, 195-196, 241, 256,

- 276, 285, 416-421, 456-457
- in rift zones: 67, 72, 74-75, 81, 83, 85
- in subduction zones: 63, 65-73, 76, 83-86, 93, 117-118, 123, 129, 223, 225, 285, 338, 416-417, 419
- sedimentary (stratigraphic) record of: 133, 138
- water released by: 90, 112
- walrus (*Odobenus rosmarus*): 311, 314, 414
- waste
 - industrial: 25, 332, 423, 428, 430, 433
- waste disposal: 25, 33-35, 253, 319-320, 342, 345, 363, 423-424, 427-432, 434-436, 439, 448-449
- wastes
 - nuclear: 437-438
- water
 - as necessary for life: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
 - density of: 58, 103-105, 112, 114, 140, 175, 180, 203, 207, 454, 463-464
 - dissolving power of: 90, 92-93, 112
 - distribution of: 90, 112
 - Earth's budget of: 144-146
 - fresh, see freshwater: 90, 105, 246, 320, 328, 337, 339, 341-342, 345, 440
 - heat properties of: 35, 100-102, 112-114, 142, 144-147, 162, 169, 171, 173, 348, 462-463
 - molecules of: 90-93, 102-107, 112-113, 135, 143-144, 207, 217, 379, 437, 463, 487
 - origin of: 1-63, 65-281, 283-339, 341-349, 351-449, 451-499
 - phases of: 99-100, 112-113
 - pore (interstitial): 135, 298
 - transmission of light in: 106, 108, 112
 - transmission of sound in: 50, 109-111, 113
- water column
 - aphotic zone in: 108, 286, 288-289, 292, 306, 352, 415, 420
 - compensation depth in: 123-124, 133, 138, 203, 288-289, 300, 315
 - Ekman spiral in: 177-178, 201, 203
 - photic zone in: 108, 123-124, 286, 288-289, 291-292, 295, 298, 300, 315-317, 322-323, 327-332, 346, 352, 401, 415, 419, 427, 443
 - stratification of: 4, 178-179, 185-186, 190-193, 201-202, 225-226, 443-444, 451, 453-454
 - wind-driven layer of: 178-179, 182, 185
- water masses
 - anoxic: 298, 315, 333-335, 342, 346-348, 361, 395, 419, 425-426, 431-432, 444-447
- water vapor: 35, 90, 99, 101-103, 114, 135, 141-148, 163-164, 168, 170-173, 454, 458, 462-463, 469, 472, 487
- wavelengths: 107, 228, 469
 - of electromagnetic radiation: 36, 56, 90, 106-109, 112-113, 145, 468-469
 - of heat energy: 145-146
 - of oceanic waves: 206, 208-209, 211, 215-217, 223, 225-230, 235, 241, 245, 247, 250, 328, 330
 - tsunamis: 1-2, 34, 70, 129, 137, 205, 208-209, 219, 222-225, 228-229, 257, 300, 437-439
- wave rays (orthogonals): 218-219, 229
- waves
 - amplitude of: 206
 - and Coriolis effect: 226, 228
 - beach sand sorting by: 267, 269
 - capillary: 208-209, 212-213, 228
 - celerity (speed of): 206-207, 214-215, 217-218, 228, 241
 - coastal modification by: 260, 262
 - complexity of: 205, 228
 - creation of: 208-211, 223, 225, 230, 241, 328, 330
 - crests of: 63, 76, 170, 206-209, 211-213, 215, 218-224, 227-228, 242-246, 250, 267-269
 - currents and: 211
 - deep-water: 209, 213-214, 216, 218, 228-229
 - depth of no motion in: 180-181
 - dispersion of: 209, 216-217, 228
 - dissipation of: 212
 - energy from: 32-33, 209, 212, 218-219, 224, 262
 - energy of: 207
 - erosion by: 25, 84, 119, 168, 221, 261-263, 273-274, 278
 - frequency of: 206
 - gravity: 208-209, 228
 - heights of: 56, 164, 205-213, 215-216, 218-220, 222-223, 225-226, 228-230, 235, 242, 248, 265, 268
 - horizontal pressure gradients in: 208
 - interference: 206, 215-216, 228
 - intermediate: 218
 - internal: 56, 196, 225-226, 228-229, 231, 322, 327, 339, 341, 346
 - Kelvin: 226, 228
 - movement of water in: 207, 213, 217
 - nutrient transport by: 327
 - periods of: 205-206, 214, 218, 220, 228, 235, 265, 327
 - progressive: 206-208, 226-229, 235, 244-245, 247, 250
 - refraction of: 218-219, 225, 262
 - restoring forces in: 176, 207-208
 - Rossby: 148, 226, 228, 230
 - shallow-water: 218, 220, 223-224, 228, 241-243, 246, 250-251
 - speed (celerity) of: 206-207, 214-215, 217-218, 228, 241
 - standing: 206, 208, 226-229, 242, 244-245, 247-248, 250
 - steepness of: 206-207, 209, 211, 213, 217-220, 228, 265, 487-489
 - surface tension and: 208-209, 212-213, 228
 - tides as: 208, 235
 - trains of: 214-216, 228-229
 - trochoidal shape of: 206, 209
 - troughs of: 29, 206-209, 213, 215, 220, 222-224, 227, 242, 245-246, 265, 267-268
 - wavelengths of: 206, 208, 226-229, 235, 245, 247, 250
 - winds and: 208-209, 211, 223-225, 230, 241, 328, 330
- weathering: 116, 135, 137-138, 291
- weather maps: 8, 226, 230, 488
- weather, weather systems: 56, 141, 147, 161, 164, 166-169, 172-173, 188, 471, 473, 476
 - and Coriolis effect: 1-2, 56, 141, 145, 147-148, 157, 160, 162, 164-169, 172-173, 212, 223, 228, 272, 279-280, 296, 463, 471, 473
 - coastal modification by: 263
- Weddell Sea E: 194-195, 202
- weed cardinalfish (*Foa brachygramma*): 392
- Wegener, Alfred: 22
- well-mixed estuaries: 339, 341, 343-344, 346

- westerlies: 32, 148, 183, 185, 201, 203
- western boundary currents: 169, 182-186, 188-189, 194, 201-202, 204, 323, 400
- wetlands: 2, 34, 127, 130, 263, 276-279, 338, 343-345, 347, 362, 425-428, 439, 442, 445-447
- whales: 26, 51-52, 112, 116, 143, 209, 294-295, 302, 306, 308, 310, 313-314, 316, 318, 348, 387, 394, 407, 414, 419, 439, 493
 baleen: 295, 306, 310, 313, 387, 414, 493
 California gray: 314, 387
 humpback (*Megaptera novaenglia*): 310, 387
 killer (*Orcinus orca*): 295, 310, 313, 407
- whale shark (*Rhincodon typus*): 308
- whip corals: 366, 392
- whip goby (*Bryaninops yongei*): 388
- Wide-Area Echo Sounders: 41
- willy willys: 167
- windrows: 190-191
- winds
 coastal modification by: 263
 fetch of: 32, 164, 210, 217, 228, 328
 geostrophic: 1-2, 56, 141, 145, 147-148, 157, 160, 162, 164-169, 172-173, 212, 223, 228, 272, 279-280, 296, 463, 471, 473, 487-488
 in wave creation: 208-209, 211, 223-225, 230, 241, 328, 330
 trade: 148-150, 152, 155, 157-158, 162, 166, 170-173, 182-186, 201, 210, 325
 westerly: 32, 148-149, 155, 159, 162-163, 168, 171, 182-185, 197, 201, 203, 210, 296
- windward: 171-172, 209, 404
- World Glory: 211
- worms
 annelid: 362-363
 Christmas tree (*Spirobranchus giganteus*): 360, 364, 372
 fan: 360, 364, 372
 innkeeper (*Urechis caupo*), lugworm (*Arenicola brasiliensis*), plume: 362-363
 marine: 388
 scale: 389, 392, 417
 tube: 355-356, 416-418, 420
- wrasses: 363, 368, 374-375, 377-378
 cheeklined (*Oxycheilinus digramma*): 375
 cleaner (*Labroides phthirophagus*): 368
 moon (*Thalassoma lunare*): 378
 redbreasted Maori (*Cheilinus fasciatus*): 377
- xanthophylls: 490-491
- Xenia sp. (soft coral): 359
- Xenocarcinus* sp. (spider crab): 366, 392
- Yangtze (Chang) River: 117
- year class strength: 331
- Yellow (Huang) River: 118
- Yellow Sea: 118
- yellow shrimp goby (*Cryptocentrus cinctus*): 393
- Yellowstone Park: 77
- yellowstreak fusilier (*Pterocaesio lativittata*): 375
- Younger Dryas period: 197
- Yucatán Peninsula, Mexico: 137, 166
- Zalophus californianus (California sea lion): 311
- zebra lionfish (*Dendrochirus zebra*): 378
- zinc: 29, 58, 97, 124, 135, 289, 292, 417, 424, 497-498
- zoanthids: 357, 359
- zooplankton: 122, 290, 292, 294-295, 299, 301, 303, 305-306, 316, 326-328, 330-331, 345, 352-355
- zooxanthellae: 275-276, 278, 322, 329, 346, 392, 400-401, 404, 418-419, 442

This textbook is made available as an open source textbook to avoid the high costs associated with commercial publishing. The textbook would sell through a publisher as an eBook for about \$100 of which the author would receive only about 10%.

The costs of producing the text are entirely borne by the author. There is no obligation for anyone to pay anything for this text. However, if you find the text valuable and choose to, you may donate by clicking the Donate button below. The suggested donation is \$10 (what the author would receive if sold for \$100 through a publisher) but even a single dollar will help keep the book available for others.

