

Introduction to Ocean Sciences

Third Edition
First electronic edition ver 3.2

DOUGLAS A. SEGAR

Contributing author Elaine Stamman Segar

© 2012 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: 978-0-9857859-0-1

This textbook was entirely produced by the author and made available as an open source textbook to avoid the high costs associated with commercial publishing. The textbook would sell through a publisher for over \$150 of which the author would receive only about 10%.

The costs of producing the text and keeping it current are entirely borne by the author. There is absolutely no obligation for anyone to pay anything for this text. However, if you find the text valuable and choose to, you may pay it forward and donate a dollar, or a few dollars to pay toward future enhancements of the text. To do so, just click the donate button below.



INDEX

- absorption 56, 106-109, 112, 146, 423, 463-466, 486
of light in water 107
spectrum 465
- Abudefduf* sp. (sergeant fish) 371, 380
- abyssal fan 85, 129, 138
- abyssal hill 61, 80, 86
- abyssal plain 61, 84-86, 127-129, 137-138, 296
- abyssal zone 296-297, 313, 410, 416
- abyssopelagic zone 298, 313, 417
- Acanthurus pyroferus* (mimic surgeonfish) 364
- accumulation rates, of sediment 126, 129-130, 132, 138
- acidity, of water 2, 333, 419
- acid rain 99, 116, 137, 249
- acorn barnacles 408
- acoustic 19, 25, 33, 49-50, 57, 111, 113
- acoustic current meter 50
- acoustic thermometry 111
- Acoustic Thermometry of Ocean Climate (ATOC) 111
- acoustic tomography 50
- Acreichthys tomentosus* (seagrass filefish) 358
- Acropora palmata* (elkhorn coral) 399-400
- Acropora* sp. (staghorn coral) 355
- acyclovir 25
- adaptations of fins 372
- adiabatic expansion 144-145, 172
- Adriatic Sea 331
- adsorption 125, 138, 287, 313
- Aegean Sea 14, 429
- aerobic 295, 313
- aesthetics 23, 29, 32
- Afghanistan 71
- Africa 12, 15-17, 63, 65, 71, 83-85, 133, 152, 158, 169, 182, 195, 211, 224, 244, 298, 321-322, 345, 429, 467
- African Plate 63
- age
of Earth 4
of sediments 134
- agriculture 2, 23, 152, 277, 331, 435-436
- Agulhas Current 183, 211-212
- air masses 142-144, 148-149, 151, 155, 160-161, 164-165, 167-168, 170-173, 203, 225, 229, 468, 482, 484
Coriolis effect and 164, 483-484
vertical movement of 143
- Alaska, Gulf of 158, 160
- Albemarle Sound (NC) 336
- Alcatraz Island, San Francisco Bay, CA 341, 436, 438
- Aleutian Islands 8, 69-70, 193, 256
- Aleutian Trench 223
- Alexandria, Egypt 15
- algae 28, 121, 265, 276, 281-283, 285-287, 296, 301, 303, 312-313, 320, 327, 330-331, 344, 348, 357, 362, 364, 368, 373, 377, 385, 388, 390-392, 395, 397-400, 402, 404, 406-410, 415, 421, 440, 442, 486
- benthic 312, 320, 357, 398, 421
- blooms, see blooms, algal 330-331, 344-345, 421
- blue-green (cyanobacteria) 301, 330-331, 344, 404
- calcareous 265, 276, 362, 398, 400, 415
- encrusting 348, 407-408, 415
- green 301, 404, 406
Halimeda sp. 265, 388
ice 409-410, 415
- algal ridge 400
- Algeria 429
- alligators 311
- Alloponetia* sp. (shrimp) 362, 388
- Alpheus bellulus* (tiger pistol shrimp) 389
- Alps 71
- aluminum 61, 90, 94, 116
- Alvin submersible 19, 54, 412
- Amazon River 133, 321
- Amblyrhynchus cristatus* (marine iguana) 310
- Amchitka Island, AK 403
- American Samoa 22
- amino acids 3, 97, 288
- ammonia 3, 31, 92, 100, 102, 283, 287, 468, 487
- amnesic shellfish poisoning (ASP) 330
- Amoco Cadiz 426, 429-430
- amphidromic systems 241-244, 250-251
- amphipods 302, 383, 411, 413, 416, 430
- Amphiprion*
A. clarkii (Clark's anemonefish) 369
A. frenatus (tomato anemonefish) 369
A. percula (clown anemonefish) 369
A. perideraion (pink anemonefish) 355, 369
- amplitude, of waves 206, 225, 228, 240, 248, 250
- anadromous fishes 343-344, 376, 381-382, 389, 391, 422, 442-443
- anal fins 364, 372-374
- Anchorage 231, 235, 275
- anchovy 23, 156, 158, 332-333
- Andes Mountains 18, 68, 155, 170
- Andrew, Hurricane 166
- anemone crab (*Dardanus* sp.) 385
- anemonefishes 368-369, 377, 384
Clark's (*Amphiprion clarkii*) 369
clown (*Amphiprion percula*) 369
pink (*Amphiprion perideraion*) 355, 369
spinecheek (*Premnas biaculeatus*) 369
tomato (*Amphiprion frenatus*) 369
- anemones 303-304, 313, 351-352, 355, 360, 368-369, 377, 384-385, 388-389, 402-403, 408, 413, 416
Haddon's sea (*Stichodactyla haddoni*) 369
rose (*Tealia lineata*) 402
sand 352, 360
- angelfishes 364
black-spot (*Genicanthus melanospilos*) 373
blue-girdled (*Pomacanthus navarchus*) 373
pearlscale (*Centropyge vrolikii*) 364
- angle of incidence 146-147, 172, 286-287, 313
- anglerfishes 373
deep-sea (*Chaunax pictus*) 362
- Angola 429
- Anguilla 381
- Anguilla sp. (Atlantic eel) 381
- angular velocity 473, 475-476, 479-480
- animals 4-5, 11, 15, 25, 29, 33, 36, 42, 51-52, 57, 89, 93, 97,

- 105, 109, 113, 116, 120-123, 136, 175, 208, 221, 225, 264, 275-276, 282-283, 287-288, 291-292, 295-299, 301-303, 305, 308-309, 311-314, 317, 320, 327-328, 331-333, 343, 348-349, 356-358, 360, 362, 370, 375, 380-381, 388, 390, 395, 398, 400, 403-404, 406-414, 416, 423, 425, 427, 431, 439-440, 442, 444, 488-489, 492
- anions 93, 97
- annelid worms 359
- anoxia 295, 331-332, 344-345, 420-422, 432, 435, 443
- Antarctica 2, 17, 20, 30, 62-63, 65, 84-85, 118, 121, 132-133, 142-143, 148-149, 153, 172, 177, 182, 185-186, 192-196, 201, 210-211, 217, 243-244, 250, 290, 294, 302, 311-312, 314, 326, 409-410, 416, 459
- Antarctic Bottom Water 193-195, 198, 201
- Antarctic Circumpolar Current 177, 182, 185-186
- Antarctic communities 410
- Antarctic Convergence 195, 201, 409
- Antarctic Divergence 195, 294
- Antarctic Peninsula 84
- Antennarius* sp. (Lembah frogfish) 380
- Antennarius striatus* (striated frogfish) 361
- Anthozoa (polypoids) 355
- anthropogenic, inputs 124, 145, 198, 295, 313, 333, 424-425, 427, 431, 440, 442-444, 468, 492-494
- antinodes, of standing waves 226-228, 242, 245, 247, 250
- Antioch, CA (San Francisco Bay) 422
- aphotic zone 108, 284, 286, 290, 302, 313, 348, 411, 416
- Appalachian Mountains 71, 83
- Aquarius 52
- Arabian Gulf, see Persian Gulf 29, 126, 155, 429-430
- Arabian Peninsula 158
- Arabian Sea 85, 117, 133
- Arabs 16
- aragonite 123, 137
- Arceichthys tomentosus* (seagrass filefish) 358
- archaea 3, 51, 97, 120, 281-286, 288, 292, 296, 298-299, 312-313, 414-416, 486-487
- arches, sea 262
- Archimedes' principle 450-451
- arcs
- island 65, 69, 71, 84-85, 163, 412, 416
 - magmatic 69-71, 84-86, 256
 - sedimentary 69, 84-86, 93, 256
- Arctic Ocean 22, 26, 73, 84, 133, 153, 156, 160-161, 193-196, 199-202, 298, 326, 409-410, 412, 416-417, 441, 444, 459
- Arctic Oscillation 160
- Arenicola brasiliensis* (lugworm) 359
- Argentina 22, 170
- Argo floats 20, 54
- Argo ROV 54
- Aristotle 15
- Armenia 71
- armor 360, 367-368, 391
- arrowhead crab (*Huenia heraldica*) 388
- Aruba 263, 358
- Asia 15-16, 33, 65, 71-72, 85, 117-119, 150, 152, 155, 158, 160, 182, 256, 311, 382
- aspect ratio 372
- assimilative capacity 420-422, 424, 432, 440-441, 443-444, 493
- associations, of species 25, 282, 333, 364, 368, 383-385, 388, 391-392, 431
- Asthenosoma*
- A. intermedium* (fire urchin) 366
 - A. varium* (fire urchin) 388
- asthenosphere 60-61, 63, 65, 67, 70, 72, 79, 84-87, 139, 280, 447, 450-453, 455
- Astropyga radiata* (sea urchin) 389, 399
- Atlantic eel (*Anguilla* sp.) 381
- Atlantic Ocean 16, 18, 58, 65, 72, 75, 78, 83-87, 108, 111, 118-120, 123, 125-126, 129, 132-133, 152-153, 155-156, 162, 166, 172, 180, 184, 188, 192-199, 201, 212, 236, 243-244, 251, 259, 269, 277, 290-291, 298, 304, 343, 397, 408, 462
- Atlantis 58
- atmosphere 2-4, 11-12, 14, 20, 33, 36, 46, 56, 58-62, 87, 90, 92, 97-99, 102, 106, 111-112, 114, 116, 119-120, 124, 126-127, 133, 136-137, 139, 141-147, 149, 151-152, 154-157, 159, 161-164, 167-168, 170-173, 176, 184, 190-191, 198-200, 202-203, 209, 212, 225, 229, 234, 248, 283, 288, 295, 297, 312, 331, 345, 376, 398, 404-405, 407-408, 415, 417, 419-420, 422, 427, 429, 435, 443, 447-449, 453-456, 458-469, 472, 482-484, 486
- convection cells in 145, 147-152, 154, 158, 170-172
- Coriolis effect in 148
- density of, 142-143, 172
- greenhouse effect in 1-3, 12-13, 32-33, 56, 82-84, 87, 89, 98-99, 102, 111, 114-115, 134, 136, 139, 141-142, 145-146, 159, 161, 172-173, 175, 189, 195, 203, 205, 212, 229, 249, 258, 271, 279-280, 314, 395, 417, 447, 453-454, 464-469
- interactions of oceans and 56, 141, 173, 203
- land-ocean interactions with 161, 163, 167, 171, 173, 320
- stratification of 142
- stratosphere of 142-143
- troposphere of, 142-144, 147-148, 159, 170, 172
- water vapor and 33, 90, 92, 99, 101-103, 114, 135, 141-148, 162, 164, 167-173, 450, 454, 458-459, 465, 468, 483
- atmospheric 145, 147-152, 154, 158, 170-172
- atolls 17, 22, 30-31, 79-80, 84, 86, 224, 228, 275-276, 278-279
- atoms 90-93, 95, 99-100, 103, 114, 116, 135, 143, 199, 282-283, 460-461, 467, 487
- Aurelia* sp. (moon jellyfish) 303-304
- Australia 17, 43, 62-63, 65, 85, 111, 133, 137, 152, 158, 166, 182, 276, 321, 345, 368
- autonomous floats 48, 55, 159, 181
- autonomous underwater vehicles (AUVs) 35, 45, 55, 57
- autotrophs 282-284, 286-287, 289, 291, 298, 301, 312-313
- AUVs (autonomous underwater vehicles) 35, 45, 55, 57
- avalanches 128-129, 137, 257
- Azerbaijan 71
- azidothymidine (AZT) 25
- Azores 16, 160
- back-arc basins 70-71, 85-86
- backscattering 107
- of light in water 107-108, 113, 146, 172, 188
 - of solar energy 146
- backshore 262-263, 265, 267, 269, 273, 278
- backwash 266, 269, 278
- bacteria 51, 97, 120, 123, 281-288, 290, 292, 295-301, 303, 312-313, 331, 348-349, 356-358, 368, 390, 411, 413-414, 416, 428-429, 431-432, 434, 443, 468, 486-487
- Baffin Bay 42, 84-85
- baguios 166

- Bahamas 119, 126, 200, 442
 Baikal, Lake, Russia 416-417
 Baja California, Mexico 248, 322, 380, 383
Balanus glandula (barnacle) 353, 406
 baleen 292, 302, 308-309, 313, 383, 410, 489
 baleen whales 292, 302, 308-309, 383, 410, 489
Balistoides conspicillum (clown triggerfish) 374
 Balkan Peninsula 71
 Baltic Sea 85, 155, 189, 295, 319, 331
 Bangladesh 166, 277, 279
 Banzai Pipeline 221
 bar-built estuaries 334, 336, 344
 bar charts 5
 barnacles 37, 301, 313, 352-353, 376-377, 395, 406-408, 415-416, 427, 440
 acorn 377, 408
 Balanus glandula 353, 406
 buckshot 406-407
 Chthamalus sp. 353, 406
 coral (Pyrgomatidae) 353
 barracuda, chevron (*Sphyræna putnamiae*), 371
 barred filefish (*Cantherhines dumerilii*), 372
 barrier beaches 265, 271-272, 274
 barrier islands 2, 255-256, 258, 261, 265, 269-274, 278-280, 334-336, 344
 barrier reefs 80, 86, 259, 275-276, 278-279, 400
 bars
 baymouth 270-271, 278
 longshore 221, 263, 265, 268-270, 273, 278
 basalt 61, 72-73
 basket star (*Gorgonocephalidae*) 355-356
 bass, striped 23, 343, 442
 bathyal zone 297, 313, 410, 416
 bathymetry 37, 41, 56-57
 bathypelagic zone 298
 bathyscaphes 54
 bathysphere 54
 baymouth bars 270-271, 278
 Bay of Bengal 85, 117, 133, 319
 Bay of Fundy, Canada 246, 249, 255, 280
 bays 16, 25, 28-29, 42, 84-85, 117, 133, 137, 193, 218-219, 227, 244-250, 253, 255, 260, 263, 270-271, 277, 279, 317-320, 325, 331, 334-336, 339-341, 420-422, 429, 432, 435-438, 442, 445, 463
 beaches 1, 116, 205, 220, 248, 256, 260-269, 271-274, 278-279, 297, 311, 331, 351, 380, 383, 404, 420, 424, 426-427, 430, 432, 434-435, 439-440, 442-444
 barrier 265, 271-272, 274
 closures of 423, 440
 grain size in 266-267
 human structures and 272, 278
 lagoons and 269, 278
 litter on 27, 31-32, 46, 116, 420, 427, 439-440, 444
 longshore drift and, 31, 130, 266-270, 272-275, 278-279, 335-336, 345
 seasonal changes in 269
 slope of 266, 269, 278
 sources of materials in, 265
 wave sorting of 267
 zones of 263-265, 267, 278
Beagle, HMS 17-18, 20, 32, 80
 Beaufort Sea 255, 269
 behavior, of marine organisms 52
 Behm, Alexander 39
 Beihai, China 237
 Beijing, China 472
 bends 53, 75
 Bengal, Bay of 85, 117, 133, 319
 Benguela Current 183
 Bennett's butterflyfish (*Chaetodon bennetti*) 361
 benthic environment 296-297, 312-313, 422, 434
 abyssal zone of 296, 313, 410, 416
 bathyal zone of 297, 313, 410, 416
 effects of sewage on, 434
 hadal zone of 296-297, 313
 intertidal (littoral) zone of 231, 248, 250, 264-265, 267, 278, 297, 312-313, 348-349, 390, 392, 395, 404, 406, 415-416
 sublittoral zone of 297, 313-314
 supralittoral zone of, see also rocky intertidal communities 31, 297, 314, 404, 407, 415-416
 benthic organisms 51-52, 296, 313, 348, 388, 430
 benthos 25, 50, 57, 292, 297-298, 304, 312-313, 318, 343-344, 348, 351, 391, 434, 437-438, 444
 Bering Sea 17, 23-24, 26, 69, 73, 85, 133, 163, 193, 195, 345, 383
 Bering Strait 84, 193
 berms 263-265, 269, 278
 Bermuda 111, 126
 Bermuda Rise 126
 Big Sur, CA (near Monterey) 262
 binary fission 377
 bioaccumulation 425, 444, 492, 494
 bioassays 424-425, 443-444, 493-494
 bioavailable 438, 440, 444
 biochemical cycles 485, 487
 biodegradable chemicals and materials 425, 444
 biodiversity 13, 34, 347, 392, 395, 417, 419, 445, 447, 491-492
 biogenous sediment 121, 129
 biogeochemical cycles 93-94, 97, 112, 114-116, 295, 440, 462
 biological age dating 43, 59, 67, 87, 89, 114-115, 134, 139, 175, 203, 447, 460-461
 biological niche 396
 biological oceanography 32, 50
 bioluminescence 300, 304
 biomagnification 425, 444, 492, 494
 biomass 33, 51, 121, 283, 285, 291-293, 296, 298-299, 301, 312-313, 315, 324, 326-328, 333, 341, 344-346, 348, 356, 391, 398, 408, 412-417, 423, 430, 434, 462, 468, 485, 487-490, 493
 biota 29, 31, 298, 314, 323, 331, 341, 348, 411, 420, 423-424, 432, 437-438, 440, 442, 462-463, 467
 bioturbation 134-135, 138, 357
 black coral (*Cirrhopathes* sp.) 388, 400
 black-headed parrotfish (*Scarus gibbus*) 367
 black-saddled mimic filefish (*Paraluteres prionurus*) 364
 black-saddled toby (*Canthigaster valentini*) 364
 black-smoker hydrothermal vents 413
 black-spot angelfish (*Genicanthus melanospilos*) 373
 black turban snails (*Tegula funebris*) 406
 blooms 28, 289, 300-301, 313-314, 323-331, 343-345, 380, 415, 422-423, 432, 443, 472, 490

- algal 330-331, 344, 421
- diatom 323, 328-329
- dinoflagellate 329-330, 344-345
- blubber 310, 383
- blue-girdled angelfish (*Pomacanthus navarchus*) 373
- blue-green algae (cyanobacteria) 301, 330-331, 344, 404
- blue-ringed octopus (*Hapalochlaena* sp.) 281
- boiling point 73, 99-102, 143, 282, 459
- bonds
 - chemical 91
 - covalent 91-93, 113
 - hydrogen 91-93, 99-103, 106, 112-113
 - ionic 91-93, 113
- bony fishes, 305, 307, 360, 375, 391
- Bores, tidal 246, 249, 251
- boron 96
- Bosnia 71
- Boston 162-163, 235
- Bothus* 305, 371
 - B. mancus* (flowery flounder) 305
 - B. sp.* (flounder) 371
- Botryllus* sp. (tunicate) 355
- boundary currents, eastern 182-184, 186-187, 201-202, 322, 382
- boundary currents, western 167, 172, 182-184, 186, 188-189, 194, 201-203, 321, 396
- box corers 42, 52, 57
- boxfishes 367-368
 - spotted (*Ostracion meleagris*) 367
- brackish. water 346, 358, 442
- Brahmaputra 85, 117, 277, 319
- brain coral (*Diploria* sp.) 355
- Brazil 133, 166, 183, 217, 321, 429
- Brazil Current 183
- breakwaters 221, 274-275, 278
- breezes, land and sea, 169, 171
- brine 29, 194, 202
- British Columbia (BC), Canada 130, 133, 160
- Brittany, France 426, 429-430
- brittle stars 385, 395, 411, 416
- bromine 96, 100
- brown cup coral (*Paracyathus stearnsii*) 402
- Bryaninops yongei* (whip goby) 384
- buckshot barnacles 406-407
- budding 377
- budget
 - heat 145-146, 171
 - water 144-146
- buffering
 - of heat 102, 153, 161
 - of pH 99
- bulkheads 424
- buoyancy 112, 286, 305, 307, 313, 348-349, 351, 371, 376, 390-392, 411, 450
- burrfishes 368
- burrowing sponge (*Oceanapia sagittaria*), 380
- butterflyfishes 360, 372, 377, 384
 - Bennett's (*Chaetodon bennetti*) 361
 - Klein's (*Chaetodon kleinii*) 370
 - Meyer's (*Chaetodon meyeri*) 371
- buttress zone 400, 415
- bycatch 24, 33
- byssal threads 407
- cables, undersea 129
- calcareous organisms 121, 133, 135
- calcite 123, 137
- calcium 2, 94-96, 99, 121-124, 126, 130-131, 135, 137, 139, 265, 296, 302, 305, 309, 368, 398, 412, 416
- calcium carbonate 2, 95, 99, 121, 123-124, 126, 130-131, 135, 137, 139, 265, 296, 302, 305, 309, 368, 398, 412, 416
- California (CA) 20, 22-24, 26, 28, 41, 67, 69, 75, 86-87, 94, 96, 117, 120, 125, 129, 158, 160, 167, 170-171, 175, 183, 187, 202, 224, 235, 248, 253, 255-257, 261-264, 267, 275, 285, 309, 311, 315, 317, 320-323, 330, 339, 353, 380-381, 383, 401-404, 406-407, 415-416, 422, 425, 434, 437, 443, 446
- California Current 183, 187
- California gray whale 309, 383
- California, Gulf of 175
- California mussel (*Mytilus californianus*) 309, 353, 381, 406
- calorie (cal) 100, 102, 113
- Camille, Hurricane 166
- camouflage, in hunting and defense 360, 362, 364, 385, 388, 391
- Canada 23, 43-44, 58, 69, 83-84, 119, 130, 139, 160, 169, 195, 235-236, 253, 255, 258-259, 277, 280, 330, 336, 429
- Canary Current 183
- Canary Islands 16, 120
- Cannery Row, Monterey, CA 23
- Cantherhines dumerilii* (barred filefish) 372
- Canthigaster valentini* (black-saddled toby) 364
- canyons, submarine 41, 83-84, 120, 129, 138, 256, 267, 278-279
- Cape Cod, MA 255, 318
- Cape Hatteras, NC 186, 188, 318
- Cape Mendocino 69
- capillary waves 208-209, 213, 227
- Carangoides* sp. (trevally) 371, 373
- Caranx melampygus* (bluefin trevally) 364
- carbonate compensation depth (CCD) 123-124, 131-133, 135, 137-138, 202, 296
- carbon dioxide 2-4, 12, 27, 29, 33, 35, 90, 97-99, 112-114, 116, 120, 124, 126, 136-137, 139, 145, 173, 195-196, 199-200, 202-203, 229, 283-284, 287, 295-296, 305, 312, 314, 332, 375, 397, 417, 419, 425, 445, 463-466, 485-487
- carbon monoxide 99
- carbon organic, ; see also organic matter 287, 296, 312, 314, 333
- carcasses 411, 414, 416
- Carcharhinus amblyrhynchos* (gray reef shark) 306, 373
- Carcharodon carcharias* (great white shark) 306
- carcinogens 410, 424, 443-444, 492-494
- Cardiidae (cockles) 351
- cardinalfish, weed (*Foa brachygramma*) 388
- Caribbean Sea 21, 84-85, 127, 141, 235, 244, 260, 301, 358, 400, 469
- Carmel, CA (near Monterey) 253
- carnivores 283-284, 291-292, 298, 301, 306, 312-313, 328, 333, 348, 350, 377, 391, 407-408
- carotenoids 486
- cartilaginous fishes 307, 313
- Cassiopeia andromeda* (upside-down jellyfish) 303
- cassiterite 27
- catadromous fishes, 343-344, 376, 391, 422

- Catarina, Hurricane, 166
cations 93, 113
caudal fins 372-373, 375, 388, 391
Caulerpa racemosa (grapeweed) 320
caves, sea 262
Cayman Islands 84, 141, 260
CCD (carbonate compensation depth) 123-124, 131-133, 135, 137-138, 202, 296
Celebes sweetlips (*Plectorhinchus celebicus*) 364
celerity 206, 214, 218
cell division 300-301
Central America 155, 158
central rift valleys 72-73, 75, 86
centripetal force 232-234, 250, 473, 475-482
Centropyge vrolikii (pearlscale angelfish) 364
cephalopods 307-309, 313
cercaria 385
cesium 96
cetaceans 308-309, 313, 390
CFCs (chlorofluorocarbons) 143
Chaetodon
C. bennetti (Bennett's butterflyfish) 361
C. kleinii (Klein's butterflyfish) 370
C. meyeri (Meyer's butterflyfish) 371
Challenger, HMS 34
Chang (Yangtze) River 117
chaos, chaotic systems 1, 12-13, 25, 33, 59, 63, 87, 141, 159-161, 163, 171-173, 175, 196, 198, 202-203, 277, 317, 334, 346, 447, 467, 469-472, 494
charts, see maps, mapping 5, 7, 10-11, 17, 37-38, 41, 164
Chaunax pictus (deep-sea anglerfish) 362
cheeklined wrasse (*Oxycheilinus digramma*) 371
Cheilinus fasciatus (redbreasted Maori wrasse) 373
chelation 324
Chelonia mydas (green sea turtle) 310, 358
chemical bonds 91
chemical oceanography 96, 140
chemical sensing, in marine organisms 380, 388-389, 412
chemosynthesis 12, 19, 58, 87, 139, 283-284, 298, 312-314, 349, 392, 412, 416-417, 488
chemotaxis 376
Chernobyl, Ukraine 441
Chesapeake Bay, VA 137, 246-247, 331, 334, 336, 421, 435-436
chevron barracuda (*Sphyræna putnamiae*) 371
Chicxulub, Mexico 136-137, 224
Chikyu 43
Chile 158, 170, 224, 429
China 22, 25, 71, 85, 117, 246
Chiso Chemical Corporation 436-437
chitons 406-407
lined (*Tonicella lineata*) 406
chlorine 91, 94-96, 100, 143
chlorofluorocarbons (CFCs) 143
chlorophylls 51-52, 56, 108, 160, 283, 293-294, 313, 321-322, 325, 344, 485-487
chloroplasts 485-487
chordates 304, 313
Christmas tree worm (*Spirobranchus giganteus*) 356
chromatophores 362, 364
chronic toxicity 431, 444
chronometers 8, 12, 15-16, 33
Chthamalus sp. (barnacle) 353, 406
Chukchi Sea 383
circulation
eddies in 29, 48, 175, 187-189, 201-202, 320, 323, 325-326, 343-344, 397, 409
Ekman spiral 177-178, 200, 202
Ekman transport 178-187, 190, 200-202, 265, 321-322, 336, 343-344, 439
Langmuir 190, 201-202, 299, 320, 325, 336
circulation, estuarine 336, 339-345, 435, 438, 444
circulation, thermohaline, 176, 190, 200-202, 225
Cirrhopathes sp. (black coral) 388, 400
Cirrhitichthys falco (Falco hawkfish) 361
clams
giant (*Tridacna gigas*) 389
Tellina sp. 358
Clark's anemonefish (*Amphiprion clarkii*) 369
Clavelina sp. (lightbulb tunicate) 355
clays 116, 119, 123, 132-133, 137-138, 224, 457
deep-sea (red) 132-133
cleaner wrasse (*Labroides phthirophagus*) 364
Clean Water Act 423
climate
deep-ocean circulation and 195, 201
interannual variations of 155, 159, 171
ocean surface currents and 167, 172, 182-184, 186-189, 194, 201-203, 321-322, 382, 396
zones of 161-163, 171
climate change 2, 12, 23, 29, 56, 98-99, 111, 136, 159, 189, 195, 198, 212, 258, 260, 277, 295, 345, 410, 431, 464, 466-467, 469, 472
climatic winds 147-150, 162-163, 169, 171, 177, 181-182, 188, 323
cycles of 83
MOC and 195-196, 198, 201, 332
sedimentary (stratigraphic) record of 133, 135, 138
susceptibility of ecosystems to 409
wave heights and 212
climatic, see climatic winds
clingfish, crinoid (*Discotrema crinophila*) 388
clinker 116
clones 377
clouds 16, 38, 56, 91, 107, 119, 124, 128, 141, 143-146, 148-149, 154, 159, 161, 164, 166-173, 176, 187, 201, 217, 286, 294, 317, 322, 359, 368, 376, 380, 412, 437, 459, 464-466
clown anemonefish (*Amphiprion percula*) 369
clownfishes see anemonefishes
clown triggerfish (*Balistoides conspicillum*) 374
Clypeaster (sand dollars) 399
cnidarians 303, 313, 370, 391
cnidocysts 303
coastal plains 81, 86, 117, 138, 256, 259, 270-271, 276, 278, 334, 340, 344
Coastal Zone Color Scanner 108, 188
coastal zones 2, 48, 108, 156, 188, 253, 278, 312, 317, 319-320, 322, 331, 333, 344, 421, 423, 431, 437-438, 442, 444
characteristics of 317, 343
currents and 183, 186-187, 201-202, 318, 320-323, 343
food webs in 323

- human structures and 272, 278
- nutrients in 320, 325, 343
- salinity in 318
- seasonal variation in 326, 343, 345
- temperature in 319
- turbidity of 320
- upwelling in 122, 156, 169, 186, 201-202, 287, 291, 293, 321-325, 328, 332, 342-345
- waves and 175, 205, 263, 319, 325
- coastline 15, 21-22, 29-30, 67, 72, 81, 83, 86, 118, 133, 182, 205, 216, 218, 221, 228, 253, 255, 257, 260-261, 263-264, 270, 275, 279
- coasts 20, 23, 28-31, 69, 81, 83-84, 117, 130, 132, 161, 166, 169, 177, 184, 186, 201, 221, 224, 236, 243-244, 253, 256-263, 265-267, 269-270, 272, 274-275, 277-278, 280, 314, 321, 331, 334, 336, 343-344, 397, 404, 408, 423-424, 443, 450, 452-454
- barrier islands on, 2, 255-256, 258, 261, 265, 269-274, 278-280, 334-336, 344
- classification depositional or erosional 253, 277
- classification primary or secondary 256
- deltas on 130, 138, 259, 277-279, 334, 344, 421-422
- formation of 256
- human structures and 272, 278
- lagoons on 29, 79-81, 130, 138, 228, 256, 269-271, 276-280, 311, 317-319, 336, 345, 383, 398-399, 415
- modification of 260
- reefs and atolls on 17, 22, 30-31, 79-80, 84, 86, 221, 224, 228, 259, 275-276, 278-280, 400
- sea-level change and, 83-84, 86-87, 130-131, 231, 256-258, 278, 453
- subduction zones near 67
- wetlands on, 2, 32, 127, 130, 138, 263, 276-279, 336, 340, 342-345, 358, 421-422, 424, 429-430, 442-444
- cobalt 27, 96, 124-125, 287
- coccolithophores 121-122, 138, 300-301, 313
- cockles (*Cardiidae*) 351
- Cocos Plate 69
- cod, Atlantic (*Gadus morrhua*) 305
- coelenterates, see cnidarians
- cohesive 127, 138-139, 280, 456-457
- Coleman's shrimp (*Periclimenes colemani*) 388
- collisions, of continents 70-72, 79, 86
- colloidal matter 125, 138, 313
- colonial organisms 303-304, 350, 355-356, 370, 377, 391
- Colorado (CO) 280
- Columbia River, WA 160
- Columbus, Christopher 15-16, 33, 87, 229, 393
- Commission on Ocean Policy, U.S., 23
- common mussel (*Mytilus edulis*), 381
- common reef squid (*Sepioteuthis lessoniana*) 307, 380
- communication, in marine organisms 388, 391
- communities
 - Antarctic 410
 - Arctic 410
 - at hydrothermal vents 413
 - chemosynthetic 4, 11-12, 282-283, 286, 292, 313, 348, 413, 415-416, 486
 - marine 2, 11, 25, 29, 32, 34, 52, 54, 78, 124-125, 167, 195, 249, 260, 267, 275, 279, 284-286, 291-293, 296-299, 301, 312-313, 320, 327-328, 333, 342, 344, 348, 352, 358, 366, 392, 396-397, 401-404, 408-410, 412-417, 423, 431-432, 435, 440, 443, 445, 486, 490-492
 - rocky intertidal 404, 415-416
- compensation depth 123-124, 133, 137, 202, 286-287, 296, 298, 312-313
- complexed ions 440, 493
- complex systems 57, 472
- computer modeling 1, 12-13, 33, 35, 47, 56-58, 141, 158, 160, 173, 175, 190, 198, 200, 203, 281, 314, 447, 467-468
- computer tomography 63
- concealment 360, 364, 366, 368, 391
- condensation 99, 144-145, 147, 172, 459
- conduction 63, 72, 105, 113, 146-147, 172, 450, 454, 458, 468, 471
- conductivity, electrical, see electrical conductivity
- cone shell (*Conus geographicus*) 367
- Congo River 85
- congregations, spawning 376
- conservative properties, of seawater 198, 201
- constituents, dissolved, in seawater 47, 95, 103, 112, 114, 189, 198, 417, 445
- contaminants 29, 37, 46, 97, 99, 113, 116, 173, 247, 318, 336, 339-341, 343-344, 346, 348, 410, 420-421, 423, 425, 432, 435-436, 438, 442-445, 462-463, 468, 494
- contamination 32, 45-46, 57, 97, 420-421, 423-425, 427-428, 430-432, 436, 438, 443-445, 463, 494
- fat-soluble 410, 436-437
- in dredged material 444
- nonpoint sources 435-436
- vs. pollution 420
- continental collisions 70-72, 79, 86
- continental crust 60-61, 63, 65, 67-70, 72, 74, 76, 81, 84-87, 450-454
- continental drift see also plate tectonics 18-19, 43, 63, 86
- continental margins 67, 81, 83, 93, 117, 130-131, 138
- continental rises 61, 138
- continental shelves 20-22, 26, 28, 32, 61, 71, 81, 83-84, 86, 115, 120, 126-131, 137-138, 183-184, 186-188, 194, 211, 224-225, 228, 241, 251, 257-259, 267, 283, 295, 297-298, 301, 313, 317, 321, 323, 325, 331-332, 334, 340, 344, 351, 397, 435, 438, 445
- continental slopes 26-27, 32, 61, 83, 86, 126-129, 133, 137, 139, 414, 438
- contour plots 6-7, 11-12
- contours 6-7, 11-12, 164, 171-172, 178-179, 201, 243, 416, 483-484
- Conus geographicus* (cone shell) 367
- convection 59, 62-63, 74, 76, 86-87, 89, 105, 113-115, 124, 139, 141, 144-145, 147-152, 154, 158, 170-172, 175, 182, 190-191, 202, 319, 325, 413, 447, 454-456, 471, 484
- convection cells 59, 62-63, 87, 89, 114-115, 124, 139, 141, 145, 147-152, 154, 171-172, 175, 182, 190, 202, 447, 454-456, 471
- convergent plate boundaries 65, 67, 69-70, 75-76, 79, 85-86, 124, 256
 - continental 70-72, 79, 86
 - oceanic 85
- conversion tables 11
- conveyor belt circulation 195-196, 295
- Cook Inlet 17, 26, 246
- Cook, James 16
- Cook Strait, New Zealand 17

- cooperation, in hunting and defense 20, 360, 368, 370, 391, 494
 Copenhagen, Denmark 95
 copepods 292, 302, 313, 315, 350, 384, 408, 411, 416
 copper 27, 58, 96-97, 124-125, 135, 277, 330, 402, 420, 422, 425, 436, 440, 493
 Copper River, AK 277
 copper rockfish (*Sebastes caurinus*) 402
 coral crabs (*Cancer*) 366
 coral reefs 1-3, 16, 24-25, 29, 52, 59, 80-81, 122, 131, 221, 228, 255-256, 260, 275-276, 278-279, 289, 298, 312-313, 320, 327, 343-344, 348, 351-353, 355, 364, 383, 392, 395-399, 401, 403, 415-417, 442, 452, 491
 corals
 black (*Cirripathes* sp.) 388, 400
 brain (*Diploria* sp.) 355
 brown cup (*Paracyathus stearnsii*) 402
 elkhorn (*Acropora palmata*) 399-400
 hard 320, 327, 353, 355-356, 380, 388, 395, 399, 491
 reef building (hermatypic) 396-397, 400, 416
 soft, 353, 355, 362, 364, 388, 395, 400, 415-416
 staghorn (*Acropora* sp.) 355
 symbiosis in 275-276, 278, 320, 327, 343, 388, 392, 396-397, 400, 414-416
 Tubastrea sp. 355
 whip 362, 384, 388
 Xenia sp. (soft coral) 355
 coral shrimp (*Dasycaris zanzibarica*) 362
 coral shrimp (*Vir philippinensis*) 388
 core, Earth's 42-43, 60, 62-63, 76, 127, 189, 454
 corers 42-44, 52, 57
 Coriolis effect
 climatic winds and 148
 Critical Concept 473
 in estuaries 336, 339-345, 435, 438, 444
 oceanic currents and 177-178, 200, 202
 tides and 241
 waves and 208, 225, 228
 weather systems and 1-2, 56, 141, 145, 147-148, 157, 159, 161, 163-168, 171-172, 212, 223, 228, 272, 279, 294, 459, 467, 469
 cormorant, double-crested (*Phalacrocorax auritus*) 311
 cormorants 311-312, 430
 cornetfish (*Fistularia commersonii*) 370
 Corpus Christi, TX C (south of Galveston) 272
 corrosion, as factor in ocean studies 36-37, 46
 cosmogenous sediment 116, 126, 130, 137-138
 countershading 364, 391
 covalent bonds 91-93, 113
 cowries 357, 388
 allied (*Primovula* sp.) 357
 egg (*Pseudosimnia* sp.) 388
 crabs 23-24, 112, 248, 301-302, 304, 311, 330, 343, 352, 359, 362, 364, 366, 368, 380, 385, 388-389, 395, 402-404, 406-408, 413, 416
 anemone (*Dardanus* sp.) 389
 arrowhead (*Huenia heraldica*) 388
 coral (*Cancer* sp.) 366
 decorator 362, 364, 385, 388
 Dorippe frascione 389
 hermit 385, 388-389, 406, 408, 416
 horseshoe (*Limulus polyphemus*) 248, 380
 king 23-24, 304
 Majidae 362
 northern kelp (*Pugettia producta*) 402
 Pagurus sp. 406
 porcelain (*Porcellanella triloba*) 388
 spider (*Xenocarcinus*) 362, 388
Crassostrea virginica (eastern oyster) 377, 442
 crests
 of oceanic ridges 76
 of waves 206-208, 212, 215, 218-223, 228, 241, 267
 Crete 14
 crinoid clingfish (*Discotrema crinophila*) 388
 crinoid cuttlefish 307
 crinoids 307, 364, 385, 388-389, 395
 crinoid shrimp (*Periclimenes amboinensis*) 362, 483
 critical thinking 12, 33, 58, 78, 86, 113, 138, 172, 202, 228, 251, 279, 314, 345, 392, 416, 444-445
 Croatia (Balkans) 71, 331
 crocodiles 311
 cross-sectional profiles 7
 crust
 continental 60-61, 63, 65, 67-70, 72, 74, 76, 81, 84-87, 450-454
 density of 59
 Earth's 4, 7, 11, 33, 59, 65, 87, 93-94, 124, 139, 280, 335, 415
 formation of 59
 oceanic 60-61, 63, 65, 67-72, 75-76, 79-81, 83-87, 123, 130, 134, 139, 276, 280, 283, 412, 450-453
 crustaceans 112, 292, 302, 304, 309, 313, 330, 348-352, 368, 373, 383-384, 408, 411, 416
 crusts, phosphorite 27-28, 33, 44, 124, 126, 137
Cryptocentrus cinctus (yellow shrimp goby) 389
 CTD samplers 47, 57, 95
 ctenophores 303-304, 313, 350-351
Cucumaria sp. (creeping sea cucumber) 356
 cum sole motion 164, 172, 177-179, 200, 202, 242, 250, 473, 480, 483
 currents
 Agulhas 183, 211-212, 429
 Antarctic Circumpolar 177, 182, 185-186
 Benguela 183
 Brazil 183
 California 183, 187
 Canary 183
 climate affected by 195, 201
 coastal 183, 186-187, 201-202, 318, 320-323, 343, 424
 Davidson 187
 deep-ocean 176, 190, 200-202, 225
 East Australian 183
 ebb 231, 245, 250
 eddies in 48, 175, 187-189, 201, 320, 323, 325, 343, 397, 409
 Equatorial 182, 185-186, 201
 flood 231, 245
 Florida 180
 generation of 176
 geostrophic 179-185, 189, 201-202, 229, 484
 Gulf Stream 17, 29, 153, 162, 167, 180, 183-184, 186-189, 195, 201-202, 225, 323, 343, 382, 458
 gyre 181-182, 202

- horizontal pressure gradients in 180-181, 202
inertial 189, 201
Kuroshio (Japan) 153, 162, 183, 189, 343
latitudinal heat transfer by 147
longshore 183
measuring 47-48, 50
open-ocean 182
Peru 183
residual 336, 339-340, 342, 344
restoring forces in, 176
rip 2, 222, 228, 268, 278
steering forces in, 176
subpolar (high-latitude) 185
surface slope and 180-181, 202
surface (wind-driven) 175-178, 180, 182, 189-190, 200-202, 225, 317
tidal 29, 190, 201, 231, 244-251, 320, 326, 336-337, 339-341, 344, 438
turbidity 32, 120, 127-129, 133, 137-138, 209, 256-257, 411, 456, 458
wave heights and 211
currents, soundings affected by 38
cuttlefish 307-309, 347, 362, 380
 broadclub (*Sepia latimanus*) 307
 crinoid 307
 flamboyant (*Metasepia pfefferi*) 347, 380
Cyanea sp. (jellyfish) 304
cyanobacteria (blue-green algae) 301, 330-331, 344, 404
cycles 4, 63, 65, 83-84, 87, 93-94, 97, 112, 114-116, 212, 248, 263, 284, 295, 298, 301, 307, 310, 313, 324-326, 329, 333, 336, 343, 345, 347, 376-377, 381, 383-385, 392, 414-415, 434, 440, 453, 462, 468, 485, 487
biogeochemical 93-94, 97, 112-116, 124, 138, 288, 295, 427, 440, 444, 462
diurnal 235-238, 240, 242, 244, 250-251, 291, 302, 313
hydrologic 90, 440
Cyclichthys orbicularis (orbicular burrfish) 367
cyclones
 extratropical 148, 161, 163, 167-168, 171, 223, 294
cyclones, see also hurricanes 148, 161, 163, 166-168, 171, 223, 294
cyclonic storms 167
Cymothoidae (fish doctor, isopod) 384
cysts 282, 325
damselishes, lemon (*Pomacentrus moluccensis*) 384
Dardanus sp. (anemone crab) 389
Dark Ages 15-16, 33
darkspotted moray eel (*Gymnothorax fimbriatus*) 374
dartfish (*Nemateleotris magnifica*) 361
Darwin, Charles 17-18, 20, 32-33, 68, 80
Dasycaris zanzibarica (coral shrimp) 362
dating (age estimation) 134
dating, by radioactivity 134
Davidson current 187
Day After Tomorrow, The (film) 198
DDT 97, 420, 423, 425, 437, 440, 443, 445
Deacon's Reef, Papua New Guinea 89, 395
Dead Sea 126
dead zones 295, 331-332, 344, 421, 430, 432, 435
decay, radioactive 63, 199, 454, 460-461
declination, lunar 238, 240, 250
decomposers 123, 138, 282-285, 287-291, 296, 300, 312-314, 328, 343, 348-349, 356-358, 391, 397, 403, 407-408, 416, 420, 425, 429
decomposition 27, 93, 97, 112, 116, 121, 126, 143, 198, 277, 282-283, 288-291, 295-296, 312, 318, 324, 329, 331, 339, 342-343, 358, 409, 411-412, 416, 420, 425, 429, 437, 443
decorator crabs 362, 364, 385, 388
deep-ocean water masses 181, 190-191
deep-sea anglerfish (*Chaunax pictus*) 360, 362, 376
Deep Sea Drilling Program (DSDP) 19, 43
deep-sea mud 131, 133
deep-sea (red) clays 132-133
deep-water wave 209, 213-214, 216, 218, 227-228
defense, see hunting and defense
deforestation 116
Delaware 255, 334
Delaware Bay 334
deltas, river 117, 130, 138, 256, 259, 276-280, 334, 344, 421-422
Dendrochirus zebra (zebra lionfish) 374
Dendronephthya sp. (soft coral) 355, 388, 395
Denmark 95
density
 absolute 207, 448
 atmospheric 143
 of Earth's crust 60
 of lithospheric plates 61
 of marine organisms 411
 relative 104, 448, 460
 stratification by 179, 448
 water 35, 46, 58, 89, 95, 102-103, 105, 112, 114-115, 139, 141, 175, 179-181, 185, 190-191, 200-203, 207, 290, 447, 449-450, 454, 459-460
deposit feeders 356-359, 390-392, 398, 411, 415-416
deposition
 glacial 118
 of sediment 84, 86, 119, 121-122, 124-126, 129-134, 138, 357, 398, 423
depth of no motion, in waves 180-181, 214
depth of seafloor see bathymetry
detritivores 283-284, 312-313
detritus 93, 113, 120-121, 126, 135, 138, 276, 278, 283, 288-289, 292, 295-298, 312-313, 324-325, 330-331, 342-344, 348-351, 355-359, 362, 390-391, 397-400, 402-403, 407-408, 411, 415-416, 456, 468
Diadema savignyi (long-spined sea urchin) 357
diagenesis 134-135, 138
diarrhetic shellfish poisoning (DSP) 330
diatom ooze 130
diatoms 117, 121-122, 130, 132-133, 135, 137-138, 282, 286, 289, 292, 300-301, 303, 312-313, 323-324, 326, 328-330, 333, 342-345, 350, 356, 377
Didemnum molle (tunicate) 355
diffusion 135, 138, 143, 172, 287, 313, 349-350, 358, 448-449, 468
dikes 72
dinoflagellates 275, 282, 286, 300-302, 313, 329-331, 333, 344-345, 368, 396
dip angle 78

- Diploastrea heliopora* (hard coral) 327
- Diploria* sp. (brain coral) 355
- Discotrema crinophila* (crinoid clingfish) 388
- dispersion 209, 215-217, 227-228, 414, 429, 434
of waves 209, 216-217, 227-228
- disposal waste, see waste disposal
- dissipation, of waves 212
- dissolution 116, 121-123, 131, 137, 139, 262-263
- diurnal cycles
in temperature 161, 167
of tides 235-236, 238, 244, 250
of zooplankton 290
- divergence 67, 72, 74, 86, 148-149, 152, 154, 161, 172, 176-178, 180-182, 185-186, 190, 193, 195, 201-202, 294, 300, 454-456
in atmospheric convection cells 148
- divergent plate boundaries 65, 67, 71, 73-74, 78-79, 85, 87, 256
- diversity 13, 25, 29, 34, 347, 376-377, 381, 383, 391-392, 395-397, 417, 419, 423, 434, 444-445, 447, 491-492
- ecosystem 34, 392, 417, 445, 491
genetic 25, 34, 376-377, 383, 391-392, 417, 445, 491
physiological 34, 392, 417, 445, 491-492
species 13, 25, 29, 34, 347, 392, 395, 417, 419, 423, 434, 445, 447, 491
- diversity of 13, 25, 29, 34, 347, 376-377, 381, 383, 391-392, 395-397, 417, 419, 423, 434, 444-445, 447, 491-492
- DNA 282, 424, 494
- doldrums (intertropical convergence zone) 148, 176, 185
- dolphins, bottlenose 331
- domoic acid 330
- Doppler shift 50
- Dorippe frasnica* (crab) 389
- dorsal fins 361, 364, 372-373, 375
- Dover, England 121-122, 139
- downwelling 63, 72, 85, 87, 148-149, 152-153, 155, 171-172, 180, 182, 185-186, 190, 201-202, 291, 294, 409, 454-456
- drag 38, 48, 63, 106, 370-373, 391
- Drebbel, Cornelius 53
- dredges 18, 43-45, 52, 57, 274
- dredging, pollution from 25, 31, 33, 341, 427, 437-438, 442, 444
- drifters 48, 57
- drift nets 24, 33, 51, 311
- drilling 19-20, 26-27, 32, 43, 57, 62, 67, 127, 134, 139, 225, 431, 445
- drogues 48, 57
- drowned river valleys 334-336, 344
- drugs 25, 27, 32-33, 368, 419, 433-434
- dunes 278
- dynamic height 180-181, 202
- Earth
age of 4
environmental change on 2
structure of 59, 87
uniqueness of 90
- earthquakes 41, 62-63, 65, 71-72, 75, 81, 128-129, 137, 205, 208, 223-225, 227-228, 256-257, 276, 278, 335, 407, 412, 423, 442
- epicenters of 128, 276
- turbidity currents and 32, 120, 127-129, 133, 137-138, 209, 256-257, 411, 456, 458
- Earth sciences 159
- East African Rift Zone 67, 72
- East Australian current 183
- East China Sea 117
- Easter Island 15, 67, 77-78
- eastern boundary currents 182-184, 186-187, 201-202, 322, 382
- eastern oyster (*Crassostrea virginica*) 377, 442
- East Pacific Rise 65, 73, 84, 138
- East Wind Drift 185, 201
- ebb currents 231, 245, 250
- Echeneis naucrates* (remora) 306, 374
- Echinocardium* sp. (heart urchin) 359
- echinoderms 265
- echolocation 390-391
- echo sounders 38-41, 56, 302
- echo sounders, wide area 40
- ecological requirements of 29, 34, 52-53, 276, 283, 291-293, 296, 300, 306, 314, 325, 328, 330, 347, 349-352, 355-360, 364, 366, 368, 371, 373, 375, 381-383, 388, 390-392, 396, 398, 407-408, 410-417, 421, 436, 445, 489, 491-492
- ecological requirements, of species 347, 390
- ecology 160, 249-250, 347, 417, 442-443
adaptation in 287, 299-300, 314, 347, 350, 356, 368, 370-376, 388, 391, 408, 411, 492
communication in 388, 391
feeding in 292, 306, 328, 349-352, 355-359, 383, 390-392, 398, 407-408, 411, 413-416
habitats in see habitats
hunting and defense in see hunting and defense
marine 347
navigation in, reproduction in see reproduction
species associations in 333, 383, 391
- ecosystems
assimilative capacity of 420-422, 424, 432, 440-441, 443-444, 493
diversity in 13, 25, 29, 34, 347, 392, 395, 417, 419, 423, 434, 445, 447, 491
- ecosystems, marine
aphotic zone as 108, 284, 286, 290, 302, 313, 348, 411, 416
classification by 281, 396, 415
communities in 396, 415
coral reefs as 1-3, 16, 24-25, 29, 52, 59, 80-81, 122, 131, 221, 228, 255-256, 260, 275-276, 278-279, 289, 298, 312-313, 320, 327, 343-344, 348, 351-353, 355, 364, 383, 392, 395-399, 401, 403, 415-417, 442, 452, 491
hydrothermal vents as 3-4, 19, 52, 54, 57, 93, 97, 104, 113, 124-125, 133, 137-139, 198, 282-283, 286, 292, 297-298, 312, 348-349, 390, 412-414, 416
kelp forests as 285, 299, 312-313, 317, 320, 345, 348, 401-404, 408, 415-417
nutrient-limited 287, 291, 314, 324, 326-328, 344
polar regions as 10, 92, 98, 102, 105, 143, 146-147, 171-172, 182, 185, 193, 200, 313, 326, 345, 392, 409-410, 415, 458-459
rocky intertidal communities as 297, 312-313, 395, 404-408, 415-416
Sargasso Sea as 188-189, 294, 299, 301, 343, 382, 408-409, 415-416
- ecosystem, terrestrial 161, 349, 360, 424
- Ecuador 21

- eddies 29, 48, 175, 187-189, 201-202, 320, 323, 325-326, 343-344, 397, 409
- eels, freshwater 343
Atlantic (*Anguilla* sp.) 381-382
- eels, moray 373-374, 376
darkspotted (*Gymnothorax fimbriatus*) 374
- EEZs (exclusive economic zones) 21-23, 26, 32-33, 427
- effluents 99, 336, 340, 344, 416, 421-422, 432-437, 443-444, 494
- egg cowrie (*Pseudosimnia* sp.) 388
- egg laying 311-312, 325, 377, 380-381, 391
- eggs 248, 304, 307, 311-313, 323, 325, 329, 333, 343-344, 347, 349, 357, 370, 376-377, 380-382, 384-385, 388, 391-392, 404, 414, 488, 492
mortality of 339, 377, 380-383, 391
pelagic 248, 329, 343, 370-371, 376, 380-383, 391-392, 442
- Egyptians, ancient 15, 172, 277
- Ekman motion 177, 200
- Ekman spiral 177-178, 200, 202
- Ekman transport 178-187, 190, 200-202, 265, 321-322, 336, 343-344, 439
- Elagatis bipinnulata* (trevally) 364
- electrical charge 90
- electrical conductivity 46-47, 95, 112-113
- electrical fields 388, 390-391
- electromagnetic radiation, spectrum of, see also light 33, 36, 55-57, 90, 106-107, 109, 112-113, 464-465
- electrons 90-92, 100, 116, 176, 283, 487
- electrostatic charge or attraction 91, 93, 127, 138, 457
- elephant seal (*Mirounga angustirostris*) 24, 309-310, 425
- elevations 6, 36, 39-40, 57, 61, 74, 76, 80, 84, 179, 182-185, 206-207, 215, 223, 225, 235, 242, 250, 278, 452, 463
- elkhorn coral (*Acropora palmata*) 399-400
- El Niño/Southern Oscillation (ENSO) 23, 149, 156-160, 171-172, 185-186, 202, 225, 294
- embryos 424, 494
- emission spectrum 465
- Emperor Seamount chain 77-80
- emperor shrimp (*Periclimenes imperator*) 388
- encrust, encrustation, encrusting organisms 320, 348, 355, 357, 377, 397-398, 400, 403-404, 407-408, 415
- endangered 23, 29, 32
- endangered species 23, 29, 32
- energy
as oceanic resource, 29, 381
from tides 32, 248, 250
kinetic 176, 178, 200, 202, 207-208, 219, 228
of waves 29-31, 127, 136, 206-210, 212-213, 215, 217-221, 224, 227, 255, 260-263, 268-269, 273, 275, 278-279, 398-400, 428
potential, 179, 182, 202, 207-208, 219, 228
- energy, solar 2, 119, 146-147, 162, 167, 171, 397, 410, 458, 463-466
- English Channel 244
- Enhydra lutris* (sea otter) 310, 403-404, 415
- ENSO (El Niño/Southern Oscillation) 23, 149, 156-160, 171-172, 185-186, 202, 225, 294
- environment
benthic 296-298, 312-314, 350, 422, 434
pelagic 296-298, 312-314, 348
- Environmental Protection Agency, U.S. (EPA) 393, 446
- enzymes 282, 287-288, 313, 414
- Ephesus, Turkey 334
- epicenters, of earthquakes 128, 276
- epifauna 297, 313, 348, 359, 362, 390, 392, 429
- epipelagic zone 298, 313-314
- Epitonium billeanum* (snail) 380
- equator 7-8, 11, 55, 62, 78, 131, 135, 138, 143, 146-149, 151, 153-157, 162, 164, 166-167, 171-173, 177, 182, 184-186, 191, 193, 201-203, 225, 228-229, 238, 240-241, 250, 294, 321, 346, 397, 459, 467, 473, 479-482
- Equatorial Countercurrent 202
- Equatorial Undercurrent 202
- equatorial zone, currents in 182, 185-186, 201
- equinoxes 146-147, 149, 172
- Eratosthenes 15, 33
- Eretmochelys imbricata* (hawksbill sea turtle) 310-311
- erosion 22, 56, 59, 70, 77-78, 80-81, 83-85, 93, 113, 115-118, 120, 130, 133-134, 136, 138, 158, 167, 209, 212, 219, 221, 228-229, 253, 255-256, 259-279, 288, 334, 359, 421, 423, 430, 438, 442, 444, 452
by extratropical cyclones 148, 161, 163, 167-168, 171, 223, 294
by glaciers 118
by rivers 116
by waves, 22, 83-84, 118, 167, 221, 261-263, 273-274, 278
human activity and 277, 442
in coastal formation and modification 83, 253, 256, 260, 263, 272-273, 277-278
lithogenous sediment and 83, 116, 118, 221
- estuaries 1, 25, 31, 50, 81, 86, 92, 96, 104, 113, 117, 130, 137, 175, 202, 223, 227, 231, 244-248, 250-251, 256, 263, 276, 279, 285, 295, 317, 325, 331, 334-337, 339-346, 368, 376, 420-424, 427, 430-438, 440, 442-446, 461, 463, 468
as marine habitats 341
bar-built, 334-336, 344
circulation in 336, 339-345, 435, 438, 444
coastal-plain 334-335, 344
contaminants in 339
Coriolis effect in 336, 339-345, 435, 438, 444
fjords as 84, 118, 127, 138, 255, 258-259, 279, 283, 295, 319, 326, 331, 334-336, 339, 344
geological origins of 334
partially mixed 193, 336-337, 339-341, 344-345, 449
pollution in 28, 339, 432, 463
salinity in 336, 339-345, 435, 438, 444
salt wedge 336-337, 339-341, 344
sediment transport in 339
tectonic 334-336, 344-345
tidal currents in 245-246
well-mixed 336-337, 339-340, 344-345
wetlands and 341
- eukaryotes (eukarya) 282, 285, 292, 299, 314
- euphausiids 302, 313-314, 349-350
- Eurasia/ (see Europe and Asia)
- Eurasian Plate 63, 85
- Europe 14, 16, 78, 81, 84-85, 133, 158, 160, 162, 171, 182, 184, 195, 198, 201-202, 244, 275, 381-382, 437, 458, 467
- Europeans voyages of discovery by 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108,

- 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
- eustasy 59, 83-84, 86-87, 115, 139, 253, 257-259, 280, 447, 450, 452-453
- eutrophication 33, 288, 314, 331-332, 344, 422, 432, 435, 443-444
- evaporation 15, 28-29, 32, 92, 95-96, 102, 106, 126, 135, 137, 142, 144-148, 150, 153-155, 157, 161-164, 167-168, 170-172, 176, 185, 191-193, 195, 198, 201, 248, 297, 318-319, 339, 404, 407-408, 429, 454, 458-460, 462, 466
- evaporites 81, 124, 126, 137-138
- Everest, Mount 36, 76
- evolution, theory of 17, 282
- exclusive economic zones (EEZs) 21, 33
- excretion 113, 375, 425
- excurrent openings 304, 350, 355, 358
- exotic terranes 69-70, 84, 86, 93
- expansion, adiabatic 144-145, 172
- exponential (scientific) notation 2
- extinctions, threats of 2, 136-138, 295, 311, 404, 419, 471, 491
- extratropical cyclones 148, 161, 163, 167-168, 171-172, 223, 294
- Extratropical cyclones 161, 167-168, 171
- Extratropical Cyclones 167
- Exxon Valdez 426, 428-431, 443
- Fairbanks, AK 88
- Falco hawkfish (*Cirrhitichthys falco*) 361
- Falkland Islands 22
- false cleaner wrasse 364
- fans, abyssal 85, 129, 138
- fan worms 356, 360, 368
- farmers 469
- farming 25, 466
- fathom 37-38
- fat-soluble contaminants 410
- faults, transform 69, 75-76, 81, 85-87, 256, 336
- fauna 298, 314, 332, 357, 390, 404-405, 414, 430
- fecal pellets 120, 122, 127, 138, 284, 288, 290-291, 296, 312, 314, 324, 343, 359
- feedback 3, 136, 410, 464, 466-467
- feeding 29, 34, 52-53, 276, 283, 291, 293, 296, 314, 325, 328, 330, 349-352, 355-357, 359, 371, 373, 375, 381-383, 388, 390-392, 396, 398, 410, 412-413, 416-417, 436, 445, 489, 491-492
- deposit 356-359, 390-392, 398, 411, 415-416
- filter 349-350, 383, 390, 392, 408, 413-414, 416
- grazers 290, 293, 300, 309, 311-313, 324, 329, 349, 356-358, 390, 392, 403-404, 407-408, 415, 421
- suspension 349-352, 355-356, 390, 392, 398, 407, 411, 416
- Ferrel cells 148-149, 152, 154-155, 161, 171, 182
- Fessenger, Reginald 39
- fetch, of winds 30, 164, 210, 217, 227-228
- Fiji 260, 306, 310, 355, 366-367, 370-371, 374, 400
- filefish 358, 364, 372
- barred (*Cantherhines dumerilii*) 372
- black-saddle mimic (*Paraluteres prionurus*) 364
- seagrass (*Acreichthys tomentosus*) 358
- filter feeders 349-350, 383, 390, 392, 408, 413-414, 416
- fins 29, 49, 303, 308, 361, 364, 368, 372-376, 388, 391
- adaptations of 372
- aspect ratio of 372
- fire goby (*Nemateleotris magnifica*) 361
- fire urchin 366, 388
- (*Asthenosoma intermedium*) 366
- (*Asthenosoma varium*) 388
- fish doctor parasites 384
- fisheries 2, 20, 22-25, 32, 34, 156, 158-159, 183-184, 249, 291, 305, 314, 317, 323-326, 333-334, 344-346, 393, 417, 419-420, 423, 425, 427, 430, 435, 441, 443, 489-491
- fishes 3, 5, 11, 14, 18, 23-25, 29, 37, 51-52, 107, 109, 112, 158, 225, 248, 276, 291-293, 296, 300-305, 307-314, 324, 326, 328-329, 332-334, 342-344, 350-352, 355, 359-361, 364, 366-368, 370-377, 381-385, 390-393, 395, 397, 400, 403, 408-411, 415, 422, 430, 432, 436-437, 442, 489-490
- anadromous 343-344, 376, 381-382, 389, 391, 422, 442-443
- bony 305, 307, 360, 375, 390-391
- cartilaginous 307, 313
- catadromous 343-344, 376, 381-382, 389, 391, 422, 443-444
- collection of 14, 24, 32, 49, 51-52, 57, 298, 311, 425, 439, 490
- fish fluke 385
- Fistularia commersonii* (cornetfish) 370
- fjords 84, 118, 127, 138, 255, 258-259, 279, 283, 295, 319, 326, 331, 334-336, 339, 344
- Flabellina rubrolineata* (nudibranch) 357
- flagella 286, 300, 314
- flagellates 301, 314, 323-324, 328-329, 343, 345, 350
- flamboyant cuttlefish (*Metasepia pfefferi*) 347, 380
- flasher scorpionfish (*Scorpaenopsis macrochir*) 384
- floats 20, 32, 48, 52, 55, 57, 60, 63, 72, 84, 87, 103, 105, 112, 139, 159, 181, 280, 401, 409, 425, 448, 450-451
- flood currents 231, 245
- floods 152, 158-159, 231, 277-278, 335, 337, 339
- flora 298, 314, 404-405
- Flores, Indonesia 14, 224
- Florida 31, 52, 113, 119, 126, 160, 162, 166, 175, 180, 186, 188, 235, 255, 258, 272, 308, 414, 467
- Florida Current 180
- Florida, Straits of 126
- flounder, *Bothus* sp. 371
- flounder, flowery (*Bothus mancus*) 305
- fluids, mixing of 35, 58-59, 87, 89, 114-115, 139, 141, 172, 175, 202, 447
- fluke, fish 385
- fluorine 96
- flyingfishes 375
- Foa brachygramma* (weed cardinalfish) 388
- focus, of earthquakes 26, 31, 36, 286, 390, 466, 469
- fog 147, 169, 322
- Folger, Timothy 17
- food chains 2, 137, 281, 284-285, 291-292, 296, 298, 300, 312-315, 317, 328, 342, 345-346, 408, 415, 447, 468, 488, 494
- food webs 23-24, 120, 129, 158, 291-293, 297, 299, 303, 312, 314, 324, 328, 332, 344, 350, 403, 407, 410, 421, 423, 425, 436-437, 442, 444, 468
- foreshore 262-263, 265, 268-269, 278-279, 404

- forked caudal fins 372, 391
 fossil fuels 2, 12, 27, 29, 31, 33, 99, 116, 124, 195, 200, 229, 249, 279, 417, 435, 464, 466
 fossil record 4
 fossils 2, 4, 12, 18, 27, 29, 31, 33, 63, 68, 99, 116, 124, 126, 130, 134-136, 138-139, 195, 200, 224, 229, 249, 279, 417, 435, 461, 464, 466
 fouling 33, 36-37, 56, 295, 331, 427, 440
 fracture zones 41, 73, 75-76, 84, 86
 fragmentation 377
 France 29, 43, 158, 249, 251, 426, 429
 Franklin, Benjamin 16-17
 Fraser River, BC, Canada 130
 freezing point 92, 99-100, 102-105, 144, 319, 345, 459-460
 frequency 50, 57, 113, 159, 166, 172, 202, 206, 214, 228, 267, 279, 330, 344-345, 404, 411, 438, 440, 443, 467
 freshwater, also see runoff 23, 27, 29, 32, 37, 61, 80, 84-85, 90, 92, 98, 104-106, 113, 116, 146, 153, 155, 161, 171, 179, 186, 191, 194, 196, 198, 201, 245-246, 275, 277-278, 312, 314, 317-319, 321, 325-326, 330-331, 334, 336-337, 339, 341-344, 375-376, 381-382, 391, 398, 409, 423-425, 435, 442, 444
 friction 69, 163-164, 176-178, 183, 186, 189, 200-202, 209, 211-212, 217, 227, 237-238, 245-246, 248, 267, 320, 336, 371, 440, 456, 464, 473, 484
 fringing reefs 80, 86, 221, 259, 275-276, 279-280, 400
 frogfishes 360-362, 371, 373, 380, 408
 Lembeh (*Antennarius* sp.) 380
 sargassumfish (*Histrio histrio*) 408
 striated (*Antennarius striatus*) 361
 fronts
 between water masses 187
 cold 167-168
 fronts between 187
 frustules 121-122, 132-133, 137-138, 289, 300-301, 313, 329
 fundamental niches 396, 407-408, 415-416
 Fundy, Bay of 246, 249, 255, 280
 fungi 120, 282-284, 290, 296, 313, 348, 357-358
 fusion, latent heat of 33, 100-102, 105, 112-114, 173, 345, 458-459
Gadus morrhua (Atlantic cod) 305, 490
 Gakkel Ridge 73, 412
 Galápagos Islands 17, 310
 Galápagos Ridge 412
 Galveston, TX 26, 235, 255, 272-273, 279, 429, 442
 Ganges River 85, 117, 277, 319
 gas, gases:
 dissolved 95-98, 112, 190-191
 greenhouse 2, 32, 114, 136, 159, 161, 173, 203, 212, 279, 464-467, 469
 natural 23, 26-27, 32-33, 43, 81, 85, 139, 277, 295, 414, 427, 442
 transfer between oceans and atmosphere 97
Gastrolepidia clavigera (scale worm) 388
 gastropods 350, 357, 368, 389, 406
 gelatinous holoplankton 303
 gelbstoff 97
 generators, wave energy 30-31
 genetic diversity 25, 34, 376-377, 383, 391-392, 417, 445, 491
 genetics 25, 34, 52, 282, 304, 376-377, 381, 383, 391-392, 414, 417, 424, 445, 488, 491, 494
Genicanthus melanospilos (black-spot angelfish) 373
 genus, in taxonomy 282, 299, 313, 404, 408, 414
 Geographic Information Systems (GIS) 56
 geological record 71
 geologists 22
 geology 2, 11, 18, 87, 139-140, 412, 456
 Georges Bank 325-326
 Georgia, GA 71, 186, 235
 Geosat satellite 41
 geostrophic flow 141, 164, 173, 175, 180, 182, 184, 187, 203, 205, 225, 229, 447, 483-484
 Germany 15, 21, 43
 ghost pipefish (*Solenostomus paradoxus*) 362
 giant clam (*Tridacna gigas*) 388-389
 Gibraltar 126, 193-194, 462
 Gibraltar, Straits of 126, 193-194, 462
 gills 308, 313, 375, 439
 glacial flour 118-119
 glacial maxima 83
 glaciation 116, 138, 452
 glaciers 2, 27, 60, 83-84, 87, 90, 116-119, 127, 130, 132-133, 135, 137-139, 196, 253, 256-259, 276, 335-336, 344, 410, 450, 452, 454
 Global Positioning System (GPS) 35-36, 48, 56
 global warming 3, 83, 159, 167, 172, 202, 453, 464, 466
 Glomar Challenger 43
Gnathophylloides mineri (urchin shrimp) 388
 goatfishes, blackstriped (*Upeneus tragula*) 359
 Gobi Desert 119
 gobies 359-361, 364, 373-374, 384, 388-389
 fire (*Nemateleotris magnifica*) 361
 Old Glory (*Amblygobius rainfordi*) 374
 whip (*Bryaninops yongei*) 384
 yellow shrimp (*Cryptocentrus cinctus*) 389
 GoFlo bottle 45-46
 gold 24, 27-28, 96
 Goldman's sweetlips (*Plectorhinchus goldmanni*) 375
 Gondwanaland 65, 85
 Goode's interrupted projection 9-11
 Gorda Plate 69
 gorgonian seahorse see pygmy seahorse
Gorgonocephalidae (basket stars) 355-356
 GPS (Global Positioning System) 35-36, 48, 56
 grab samplers, 42-43, 52, 57-58
 graded beds 128, 137-138
 grain size 31, 116, 127-130, 137-139, 266, 268-269, 272, 278, 280, 396, 423, 442, 457-458
 Grand Cayman Island 141
 granite 61, 265
 grapeweed (*Caulerpa racemosa*) 320
 graph 5, 11-12, 470
 graphs 5
 Graphs 5, 11
 grasses 264, 270, 276, 278, 282, 299, 311, 313, 358
 gravel 27-28, 116, 128, 137, 278-279, 317, 352, 381-382, 430
 gravity 36, 42-43, 57, 60, 62-63, 90, 106, 120, 193, 207-209, 213, 218, 221, 227, 231-232, 234, 266, 376, 447-448, 456, 473, 476-480, 482
 buoyancy of fishes and 376
 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 193
 waves and 176, 207-208
 gravity corers 42-43
 gray reef shark (*Carcharhinus amblyrhynchos*) 306, 373
 grazers, grazing 290, 293, 300, 309, 311-313, 324, 329, 349, 356-357, 390, 403-404, 407-408, 415, 421
 Great Barrier Reef 276
 Great Britain, see United Kingdom 21-22, 43, 217, 429, 435, 441
 great circle 8
 Great Lakes of North America 227
 great white shark (*Carcharodon carcharias*) 24, 306
 Greece 71, 331, 429
 Greeks, Ancient 15, 83, 334
 greenhouse effect 1-3, 12-13, 33, 56, 82-84, 87, 89, 98-99, 102, 111, 114-115, 134, 136, 139, 141-142, 145-146, 172-173, 175, 189, 195, 203, 205, 212, 229, 249, 258, 271, 314, 395, 417, 447, 453, 463-464, 466-468
 greenhouse gases 2, 32, 114, 136, 159, 161, 173, 203, 212, 279, 464-467, 469
 Greenland 2, 10, 16, 73, 78, 84, 118, 193-196, 200-201, 290, 441
 Greenland Sea 193
 Greenwich, England (near London) 8, 11
 groins 273-275, 278-279, 424
 Groundwater 90, 113, 146, 172, 283, 424-425, 427, 454
 grunion (*Leuresthes tenuis*) 248, 380
 Guam 22, 255
 Gulf Stream 17, 29, 153, 162, 167, 180, 183-184, 186-189, 195, 201-202, 225, 323, 343, 382, 458
 Gulf War 430
 guyots 80, 86
Gymnosarda unicolor (dogtooth tuna) 305
Gymnothorax fimbriatus (darkspotted moray eel) 374
 gyres 153, 177, 181-188, 194, 201-203, 289, 294, 312, 318, 321-322, 326, 343, 382, 408, 415, 439-440
 subpolar (high-latitude) 185, 201
 subtropical 153, 177, 182-185, 187-188, 202, 289, 294, 312, 382, 408, 439-440
 habitats 11, 24, 32-33, 52-53, 57, 248, 270, 276, 311, 331, 343, 345, 347-349, 358, 362, 381-382, 388, 390, 392, 408, 415, 422-423, 442-444, 485, 491
 hadal zone 296, 313
 Haddon's sea anemone (*Stichodactyla haddoni*) 369
 Hadley cells 148, 152, 154-155, 161, 171, 182
 hadopelagic zone 298
 half-life 199, 460-461
Halimeda sp. (algae) 265, 388
 haloclines 179, 191, 193-194, 202, 318-319, 322, 326, 336-337, 339-340, 342-345, 409, 415
Hapalochlaena sp. (blue-ringed octopus) 281, 368
 harbors 25, 209-210, 221, 223, 228, 231, 235, 244, 246, 271, 274-275, 278, 309, 331, 334-336, 341, 403, 420, 431, 437, 440
 harbor seal (*Phoca vitulina*) 309
 hard parts 2, 93, 95, 113, 116-117, 120-123, 137-138, 289, 296, 302, 312-313, 327, 345, 352, 398, 400, 415
 harmonics 227-228
Harpa major (harp shell) 350
 harp shell (*Harpa major*) 350
 hatchetfish 411
 Hawaii 3, 15-16, 21-22, 30-31, 34, 59, 62-63, 76-78, 115, 125, 129, 160, 170, 221, 223-225, 255-257, 262, 265-266, 279, 310, 320, 358, 364, 367, 371-372, 380, 383, 421, 429
 Hawaiian Island-Emperor Seamount chain 77-78, 80
 hawkfishes 360-361, 400
 Falco (*Cirrhitichthys falco*) 361
 longnose (*Oxycirrhites typus*) 400
 headlands 219, 227, 260-262, 265, 267-268, 270-271, 279
 Heard Island 111
 heat 1, 3, 12-13, 31, 33, 52, 59, 63, 72-74, 76, 83, 87, 89, 92, 99, 101-102, 105, 112-114, 124, 139, 141-143, 145-148, 150-152, 158, 161-162, 164, 167-169, 171-173, 175, 184, 188-191, 195-196, 198, 201-203, 205, 209, 213, 227, 229, 248, 284-285, 310, 314, 317, 345, 383, 412-413, 417, 420, 447, 450, 454-455, 458-461, 464-469, 471
 Earth's budget of 145-146
 latent 33, 92, 100-102, 105, 112-114, 145-147, 164, 171-173, 345, 458-459
 sensible 100, 102, 113, 146, 167, 172
 heat capacity 33, 89, 92, 100-102, 112-114, 142, 150-151, 161-162, 167-168, 171-172, 213, 229, 345, 458-459
 heat transfer 143, 146-147, 171, 454, 458, 467-469
 Heezen, Bruce 19, 40, 56, 58, 140
 helium 35, 62, 90, 96, 439, 450
 herbicides 422, 444
 herbivores 283-284, 290-291, 296, 298, 301, 312-313, 324, 328-330, 350, 356, 392, 407
 hermaphroditism 377
 hermatypic (reef-building) corals 80, 259, 275, 278, 327, 352, 396-397, 400, 415-416, 421
Hermisenda crassicornis (horned nudibranch) 402
 hermit crabs 385, 388-389, 406, 408, 416
 Herodotus 14-15, 34
 herring gull (*Larus argentatus*) 311
 herrings 292, 305, 307
Heteractis magnifica (anemone) 355
 heterocercal caudal fins 373, 391
 heterotrophs 282-284, 290, 312
 high-latitude gyres 177, 182
 high-pressure zones 147-148, 150, 152, 157-158, 160, 164, 483-485
 high seas 20, 24, 32-33, 427
 high-tide line 231, 250, 262-263, 265, 269, 279, 297, 311, 380, 404, 407
 high-tide zone 404, 407-408, 415
 hills, abyssal 61, 80, 86
 Hilo, Hawaii 170
 Himalaya Mountains 65, 71-72, 85-86, 152
Hippocampus bargibanti (pygmy seahorse) 362
Hippocampus kuda (spotted seahorse) 362
Hippolyte commensalis (humpbacked shrimp) 388
Histrion histrio (sargassumfish) 408
 HIV/AIDS 25, 424
 HIV/AIDS virus 25, 424
 Hokule'a 34
 holoplankton 301-304, 313

- Homer, AK 270
hominids 5
Homo erectus 14
Homo sapiens 282
Honolulu, Hawaii 170
horned nudibranch (*Hermisenda crassicornis*) 402
horned sea star (*Protoreaster nodosus*) 399
horse latitudes 148, 154
horseshoe crab (*Limulus polyphemus*) 380
hot spots 62-63, 66, 76-80, 84, 86, 124, 256, 276, 280, 452
Huang (Yellow) River 117
Hudson Bay, Canada 85
Hudson River 246, 335-336
Huenia heraldica (arrowhead crab) 388
Hugo, Hurricane 166
humidity 404, 407, 472
humpbacked shrimp (*Hippolyte commensalis*) 388
humpback whale (*Megaptera novaenglia*) 308
hunting and defense 14, 23, 32-33, 39, 53, 58, 272, 291, 308-310, 330, 345, 348-351, 359-362, 364, 367-368, 371, 373-374, 376-377, 390-391, 404, 407, 410-411, 415-416, 492
 camouflage in 360, 362, 364, 385, 388, 391
 concealment in 360, 364, 366, 368, 391
 group cooperation in 301, 305, 360, 368, 370-371, 390-391
 lures in 52, 360-362, 373, 390, 411
 poisons in 330, 348, 360, 368, 391-392
 speed in 360
 spines and armor in 106, 286, 348, 360, 364, 367-368, 373-374, 388-389, 391
hurricanes 1-2, 56, 117, 141, 145, 147, 157, 159, 163-167, 171-172, 211-212, 223, 228, 271-272, 277, 279, 459, 467, 469, 491
Hurricanes 164-166, 171, 223, 228, 467
hydration 93, 113
hydrocarbons 97, 414, 416, 425, 427-429, 431, 435, 445
hydrocarbons, polyaromatic (PAHs) 431, 444
hydrogen 3-4, 11, 31, 62, 90-93, 99-103, 105-106, 112-113, 135, 199, 283, 287, 295, 312, 339, 344, 348, 412-414, 416, 420, 440, 486-488
hydrogen bonds 91-93, 99-103, 106, 112-113
hydrogenous sediment 116, 124, 126-127, 130, 137-138
hydrogen sulfide 4, 283, 295, 312, 339, 344, 348, 412, 414, 416, 420
hydrographic surveys 17
hydrographic wire 46
hydroids 357, 368, 385, 395, 408, 413, 416
hydrologic cycles 90, 440
hydrophones 43, 57, 111, 113
hydrosphere 60-61, 86
hydrostatic pressure 277, 279
hydrothermal minerals 27, 33, 124, 133
hydrothermal vents 3-4, 19, 52, 54, 57, 93, 97, 104, 113, 124-125, 133, 137-139, 198, 282-283, 286, 292, 297-298, 312, 348-349, 390, 412-414, 416
 black-smoker 413
Hymenocera elegans (harlequin shrimp) 349
hypoxia 331-332, 344-345, 422, 432, 444
Hypselodoris bullocki (nudibranch) 380
ice
 density of 103-105
 formation of 104, 460
 heat-buffering effect of 102
 ice ages 83-84, 86-87, 118, 124, 195-196, 198, 277, 334, 450, 454, 464, 467
 ice algae 409-410, 415
 ice exclusion 161, 191, 193-194, 201-202, 409, 415
 Iceland 15-16, 23, 73, 76, 78, 160, 195, 201
 Icelandic Ridge 78
 ice-rafted sediment 133
 ice sheets 2, 83-84, 90, 135, 149, 193, 196, 410, 453, 459, 467
 iguana, marine (*Amblyrhynchus cristatus*) 310
 incidence, angle of 146-147, 172, 286-287, 313
 incubation 377
 incurrent openings 304, 350, 355
 India 16, 63, 65, 71-72, 85-86, 152, 158, 223-224, 256, 277
 Indian Ocean 17-18, 22, 85-86, 111, 117, 133, 150, 152, 156, 160, 166, 182, 193, 195, 211, 222-224, 243, 298, 321
 Indo-Australian Plate 71, 85
 Indonesia 14, 27, 62, 70-71, 136, 156-158, 171, 223-224, 256, 281, 303, 307, 310, 321, 350, 353, 355-357, 359, 361-362, 364, 366, 369, 380, 384, 388-389, 399
 Indonesian Arc 85
 Indus River 85, 117
 Industrial Revolution 2, 200, 295, 419
 industrial waste 23, 330, 424
 inertial currents 189, 201
 inertial period 473, 481-482
 infauna 297, 313, 348, 358, 390, 392, 429, 434, 443
 innkeeper worm (*Urechis caupo*) 358-359
 in osmosis 343-344, 375-376, 381-382, 389, 391, 422, 442-444
 in situ measurements 57, 200
 interference, in waves 206, 215, 227-228
 intermediate waves 217-218, 228
 internal waves 195, 225, 228-229, 320, 325, 336, 339, 343, 345
 International Ocean Drilling Program (IODP) 43, 67, 140
 International Seabed Authority (ISA) 21-22
 International System of Units (SI) 11-12, 96, 100
 interstitial (pore) water 27, 135, 138, 296, 358, 390, 414
 intertidal (littoral) zone 231, 248, 250, 264-265, 267, 278, 297, 312-313, 348-349, 390, 392, 395, 404, 406, 415-416
 intertropical convergence zone (ITCZ, doldrums) 148, 176, 185
 inverse estuaries 339, 344
 invertebrates 5, 11-12, 51-52, 282, 301-302, 304-306, 310, 313-314, 323, 329-330, 334, 342-343, 345, 351, 353, 355, 359-360, 362, 364, 366, 368, 375-377, 381, 388-391, 397-400, 403, 409-410, 412-413, 415-416, 422, 442-444, 489
 iodine 96, 100, 440
 ionic bonds 91-93, 113
 ions 91, 93, 95, 99, 104, 106, 112-113, 124-125, 281, 283, 287-289, 295, 299, 324, 375, 459, 462, 487
 complexed 440, 493
 Iran 71
 Iraq 430
 iridium 96, 136
 iron 27, 37, 58, 60-62, 90, 94, 96-97, 116, 124-125, 133-135, 265, 283, 287, 289, 295, 312, 314, 324, 409, 412-413, 417, 445
 iron oxide 125, 133
 ironshore 260
 Irrawaddy River 117
 island (mountain) effect 161, 170
 islands, barrier 2, 255-256, 258, 261, 265, 269-274, 278-280,

- 334-336, 344
 islands, sedimentary and magmatic arc 69-71, 84-86, 93, 256
 islands, volcanic 69-71, 78, 80, 84-86, 224, 256-257, 276, 280
 Isobaric contour maps 484
 isobars 6, 483-485
 isopods 404, 407, 415-416
 isopycnals 6, 12
 isostasy 59, 61, 86-87, 115, 139, 253, 280, 447, 450-451
 isostatic leveling 77, 83-84, 86-87, 257-260, 272, 279-280, 450, 452-454
 isotherms 6, 12, 152-153, 172
 isotopes 87, 97, 113, 135, 139, 199, 202-203, 440, 460-461
 Israel 15, 172
 Italy 15, 331, 429
 Ivan, Hurricane 211
 IXTOC oil rig explosion 427-428, 430
 Jalisco, Mexico 224
 Jamaica 335
 Jamaica Bay 335
 Japan 22-23, 38, 43, 67, 70, 136, 153, 160, 162, 195, 202, 205, 222, 224, 331, 343, 423, 436-437, 441, 443-444
 Japan (Kuroshio) Current 153, 162, 183, 189, 343
 Japan, Sea of 331, 441, 444
Jason II ROV 53-55
Jason Jr. ROV 54
 Java 71, 85, 223-224
 Java Sea 85
 jellyfish 5, 23, 303-304, 311, 313, 350-351, 439
 jet streams 119, 148, 160, 172, 225, 228-229
 jetties 273-275, 278-280
 Johnson Sea Link 52
 JOIDES Resolution 43
 Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection (GESAMP) 419
 joule (J) 100, 113, 228
 Juan de Fuca Ridge 73
 juveniles, of marine organisms 270, 276, 278, 300-301, 304-305, 313, 328-329, 333, 342-343, 364, 377, 381-382, 385, 422, 430, 442, 488, 490, 492-494
 Kahoolawe, Hawaii 170
 Kailua-Kona 170
 Katrina, Hurricane 166, 277
 Kauai, Hawaii 255, 279
 Kealakekua Bay, Hawaii 16
 Keeling Atoll 80
 kelp 285, 299, 312-313, 317, 320, 345, 348, 401-404, 408, 415-417
 kelp forests 312, 348, 401-404, 415-417
 Kelvin waves 225, 228
Kentrodoris rubescens (nudibranch) 380
 Kilauea volcano 59, 76-77, 256-257, 266
 killer whale (*Orcinus orca*) 292, 308-309, 403
 kinetic energy 176, 178, 200, 202, 207-208, 219, 228
 king crab 23-24, 304
 Klein's butterflyfish (*Chaetodon kleinii*) 370
 Kona, Hawaii 30
 Krakatau (Krakatoa) 70-71, 120, 136, 223-224
 krill 292-293, 302, 313, 345, 349, 392, 410, 416
 Kuril Islands 22
 Kuroshio (Japan) Current 153, 162, 183, 189, 343
Labroides phthirophagus (cleaner wrasse) 364
 lagoons 29, 79-81, 130, 138, 228, 256, 269-271, 276-280, 311, 317-319, 336, 345, 383, 398-399, 415
 Laguna Madre, TX (south of Galveston) 339
 Lanai, Hawaii 224
 landfills 424, 427, 432-433, 436
 land-ocean-atmosphere interactions 171
 Landsat satellite 341, 346
 landslides 74, 116, 120, 208, 223, 256-257, 278, 280
 Langmuir circulation 190, 201-202, 299, 320, 325, 336
 La Niña 156-159, 171
 lanternfish 411
 La Rance, France (English Channel, French coast) 29, 249, 251
Larus argentatus (herring gull) 311
 larvae 106, 121, 248, 301, 304, 313, 323, 325, 329, 333, 342-345, 349, 368, 370, 377, 380-382, 384-385, 391, 407, 414, 488, 490, 492, 494
 lasers 55, 106-107
 Lassen, Mount, CA (near CA-OR border) 69
 latent heat of fusion 33, 100-102, 105, 112-114, 173, 345, 458-459
 latent heat of vaporization 33, 92, 100-102, 112-114, 144, 146-147, 171-173, 458-459
 lateral line 390
 Laticauda colubrine (banded sea snake) 310
 latitude 7-9, 11-12, 15, 33, 78, 114, 125, 146-150, 152, 154-155, 161-163, 171, 173, 184, 189, 191, 195, 200, 225, 229, 238, 241, 244, 260, 298, 326, 417, 459, 468, 473, 476, 479, 481-482
 latitudinal imbalance, of Earth's heat energy 145, 171
 latitudinal transfer, of heat 1, 12-13, 33, 89, 114, 141, 172, 196, 205, 229, 317, 345, 447, 458
 latitudinal variation, of marine environments 298
 lava 44, 59, 72-73, 76, 93, 170, 255-256, 266, 407
 Law of the Sea conferences 20-22, 29, 32-33
 law of the Sea Treaty (LOS) 21-22, 29, 32-33, 433-436
 leaching 113, 116, 125, 138
 leatherjacket see black-saddled mimic filefish
 Lebanon 15
 leeward 80, 169-172, 209, 400
 Lembeh frogfish (*Antennarius* sp.) 380
 lemon damselfish (*Pomacentrus moluccensis*) 384
Leuresthes tenuis (grunion) 248, 380
 levees 28, 259, 277-279, 336, 421-422
 lichens 404, 415
 light
 infrared 36, 106-108, 145-146, 188, 463-466
 primary production and 1, 11-12, 35, 58-59, 81, 87, 89, 97, 107-108, 112-115, 120, 125, 137, 139, 260, 276, 281, 283-287, 289, 295-300, 312-314, 320-321, 343-344, 347-349, 392, 395, 397, 401, 412, 415, 417, 419, 421-422, 445, 447, 485-488, 492-493
 ultraviolet 3, 36, 106-108, 143, 146, 287, 463-465, 486
 underwater transmission of 106, 112, 114
 light-limited productivity 1, 12, 35, 58-59, 87, 89, 114-115, 139, 281, 314, 347, 392, 395, 417, 419, 445, 447, 485
 limestone 126, 398, 414
 limiting nutrients 287-289, 295, 312-314, 421
 limpets 404, 406-407, 413, 415-416
Limulus polyphemus (horseshoe crab) 380
Linckia laevigata (sea star), 384

- lined chiton (*Tonicella lineata*) 406
lionfishes 373-374
 zebra (*Dendrochirus zebra*) 374
lipids 97
lithogenous (terrigenous) sediment 81, 116-120, 123-124, 126, 128-133, 137-138, 287, 296, 329
lithosphere 60-63, 67, 70, 72, 74-76, 79, 85-86, 451
lithospheric 22, 60, 63, 65-67, 70, 72-76, 79-81, 84-86, 93, 123-125, 129, 133, 135, 138-139, 195, 241, 256, 276, 283, 412-414, 416, 452-453
lithospheric plates 60-63, 65, 72, 75, 77-78, 81, 85-86, 93, 256, 450-452, 472
litter 125, 276, 349, 440
littoral (intertidal) zone 231, 248, 250, 264-265, 267, 278, 297, 312-313, 348-349, 390, 392, 395, 404, 406, 415-416
littoral (longshore) drift 31, 130, 266-270, 272-275, 278-279, 335-336, 345
Littorina sp. (periwinkles) 404, 407, 415
lizardfishes 360-361
 twospot (*Synodus binotatus*) 361
lobster pots 51-52, 307
lobsters 51-52, 112, 302, 304, 307, 368
logarithmic scales 5, 99, 301
log plots 5-6
Loihi Seamount, Hawaii 77, 256
Loma Prieta earthquake 41, 75, 129, 137, 256, 276
Long Island, NY 247, 274, 325
Long Island Sound 247
longitude 7-8, 11-12, 14-16, 33, 238, 468
longnose hawkfish (*Oxycirrhites typus*) 400
longshore bars 221, 263, 265, 268-270, 273, 278
longshore currents 190, 202, 213, 228, 266, 278
longshore (littoral) drift 31, 130, 266-270, 272-275, 278-279, 335-336, 345
Long Valley, CA (east of San Francisco near C-NV border) 120
Long Valley caldera 120
Lorenz, Edward 470, 472
Lorenzian waterwheel 470-471
Los Angeles, CA 433-436
Louisiana (LA) 138, 166, 277, 414, 435
low-pressure zones 147-148, 150, 152, 157-158, 163-165, 167-168, 171, 187, 189, 225, 483-484
low-tide lines 231, 248, 250, 261-265, 269, 276, 278, 297, 398, 404
low-tide terrace 265, 278
low-tide zone 404, 408, 415
lugworm (*Arenicola brasiliensis*) 358
lunar month 237-240, 250
lunate caudal fins 372-373, 391
lures, in hunting and defense 52, 360-362, 373, 390, 411
Macdonald Seamount chain 77-78, 417
Macedonia (Balkans) 71
Mackenzie delta, Yukon, Canada 277
mackerel 292, 376, 489
macroalgae 285, 298-299, 313, 320, 342, 345, 356-357, 377, 390, 397, 401, 407-408, 415-416
Macrocystis sp. (kelp) 285, 320
Madagascar 85, 152
Madden-Julian Oscillation (MJO) 159
Magellan, Ferdinand 16, 429
magma 61, 63, 67, 69-74, 76, 78, 85-86, 412-413, 416
magmatic arcs 69-71, 84-86, 256
magmatic rocks 74, 78, 416
magnesium 94-96, 126, 283, 287, 412, 487
magnetic fields 62, 78, 134, 139, 388, 390-391
magnetism 63
Maine, Gulf of 326
maine (ME) 169, 326, 407
Majidae (crabs) 362
major constituents, of seawater 95-96
malaria 437, 445
Malaysia 22
Malibu Beach, CA (north of Los Angeles) 267
mammals, marine 3, 18, 31, 52, 111, 158, 305, 307, 309-310, 313, 331, 333, 360, 364, 370, 383, 403, 410, 430-431, 439, 442-444
manatee (*Trichechus manatus*) 357
mandarinfish (*Synchiropus splendidus*) 380
manganese 20, 22, 27-28, 33, 44, 94, 96, 124-126, 135, 137-139, 283, 412-413
manganese nodules 20, 22, 27-28, 33, 44, 124-126, 137-138
mangroves, mangrove swamps 2, 97, 255-256, 264, 270, 276, 278, 282, 342, 344, 395, 422, 443
Manta birostris (manta ray) 306, 308, 375, 388, 400
mantle, Earth's 60-63, 65, 67, 69-70, 72, 74, 76, 83, 85-87, 93, 124, 388, 447, 451-452, 454-456
maps, mapping 1, 5-17, 19, 21, 32, 34, 36-41, 43, 55-58, 87, 164, 167-168, 181, 189, 225, 228-229, 248, 257, 332, 346, 421, 437, 483-484
marginal seas 27, 74, 81, 84-86, 95, 117-118, 126, 130, 138, 155, 171, 318-319, 331, 344, 409
Marginopora vertebralis (foraminifera) 122
margins, continental 67, 81, 83, 93, 117, 130-131, 138
Mariana Arc 124, 412
Mariana Islands 70
Mariana Trench 18, 54, 70
mariculture 25
marine mammals 3, 18, 24, 31, 52, 111, 158, 305, 307, 309-310, 313, 323, 331, 333, 360, 364, 370, 383, 403, 410, 430-431, 439, 442-444, 446
marine organisms
 behavior of, //347-391 52
 benthic 29, 50-52, 57, 122, 293, 296-298, 301, 304, 306, 308, 312-314, 320, 331-332, 342, 344, 348, 350-352, 356-358, 376-377, 381, 388-392, 397-398, 410, 415-416, 421-422, 430, 432, 434, 439, 442-443
 calcareous 121-124, 131-133, 135, 137-138, 265, 276, 301, 303, 313, 320, 362, 398, 400, 415
 chemical sensing in 380, 388-389
 classification of 282
 colonial 303-304, 350, 355-356, 370, 377, 391
 communication in 388, 391
 density of 411
 detritus of 93, 113, 120-121, 126, 135, 138, 276, 278, 283, 288-289, 292, 295-298, 312-313, 324-325, 330-331, 342-344, 348-351, 355-359, 362, 390-391, 397-400, 402-403, 407-408, 411, 415-416, 456, 468
 distribution of 298
 effects of toxins on 424-425, 443-444, 492-494
 excretions from 97, 113, 284, 288, 312, 314, 346, 375, 424-

- 425, 431, 436
 eyes in 389, 410, 415
 fouling by 33, 36-37, 56, 427, 440
 hard parts of 2, 93, 95, 113, 116-117, 120-123, 137-138, 289, 296, 302, 312-313, 327, 345, 352, 398, 400, 415
 magnetic fields sensed by 390
 navigation in 388, 391
 oviparous 377, 391
 ovoviviparous 377, 391
 pelagic 50-51, 57, 122, 131, 138, 292-293, 296-298, 305, 312-314, 348, 350, 356, 364, 370, 376-377, 380-381, 390, 392, 410, 416, 422, 442
 siliceous 116, 122-123, 131-133, 135, 137-138, 289, 300, 314
 tides and 248
 viviparous 380, 392, 404
 wetlands and 2, 32, 127, 130, 263, 276-279, 336, 340, 342-344, 358, 422, 424, 429-430, 442-444
- marine organoisms
 diversity of 13, 25, 29, 34, 347, 376-377, 381, 383, 391-392, 395-397, 417, 419, 423, 434, 444-445, 447, 491-492
- marlin 372
- Marquesas Islands 15
- Mars 2, 18, 36, 41, 90, 424
- marshes, salt 81, 97, 256, 276, 283, 342, 430
- marsh grass, *Spartina* sp. 357
- Maryland (MD) 129, 270, 331
- Massachusetts (MA) 40, 162-163, 235, 255, 318
- mass wasting 120
- mathematical modeling 12, 14, 33, 47, 56-58, 149, 157, 159, 173, 182, 185, 190, 200, 203, 238-241, 248, 284, 295, 314, 410, 462, 464, 466-470, 472, 490, 493
- Maui, Hawaii 265
- Mauna Loa, Hawaii 3, 77
- Maury, Matthew Fontaine 17
- maximum sustainable yield 13, 23, 25, 33-34, 317, 333, 344-346, 395, 417, 447, 489-491
- meanders 148, 172, 188-189, 201-202, 225, 229
 of Gulf Stream 188-189, 201, 323
 of jet streams 148-149, 167-168, 171, 225, 409
- mechanical current meters 49
- Medea* ROV 53-55
- Mediterranean Sea 14-15, 32, 85, 126, 129-130, 155, 160, 192-195, 201-202, 318, 339, 381-382, 462
- Megaptera novaengliae* (humpback whale) 308
- Mekong River, Delta 117
- Melithaea sp. (gorgonian sea fan) 355
- menhaden 23, 305, 331
- Mercator projection 8-12, 14, 39
- mercury 46, 90, 96-97, 106, 330, 420, 425, 436-437, 448
- Meridional Overturning Circulation (MOC) 195-196, 198, 201, 295, 332
- meroplankton 301-302, 304, 313, 377, 380, 391
- mesopelagic zone 298
- mesoscale eddies 189, 201
- mesosphere 143
- metacercaria 385
- metamorphosis 296, 313
- Metasepia pfefferi* (flamboyant cuttlefish) 347, 380
- meteorites 3, 62, 116, 126-127, 136-137, 208, 223-224
- meters, current 47, 49-51, 57
- methane 2-4, 23, 27, 32, 90, 99, 114, 128, 283, 412-414, 416, 463, 466
- methane hydrates 23, 27, 32, 128
- methylmercury 425, 436-437, 443
- Mexico 2, 20, 22, 26, 69, 83, 85, 117, 127, 133, 136-137, 160, 166, 172, 175, 180, 196, 211, 224, 235-236, 244, 251, 258, 269, 311, 331-332, 414, 426-428, 430, 435
- Mexico, Gulf of
 dead zone in 332
 oil rigs in 23, 26, 32, 442
- Mexico, Gulf of CA 175
- Meyer's butterflyfish (*Chaetodon meyeri*) 371
- Miami Beach, FL 272, 279
- Miami, FL 272, 279
- Microalgae 342, 344, 356, 390, 397, 416, 421
- Micronesia 15, 32
- Micronesians 14, 16, 33
- micronutrients 324, 344, 409
- microorganisms 4, 11, 51-52, 106, 129, 283-285, 296, 348, 399, 423, 445
- Mid-Atlantic Ridge 13, 65, 72-73, 83-84, 86, 126, 412
- Middle East 83
- middle-tide zone 404, 407-408, 415-416
- mid latitudes 167, 178, 191, 321, 329, 405
- migration, and reproduction 14, 52, 77, 150-151, 258, 270, 272, 278, 290-291, 295, 302, 343, 375, 381-383, 393, 410
- mimicry 360, 362, 364
- mimic surgeonfish (*Acanthurus pyroferus*) 364
- Minamata, Japan 423, 436-437, 443, 446
- Mindoro Island, Philippines 224
- mining, seafloor 21-22, 27-29, 32, 116, 124, 317, 412
- Minoan civilization 14, 224
- minor constituents, of seawater 96-97
- miracidium 385
- Mirounga angustirostris* (elephant seal) 24, 309-310, 425
- Mississippi (MS) 117, 166, 196, 259, 277, 279, 332, 334, 435, 442
- Mississippi River 259, 279, 332, 334, 435
- Mississippi Sound 442
- mixed (surface) layer, of ocean water 20, 38, 58, 98, 105, 114, 131, 157-158, 176-177, 179-182, 184-186, 190-192, 194, 196, 199-203, 207, 283, 290-291, 294, 296, 298, 301, 308, 312-314, 318-319, 321-331, 336, 339-340, 342-345, 348, 408-409, 416, 449, 458, 468, 486
- mixed tides 235-236, 238, 244-245, 250-251, 380
- mixing of 197-198
- mixing, of water masses 47, 95-96, 98, 114, 139, 152, 158, 168, 175, 185, 190-191, 193-195, 198, 201-202, 228, 247, 291, 294-295, 299, 318-320, 324-325, 327-329, 331, 334, 336-337, 339, 343-344, 376, 381, 408-409, 414-415, 420, 447, 449-450, 468
- Mnemiopsis leidyi* (ctenophore) 303
- MOC (Meridional Overturning Circulation) 195-196, 198, 201, 295, 332
- modeling, mathematical 12, 14, 33, 47, 56-58, 149, 157, 159, 173, 182, 185, 190, 200, 203, 238-241, 248, 284, 295, 314, 410, 462, 464, 466-470, 472, 490, 493
- molecules
 clustering of 104-105, 370, 459
 friction between 176
 polar 92, 100

- water 4, 90-93, 99-100, 102-107, 112-113, 135, 143-144, 176, 191, 199, 207-208, 212-214, 217, 219, 375, 440, 456, 459, 483, 487
- mollusks 116, 138, 265, 303, 307-309, 311, 313, 350-352, 357, 366, 368, 385, 388-389, 395, 398, 408, 416, 440, 442
- bivalve 351-352, 368, 385, 398
- gastropod 350, 357, 368, 389, 406
- Molokai, Hawaii 262
- molybdenum 27, 96
- monsoons 16, 152-153, 155, 161, 172, 279, 319
- Montenegro (Balkans) 71
- Monterey 23, 41, 129, 253, 255, 261-263, 285, 309, 311, 320, 353, 401-402, 406, 422
- month, lunar 237-240, 250
- Montrose Chemical Corporation 436
- moon
- declination of 238, 240, 250
- gravitational attraction of 208-209, 232, 250
- moon wrasse (*Thalassoma lunare*), 374
- moraines (deposition sites) 258-259
- moray eels 373-374, 376
- Morocco 429
- mosquitoes 106, 437
- Moss Landing Power Plant, CA (near Monterey) 422
- Most weather maps in newspapers 484
- mountain (island) effect 161, 170
- mountain ranges 37, 59, 61, 63, 69, 75, 117, 155, 162, 169, 171, 259
- Mozambique 429
- mud 18, 36, 38, 41-42, 116, 129, 131, 133, 276, 297, 312, 358, 364, 367, 423
- mud snail (*Nassarius papillosus*) 367
- multibeam sonar 40-41
- mussels 330, 343, 352-353, 381, 406, 408, 412-413, 415
- California (*Mytilus californianus*) 309, 353, 381, 406
- common (*Mytilus edulis*) 381
- mutagens 424, 443, 493-494
- Mytilus californianus* (California mussel) 309, 353, 381, 406
- Mytilus edulis* (common mussel) 381
- NADW (North Atlantic Deep Water) 193, 195-196, 198-199, 201-202, 290
- Nansen bottles 45
- Nansen Fracture Zone 84
- Nansen, Fridtjof 177
- narcosis 53, 376
- Nassarius papillosus* (mud snail) 367
- National Academy of Sciences 422, 427-428, 446
- Nautilus pompilius* (chambered nautilus) 307, 309, 411
- navigation, in marine organisms 388, 391
- Navy, U.S. 17, 25, 211, 229, 442
- neap tides 237, 239-240, 250-251, 380
- nearshore 27, 31, 127, 130, 137, 169, 187, 191, 260, 263, 330, 340, 421, 435, 442
- Nebrius concolor* (nurse shark) 306, 308
- nekton 301, 304-305, 313-314, 324-325, 331, 344, 350-351, 391
- Nemanthus annamensis* (colonial anemone) 355
- Nemateleotris magnifica* (fire goby) 361
- Nembrotha rutilans* (nudibranch) 380
- neritic province 297-298, 313
- nets, collection 14, 24, 32, 49, 51-52, 57, 298, 311, 425, 439, 490
- neurotoxic shellfish poisoning (NSP) 330
- neutrons 90
- Nevada (NV) 117, 155, 170, 172
- New Brunswick, Bay of Fundy, Canada 255
- New England coast 325
- Newfoundland 16
- New Jersey (NJ) 225, 260-261, 273, 325, 331-332, 424, 435
- New Orleans, LA 166, 277
- Newton, Isaac 231-232
- Newton's law of gravitation 232
- New York Harbor 244, 246, 334-336, 420
- New York (NY) 34, 87, 139-140, 203, 225, 235, 237, 244, 246, 251, 274, 331, 334-336, 393, 417, 420, 424, 435, 446, 472, 494
- New Zealand 15, 17, 27, 258-259, 264, 336
- Nicaragua 224
- niches
- ecological 34, 392, 396, 405, 417, 445, 491
- fundamental 396, 407-408, 415-416
- survival 396, 415-416
- nickel 27, 60, 62, 90, 96, 124-125
- Niger delta 277
- Nigeria 277
- Nile delta 277
- Ninety East Ridge 85
- nitrates 95, 135, 283, 287-288, 290, 295, 330, 412, 416, 468, 487
- nitrogen 4, 29, 31, 53, 61, 95-98, 112, 143, 170, 185, 225, 283, 287-290, 295, 312, 314, 324, 328-330, 376, 409, 417, 421, 432-433, 435, 443, 445, 463, 466, 468, 485-487
- as nutrient, in photosynthesis 1, 5, 12, 35, 58-59, 87, 89, 113-115, 133, 135, 139, 156, 158, 183, 185-186, 189, 195, 201-202, 225, 276-278, 280-281, 283-285, 287-291, 293-296, 298-301, 312-314, 318-321, 323-324, 326-327, 329-331, 341-345, 347, 356, 375, 385, 392, 395-398, 400-401, 404, 407-409, 415, 417, 419, 421-422, 431-433, 435-436, 443, 445, 447, 485, 487, 492-493
- biogeochemical cycle of 289
- in seawater 95-98, 112, 190-191
- nitrogen narcosis 53, 376
- noble gases 90
- nodes, of standing waves 226-228, 242, 245, 247, 250
- nodules
- manganese 20, 22, 27-28, 33, 44, 124-126, 137-138
- phosphorite 27-28, 33, 44, 124, 126, 137
- noise, ocean 112
- nonconservative properties of seawater 198, 201
- nonindigenous species 33, 423, 442, 444
- nonlinear relationships 5-6, 11-12, 33, 87, 173, 203, 334, 346, 467, 469-472
- nonpoint sources of pollution 435-436, 443-444
- North American Plate 65, 67, 69, 75
- North Atlantic deep water 198
- North Atlantic Deep Water 193, 195-196, 198-199, 201-202, 290
- North Atlantic Deep Water (NADW) 193, 195-196, 198-199, 201-202, 290
- North Atlantic Gyre 382, 415
- North Atlantic Oscillation (NAO) 160
- North Carolina (NC) 58, 318, 336

- North Equatorial Current 182
 northern kelp crab (*Pugettia producta*) 402
 North Pacific Gyre 343, 382, 439
 North Pole 7-8, 11, 72, 84, 134, 238, 473-474, 476
 North Sea 26, 39, 85, 244, 381
 North Star 7, 15
 Norway 15, 29, 84, 129, 381
 Norwegian Sea 193-194
 Nova Scotia, Canada 44, 58, 129, 235, 246, 249, 429
 nucleus, of atoms 90-92
 nudibranchs 35, 357, 368, 377, 380, 388, 392, 402-403, 408, 416
 Flabellina rubrolineata 357
 horned (*Hermisenda crassicornis*) 402
 Hypselerodis bullocki 380
 Kentrodoris rubescens 380
 Nembrotha rutilans 380
 nurse shark (*Nebrius concolor*) 306, 308
 nutrient-limited 287-289, 291, 295, 312-314, 324, 326-328, 344, 421
 nutrients 1, 5, 12, 35, 58-59, 87, 89, 113-115, 133, 135, 139, 156, 158, 183, 185-186, 189, 195, 201-202, 225, 276-278, 280-281, 283-285, 287-291, 293-296, 298-301, 312-314, 318-321, 323-324, 326-327, 329-331, 341-345, 347, 356, 375, 385, 392, 395-398, 400-401, 404, 407-409, 415, 417, 419, 421-422, 431-433, 435-436, 443, 445, 447, 485, 487, 492-493
 anthropogenic 295, 331-332, 344-345, 420-422, 430, 432, 435, 443
 in coastal zones, 287, 320, 323-325, 343
 in estuaries 341
 limiting, 287-289, 295, 312-314, 327, 421
 primary production and 287, 289, 312, 329, 343
 recycling of 287, 329, 343
 transport of 289
 uptake of 287
 vertical distribution of 291
 Oahu, Hawaii 78, 170, 221, 257, 279
 Oakland, CA (on San Francisco Bay) 276
Oceanapia sagittaria (burrowing sponge) 380
 Ocean Drilling Program (ODP) 43, 67
 oceanic 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108, 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
 oceanic crust 60-61, 63, 65, 67-72, 75-76, 79-81, 83-87, 123, 130, 134, 139, 276, 280, 283, 412, 450-453
 oceanic plateaus 69-70, 86, 130, 133
 oceanic province 297-298, 313
 oceanic ridges 22, 60, 63, 65-67, 70, 72-76, 79-81, 84-86, 93, 123-125, 129, 133, 135, 138-139, 195, 241, 256, 276, 283, 412-414, 416, 452-453
 crests of 76, 170
 earthquakes on 61, 65, 72
 sedimentation on 27, 33, 124
 transform faults in 69, 75-76, 81, 85-87, 256, 336
 types of 72
 volcanism in 73
 oceanography: see also ocean sciences 4, 13-14, 17-19, 23, 32-34, 45, 50, 56-58, 88, 95-96, 139-140, 203, 229, 315, 336, 346, 393
 oceans
 aesthetic aspects of 23, 25, 29, 31-32, 419-420, 422-423, 431-432, 439-440, 444
 assimilative capacity of 420-422, 424, 432, 440-441, 443-444, 493
 benthic environments in 296-298, 312-314, 350, 422, 434
 climate zones of, 161-163, 171
 color of 107
 exploration of 14-16, 19, 22, 26, 32, 54-55, 88, 317, 414, 445
 formation of 4
 foundations of life in 281
 interactions of atmosphere and 56, 141, 173, 203, 468
 land-atmosphere interactions with, 161-163, 171
 noise in 112
 origin of life in 4
 pelagic environments in 50-51, 57, 122, 131, 138, 292-293, 296-298, 305, 312-314, 348, 350, 356, 364, 370, 376-377, 380-381, 390, 392, 410, 416, 422, 442
 plant life in 5, 11-12, 14-15, 17, 25, 28-31, 36, 81, 90, 93, 97-98, 105, 107, 116, 121, 143, 160, 175, 185, 249, 263, 265, 276, 281-282, 284-287, 292, 295-296, 298-299, 301, 303, 312-313, 317, 320, 327, 330-331, 336, 342, 344, 348-350, 356-357, 362, 364, 368, 373, 377, 385, 388, 390-392, 395, 397-404, 406-410, 415, 420-422, 432-434, 436-437, 440-442, 445, 466, 485-489, 492
 pycnocline zone of 179, 190-192, 201, 449
 recreational uses of 1, 13, 23, 25, 29, 32, 253, 266, 423, 432
 residence times in 29, 89, 94, 96, 113-115, 118, 138-139, 141, 143, 172-173, 253, 276, 280-281, 295, 298, 312, 314, 317-318, 326, 329, 331, 342-346, 409, 419-422, 432, 436, 440, 442-445, 447, 461-463
 surface height of 36, 39, 57, 179-181, 183-184, 215, 225-226, 235, 242, 250
 surface microlayer of 46, 106, 348-349
 surface (mixed) zone of 20, 38, 58, 98, 105, 114, 131, 157-158, 176-177, 179-182, 184-186, 190-192, 194, 196, 199-203, 207, 283, 290-291, 294, 296, 298, 301, 308, 312-314, 318-319, 321-331, 336, 339-340, 342-345, 348, 408-409, 416, 449, 458, 468, 486
 ocean sciences: 2, 5, 7, 10-11, 13-14, 20, 54, 56-57, 90, 299, 447
 ocean thermal energy conversion (OTEC) 30-32
 octopi 281, 362, 366, 368, 377
 blue-ringed (*Hapalochlaena* sp.) 281, 368
 Octopus luteus 366
 Odobenus rosmarus (walrus) 309-310, 410
 of tidal currents 29, 190, 201, 231, 244-251, 320, 326, 336-337, 339-341, 344, 438
 of waves 206-207, 214-215, 217-218, 227-228, 241
 oil (petroleum) 20, 23, 26-27, 32-33, 43, 81, 85, 97, 139, 277, 295, 414, 425, 427-428, 442-443, 445
 oil spills 2, 23, 332, 426-431, 443
 Okhotsk, Sea of K 195
 Okushiri, Japan 224
 old glory goby 374
 Old Glory goby (*Amblygobius rainfordi*) 374

- Oman, Gulf of 429
- omnivores 283-284, 290, 298, 301-302, 312-313, 348, 350, 380, 391
- onshore-offshore transport 323
- ooliths 126
- oozes 19, 123, 129-133, 135-138
 diatomaceous 133
 radiolarian 130-132, 138
- operculum 368, 407
- optimum concentration range, of toxins 492-493
- orange-fin filefish see barred filefish
- orbicular burrfish (*Cylichthys orbicularis*) 367
- orbicular (*Cylichthys orbicularis*), 367
- orbital motion 213-214, 221-222, 227, 232, 267, 478
- orbital velocity 127, 137, 240-241, 244, 250, 267-268, 278, 473-477, 481-482
- Orcinus orca* (killer whale) 292, 308-309, 403
- Oregon (OR) 69, 73, 160, 162-163, 225, 295, 330-332, 416
- organic matter 27, 81, 97-98, 108, 112, 116, 120-123, 126, 128, 134-135, 137-138, 276-277, 282-284, 286-288, 291-292, 295-297, 301, 312, 324, 328, 330-331, 343, 348-349, 357-358, 390, 397, 414, 421-422, 431-435, 440, 443, 457, 485-486, 488, 493
- organisms 2-4, 11-12, 18, 25, 29, 31, 33-34, 36-37, 42, 50-51, 53, 56-58, 84, 87, 89, 92-93, 95, 97-98, 105-106, 112, 115-117, 120-122, 124-125, 127, 129-131, 133-135, 137-139, 158, 189, 256, 262, 281-285, 287-289, 291-293, 296-299, 301, 303-305, 312-314, 320, 324, 330-331, 341-352, 357, 360, 362, 364, 366, 368, 370, 375, 377, 383, 388, 390, 392, 395-397, 403-404, 407-408, 410-412, 414-415, 417, 420, 423-425, 427, 430-432, 434-436, 439-440, 444-445, 456, 460-461, 486-489, 492-494
 classification of 281
- Origin of Species (Darwin) 17
- Orinoco River, Venezuela 155, 321
- orthogonals (wave rays) 218-219, 228-229
- oscillation(s) 3, 84, 149, 155-160, 171, 185, 205, 207, 225-227, 242, 258, 375, 431, 471, 478
 in standing waves 206, 208, 226-228, 241-247, 250-251
 ocean-atmosphere 23, 149, 156-161, 171-172, 185-186, 202, 225, 294
 tuned 188, 227-228, 242, 244, 250
- osmoregulation 375, 391
- osmosis 375, 391
- osmotic pressure 344, 371, 375, 391
- Ostracion meleagris* (spotted boxfish) 367
- OTEC (ocean thermal energy conversion) 30-32
- otter trawls 51
- outfalls 31, 33, 421, 424, 427, 432, 434-435, 443-444
- overfishing 23-25, 305, 313, 326, 333, 345, 420, 425, 443
- overturning 105, 195-196, 201
- oviparous species 377, 391
- ovoviviparous species 377, 391
- oxidation 133, 135, 283, 296, 486
- Oxycheilinus digramma* (cheeklined wrasse) 371
- Oxycirrhites typus* (longnose hawkfish) 400
- oxygen 4, 11-12, 35, 47, 58, 61, 87, 90-93, 96-100, 112, 116, 121, 124, 126, 135, 138, 143, 158, 170, 198-199, 201, 283, 285, 287, 290, 295, 305, 312, 314, 330-332, 344-345, 348, 358, 375-376, 390, 392, 404, 408, 412-417, 420-422, 429, 432, 440, 466, 485-488
 demand 331, 344, 432
 depletion of 295, 331-332, 344-345, 420-422, 432, 435, 443-444
 in seawater 47, 95-98, 112, 124, 126, 135, 190-191, 290, 295, 312, 314, 348, 412-413, 420, 422
- oysters 130, 277, 301, 304, 330, 343, 352-353, 377, 423, 430, 440, 442
 eastern (*Crassostrea virginica*), spiny 377, 442
- ozone 119, 142-143, 172-173, 200, 287, 314, 463, 466
- ozone layer, depletion of 119, 143, 172-173, 287
- Pacific Decadal Oscillation (PDO) 160-161, 171, 431
- Pacific Ocean 14, 16, 18, 22-25, 27, 62-63, 65-67, 69-70, 77, 84-86, 111, 119, 123, 125, 129, 132-133, 138, 152-153, 156-157, 159-160, 162, 171, 186-187, 192-193, 202, 210, 223-225, 229, 236, 244, 262, 267, 289-291, 295, 298, 332, 382-383, 400, 425, 429, 433
- Pacific Plate 67, 69-70, 75, 77-78, 84
- Pacific salmon 382
- Pagurus sp. (crab) 406
- paints, antifouling 32, 427, 440, 444
- Palau 260, 262, 303, 362, 373, 400
- Palm Beach, FL (north of Miami) 272
- Pamlico Sound, NC 336
- Panama 223, 251
- Pangaea 63, 65, 71, 81, 83, 85, 256, 453
- Papua New Guinea 15, 35, 89, 122, 224, 303, 305-307, 320, 327, 349-350, 352-353, 355-358, 361-362, 364, 366-367, 369-374, 380, 384, 388-389, 395, 399-400
- parachute drogues 48, 456
- Paracyathus stearnsii* (brown cup coral) 402
- Paraluteres prionurus* (black-saddled mimic filefish) 364
- paralytic shellfish poisoning (PSP) 330, 344
- Parapercis hexophthalma* (speckled sandperch) 374
- parasites 25, 282, 364, 368, 383-385, 391, 431
- parasitism 333, 383, 391
- Pardachirus pavoninus* (peacock sole) 362
- Pardo, Arvid 20
- parrotfish, black-headed (*Scarus gibbus*) 367
- partially mixed estuaries 193, 336-337, 339-341, 344-345, 449
- partial tides 240, 243, 250
- particulate matter 93, 256, 296, 342, 422, 434
- passive margins 81, 83-86, 259, 317, 334, 344
- Patagonia 17
- pathogens, see also toxins, toxicity 423-424, 432-434, 443
- PCBs 97, 420, 423, 425
- PDO (Pacific Decadal Oscillation) 160-161, 171, 431
- PDRs (precision depth recorders) 39-41
- peacock sole (*Pardachirus pavoninus*) 362
- pearlscale angelfish (*Centropyge vrolikii*) 364
- pectoral fins 372-375, 391
- pelagic 50-51, 57, 122, 131, 138, 292-293, 296-298, 305, 312-314, 348, 350, 356, 364, 370, 376-377, 380-381, 390, 392, 410, 416, 422, 442
- pelicans, brown (*Pelecanus occidentalis*) 311
- pelvic fins 372, 375
- penguins 143, 158, 298, 311-312, 345, 410, 494
 Adélie (*Pygoscelis adeliae*) 311
- Pennatulacea (sea pens) 351-352, 366, 388, 398, 402
- Pennsylvania (PA) 441
- Pensacola, Fla. 235
- Periclimenes 362, 388

- P. amboinensis* (crinoid shrimp) 362
P. cf. tosaensis 388
P. cf. venustus 388
P. colemani (Coleman's shrimp) 388
P. imperator (emperor shrimp) 388
P. soror (sea star shrimp) 388
 periods, of waves 205-206, 214, 218, 220, 227-228, 235, 265, 325
 periwinkles, *Littorina* sp. 404, 407
 Persian Gulf 29, 126, 429-430
 Peru 17, 21, 23, 156-158, 171, 183, 224, 321
 Peru Current 183
 petroleum 20, 23, 26-27, 32-33, 43, 81, 85, 97, 139, 277, 295, 414, 425, 427-428, 442-443, 445
 petroleum hydrocarbons, 97, 425, 445
Pfiesteria piscicida 368
 pH 47, 99, 113, 123-124, 126, 404, 408, 412, 415
Phalacrocorax auritus (double-crested cormorant) 311
 pharmaceutical products, from marine organisms 25, 27, 32-33, 368, 419, 433-434
 phase changes, of water 99-101, 112-113
 Philadelphia, PA 393, 429, 435
 Philippine Plate 70
 Philippines 16, 18, 21-22, 25, 27, 68, 71, 85, 119, 166, 224, 306, 320, 355-356, 364, 367, 374, 429
Phoca vitulina (harbor seal) 309
 Phoenicians 15
 phosphates 95, 126, 135, 198, 287, 290, 305, 329, 432, 487
 phosphorite nodules and crusts 27-28, 33, 44, 124, 126, 137
 phosphorus 27, 95-96, 100, 126, 185, 225, 283, 287-289, 312, 314, 324, 328-329, 409, 417, 433, 445, 468, 485-487
 photic zone 24, 27, 97, 108, 113, 284-291, 293-300, 302, 308, 312-314, 318, 320-321, 325-331, 343-345, 348, 351, 356, 364, 381, 390, 395-397, 409, 411-412, 415-416, 422
 photophores 411
 photosynthesis 1, 11-12, 35, 58-59, 81, 87, 89, 97, 107-108, 112-115, 120, 125, 137, 139, 260, 276, 281, 283-287, 289, 295-300, 312-314, 320-321, 343-344, 347-349, 392, 395, 397, 401, 412, 415, 417, 419, 421-422, 445, 447, 485-488, 492-493
Physalia physalis (Portuguese man-of-war) 303-304, 350, 370, 377
 physical oceanography 45, 57, 203, 336
 phytoplankton 51, 55-57, 107-108, 116, 122, 132, 138, 143, 156, 185-187, 201-202, 225, 285-296, 298-302, 312-314, 320, 323-331, 333, 342-345, 348-350, 370, 377, 380, 390, 392, 397-398, 409-410, 415, 421-423, 443, 488-490, 493
 piers 205, 228, 253, 275, 336, 424
 Pinatubo, Mount, Philippines 68, 119-120
 pinnipeds 309-311, 313
 pipefish, ghost (*Solenostomus paradoxus*) 362
 pistol shrimp (*Synalpheus* sp.) 389
 piston corers 42-43
 plains, abyssal 61, 84-86, 127-129, 137-138, 296
 plankton 51, 56-57, 107, 113, 122, 275, 287, 298-299, 301, 304, 306-309, 312-314, 323, 325-326, 328, 330, 333, 343-344, 351, 355, 372, 380-381, 388, 403, 407-408, 430, 439
 plankton nets 51
 plastics, pollution from 27, 46, 116, 439-440, 444
 plateaus, oceanic 69-70, 86, 130, 133
 plate boundaries 63, 65-67, 69-71, 73-76, 78-79, 81, 85-87, 124, 256, 336
 convergent 67-73, 83, 85-86, 93, 223, 256, 336, 414
 divergent 22, 65, 67, 70, 72-76, 79-81, 84-86, 123-125, 129, 133, 135, 139, 276, 412-413, 416, 452-453
 transform 69, 75-76, 81, 85-87, 256, 336
 plates, lithospheric (tectonic) 60-63, 65, 72, 75, 77-78, 81, 85-86, 93, 256, 450-452, 472
 plate tectonics 18, 59, 62-63, 79-80, 85-87, 94, 115, 133-135, 256, 281, 420, 450, 453, 455, 468, 472
 platinum 27, 96
Plectorhinchus celebicus (Celebes sweetlips) 364
Plectorhinchus goldmanni (Goldman's sweetlips) 375
 plume worms 413
 plutonium 440-441
Pocillopora sp. (hard coral) 327
 Point Lobos State Park, CA (near Monterey) 253
 polar bears 298, 410
 polar cells 148, 155, 171
 Polaris 7
 polarity, of molecules 92, 100
 polar regions 10, 92, 98, 102, 105, 143, 146-147, 171-172, 182, 185, 193, 200, 313, 326, 345, 392, 409-410, 415, 458-459
 Pole Star 7-8
 pollution 1-2, 11, 21, 25, 32, 90, 97-98, 116, 311, 333, 407, 419-422, 424-425, 427, 430-432, 434-437, 440, 442-446, 461-462, 491, 493
 polyaromatic hydrocarbons (PAHs) 431, 444
 Polynesia 15, 32, 80
 Polynesians 14-17, 33
 polypoids (Anthozoa) 355
 polyps 327, 344, 352-353, 355, 357, 362, 364, 370, 373, 391, 400
Pomacanthus navarchus (blue-girdled angelfish) 373
Pomacentrus moluccensis (lemon damselfish) 384
 porcelain crab (*Porcellanella triloba*) 388
Porcellanella triloba (porcelain crab) 388
 pore (interstitial) water 27, 135, 138, 296, 358, 390, 414
 porpoises 221, 309, 313
 Portland, OR 162-163
 Portugal 429
 Portuguese man-of-war (*Physalia physalis*) 303-304, 350, 370, 377
 Poseidonius 15, 33
 potassium 94-96, 113
 potential energy 179, 182, 202, 207-208, 219, 228
 practical salinity units (PSU) 95, 104, 460
 precipitation
 atmospheric 15, 20, 25, 79-80, 83, 89-90, 99, 102, 113, 116, 119-121, 126, 128, 135, 137, 141, 144-149, 153-155, 157-158, 161-163, 165-172, 191, 193, 199, 249, 263, 277, 288-289, 292, 294, 297, 299, 317-319, 339, 395, 404, 408, 410-411, 420, 435-436, 442, 459, 462, 464, 467, 472
 of salts 27, 33, 95-96, 124, 126, 133, 462
 precision depth recorders (PDRs) 39-41
 predation see hunting and defense
 predators 24-25, 34, 248, 276, 291-292, 301, 303, 305, 307-308, 311, 343-344, 347-349, 356, 360, 362, 364, 366-368, 370-371, 373, 375-377, 380-382, 384-385, 388-392, 398, 403-404, 407-408, 410, 413, 415, 417, 442, 445, 470, 488-489, 491-492
Premnas biaculeatus (spinecheek anemonefish) 369

- pressure
 atmospheric 6, 36-37, 103, 143, 148, 151-152, 157, 163-165, 167-169, 209, 223, 225
 gradient balanced by centripetal force 141, 164, 172-173, 175, 179-185, 187, 189, 201-203, 205, 225, 229, 447, 483-484
 high 81, 148, 177, 187, 298, 412
 hydrostatic 277, 279
 low 149, 158, 164, 173, 177, 203, 411
 pressure gradients 147-148, 164, 169, 171-173, 177, 179-185, 189-190, 200-203, 207-208, 215, 228-229, 233-234, 242, 250, 479-480, 482-485
 vapor 142, 144, 454, 483
 water density and 35, 46, 58, 89, 102-103, 112, 114-115, 124, 139, 175, 191, 198, 203, 447, 449-450, 459
- Priacanthus hamrur* (crescent-tailed bigeye) 366
- primary production 5, 114, 283-287, 289, 291-292, 294-295, 312-314, 321, 323-324, 326, 329, 332-333, 342-345, 348, 401, 412, 414-416, 421, 444, 487-489, 493
- primary productivity 81, 121-122, 126, 138, 156, 185, 187, 287-289, 291-295, 302, 312-313, 320-322, 324-328, 331-333, 342-344, 349, 356, 397, 401, 408-409, 415, 421, 442-443, 485
- prime meridian 8, 11
- Primovula* sp. (allied cowrie) 357
- Prince Edward Island, Canada 330
- Prince William Sound, AK 256, 426, 429-431
- Prochlorococcus* sp. (photosynthetic cyanobacteria) 299
- production
 nutrient limited 287, 291, 314, 324, 326-328, 344
 primary 5, 81, 114, 121-122, 126, 138, 156, 185, 187, 283-289, 291-295, 302, 312-314, 320-329, 331-333, 342-345, 348-349, 356, 397, 401, 408-409, 412, 414-416, 421, 442-444, 485, 487-489, 493
 secondary 283-284
- profile, cross sectional 60, 157, 165, 167-168, 194, 368, 371
- profiling, seismic 43-44
- progressive waves 206-208, 226-228, 235, 244-246, 250
- projections, map 7-12, 14, 39, 300, 303, 360, 490
- prokaryotes 282, 313, 348
- protein 23, 283, 345, 486, 488-489
- protists 282, 313, 348, 392
- protons 90, 92
- Protopalycha* sp. (zooanthid) 355
- Protoreaster nodosus* (rhinoceros sea star) 399
- protozoa 292, 303
- Protula magnifica* (spiral fan worm) 356
- Pseudanthias huchtii* (threadfin anthias) 372
- Pseudosimnia* sp. (egg cowrie) 388
- PSU (practical salinity units) 95, 104, 460
- Pterocaesio lativittata* (yellowstreak fusilier) 371
- pteropods 2, 122-123, 130, 137-138, 303, 313, 350
- Ptolemy 15
- Puerto Rico 22, 84, 399, 429
- pufferfish 364
- Puget Sound, WA 27, 248, 336
- Pugettia producta* (northern kelp crab) 402
- purse seines 51
- Pu'u O'o, Hawaii 76
- pycnoclines, see also haloclines, thermoclines 157, 172, 178-179, 181, 184-186, 190-193, 200-202, 225, 228, 295, 314, 319-320, 343-344, 447, 449-450
- pygmy seahorse (*Hippocampus bargibanti*) 362
- Pygoscelis adeliae* (Adélie penguins) 311
- Pyrgomatidae (barnacle) 353
- Pythagoras 15
- Pytheas 15
- Qatar 429
- quill-backed rockfish (*Sebastes maliger*) 402
- radiation
 electromagnetic 33, 36, 48, 55-57, 90, 106-109, 112-113, 463-465
 of heat 145-147, 172, 450, 463
 solar 28, 87, 90, 119, 141, 145-152, 154, 161-162, 167-169, 171, 176, 179, 191, 234-235, 238-240, 242, 245, 283, 319, 323-324, 326, 397, 408, 415, 454, 458, 460, 463-466
- radioactivity 59, 87, 89, 97, 114-115, 139, 175, 203, 314, 424, 441, 447, 460
 dating by decay of radioactive isotopes 134
 in tracing water masses 47, 198-203, 440
 parent and daughter atoms 87, 139, 203, 300, 382, 460-461
- radioisotopes (radionuclides) 60, 77, 95, 97, 112-114, 139, 199, 201-202, 440-441, 444, 460-461
- radiolaria 122-123, 131-132, 135, 137-138, 282, 302-303, 313
- radiolarian oozes 130-132, 138
- radionuclides see radioisotopes
- radio waves 36, 106-107
- raggy scorpionfish (*Scorpaenopsis venosa*), 362
- rainbow runner (*Elagatis bipinnulata*) 364
- Rainbow trout (*Oncorhynchus mykiss*) 375
- rain, rainfall, see also precipitation, atmospheric 15, 20, 25, 79, 83, 89-90, 99, 102, 113, 116, 119-121, 126, 137, 141, 144-149, 153-155, 157-158, 161-163, 165-172, 191, 193, 199, 249, 263, 277, 288-289, 292, 294, 297, 299, 317-319, 339, 395, 404, 408, 411, 420, 435-436, 442, 459, 462, 464, 467, 472
- Raritan Bay, NJ 335-336
- rays
 blue-spotted (*Taeniura lymma*) 306
 manta (*Manta birostris*) 306, 308, 375, 388, 400
 torpedo (Torpedinidae) 306
- rebreather device, scuba 35
- recreation, oceans and 1, 13, 23, 25, 29, 32, 253, 266, 423, 432
- recycling
 nutrients 287-289, 312, 329, 343
 of human products 424
- redbreasted Maori wrasse (*Cheilinus fasciatus*) 373
- red-cheeked fairy basslet, see threadfin 372
- red (deep-sea) clays 123, 133, 138
- Red Sea 15, 19, 74, 85, 124, 126, 133, 155, 302, 306, 318, 339, 367, 370, 388, 462
- red tides 330
- red urchin (*Strongylocentrotus* sp.) 403
- reef flats (terraces) 398-400, 415
- reefs
 atolls 17, 22, 30-31, 79-80, 84, 86, 224, 228, 275-276, 278-279
 barrier 80, 86, 259, 275-276, 278-279, 400
 fringing 80, 86, 221, 259, 275-276, 279-280, 400
- reef whitetip shark (*Triaenodon obesus*) 306-307
- 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 31-32, 116, 420, 427, 439-440, 444
- relationships, nonlinear 5-6, 11-12, 33, 87, 173, 203, 334, 346, 467, 469-472
- relict sediments 130-131, 138, 257
- remora (*Echeneis naucrates*) 306, 374-375, 388
- remotely operated vehicles (ROVs) 27, 53-55
- reproduction
 - asexual 377, 391
 - hermaphroditic 377, 391
 - migration and 14, 52, 77, 150-151, 258, 270, 272, 278, 290-291, 295, 302, 343, 375, 381-383, 393, 410
 - separate-sex 376
 - timing in 380
 - vegetative 377
- reservoirs, oil and gas 81, 85
- residence time 29, 89, 94, 96, 113-115, 118, 138-139, 141, 143, 172-173, 253, 276, 280-281, 295, 298, 312, 314, 317-318, 326, 329, 331, 342-346, 409, 419-422, 432, 436, 440, 442-445, 447, 461-463
- residual currents 336, 339-340, 342
- resources 1, 11, 14, 20-25, 27-29, 32-33, 173, 292, 315, 333, 360, 368, 381, 419-420, 423-424, 427
- respiration 4, 11-12, 97-98, 112-113, 283, 286-287, 290, 292, 295, 298, 312-314, 331-332, 344, 346, 358-359, 421-422, 485, 487-488
- restoring forces, currents and, waves and 176, 207-208, 227-228
- resuspension, of sediments 115, 127, 139, 141, 172, 253, 276, 280-281, 314, 320, 447, 456-457
- reversing thermometers 46-47
- Rhincodon typus* (whale shark) 306
- rhinoceros sea star (*Protoreaster nodosus*) 399
- rhodophyta 320
- Rhopalaea* sp. (tunicate) 355
- ridges oceanic, see oceanic ridges
- rift zones, see also specific zones 65, 67, 71-76, 81, 83, 85-86
- rings, Gulf Stream 188-189, 201, 323
- Rio de Janeiro, Brazil 244
- Rio Grande Rise 78
- rip currents 2, 222, 228, 268, 278
- rivers
 - deltas of 117, 130, 138, 256, 259, 276-280, 334, 344, 421-422
 - erosion by 116
 - oxygen depletion in 331, 422, 432, 435, 444
 - sediments transported by 116
 - tidal currents in 245-246, 249, 251
- roaring forties 149
- Robinson projection 9-10
- rockfishes
 - copper (*Sebastes caurinus*) 402
 - quill-backed (*Sebastes maliger*) 402
- rocky intertidal communities 297, 312-313, 395, 404-408, 415-416
- Rocky Mountains 83, 155
- Romania (Balkans) 71
- rose anemone (*Tealia lineata*) 402
- Rossby waves 148, 225, 228-229
- Ross, John 42
- rounded caudal fins 372
- ROVs (remotely operated vehicles) 27, 53-55
- Royal Society 18
- runoff, freshwater 23, 27, 29, 32, 37, 61, 80, 84-85, 90, 92, 98, 104-106, 113, 116, 146, 153, 155, 161, 171, 179, 186, 191, 194, 196, 198, 201, 245-246, 275, 277-278, 312, 314, 317-319, 321, 325-326, 330-331, 334, 336-337, 339, 341-344, 375-376, 381-382, 391, 398, 409, 423-425, 435, 442, 444
- Russia 22, 71, 195, 382, 416, 441
- Ryukyu Trench 67
- Sabellidae (tube worms) 352
- saccopharyx fish 411
- Sacramento River, CA 339
- Sahara Desert 119-120
- Saint Lawrence River, Canada 196
- Sakhalin Island, Russia 445
- salinity 29, 35, 39, 46-47, 50, 56-58, 89, 92, 94-98, 103-106, 109-115, 119, 124, 126, 133, 139, 141-142, 152-155, 161, 171-172, 175-176, 179, 181, 190-193, 196-198, 200-203, 275-276, 278, 296-298, 303, 313, 317-319, 327-328, 336-337, 339-344, 346, 348, 375-376, 391, 396, 398, 404, 407-409, 415, 417, 422-423, 442-443, 447, 449, 454, 459-460, 491, 493-494
 - and solubility of gases 97-98
 - as conservative property 198
 - electrical conductivity and, in estuaries 46-47, 95, 112-113
 - ice formation and 105, 161, 191, 193-194, 201-202, 409, 415
 - in coastal oceans 318-319
 - in rocky intertidal communities 297, 312-313, 395, 404-408, 415-416
 - ocean surface 153, 161
 - of marginal seas 118, 155, 318-319
- salmon 160, 343, 381-383, 422, 431-432, 442
 - Pacific 382
- salps 303-304, 313, 350-351, 355
- salt marshes 81, 97, 256, 276, 283, 342, 430
- salts, dissolved, see also salinity 81, 94-95, 102-106, 112-113, 161, 191, 375, 459, 483
- salt wedge estuaries 336-337, 339-341, 344
- Samoa 15, 22
- samplers, sampling
 - bottles for 45-47, 51
 - contamination of 45
 - core 42-43
 - CTD 47, 57, 95
 - grab 42-43, 52, 57-58
 - of marine organisms 51
 - of seafloor 18, 42-45, 52, 57, 257, 274
 - of seawater chemistry 45-47, 51, 57, 95
 - rosette 47
- San Andreas Fault, CA 69, 75, 87
- sand anemones 352, 360
- sand burrow 388
- sand dollars (*Clypeaster* sp.) 398-399
- sand dunes 255-256, 263, 265, 269-271
- San Diego Bay, CA 339
- Sand, oolite 126
- sandperches, speckled (*Parapercis hexoptalma*) 374
- Sandy Hook Bay, NJ 335-336
- San Francisco Bay 28, 117, 244, 277, 279, 336, 339-341, 420-422, 432, 436, 438, 442, 463

- San Francisco, CA 8, 28, 75, 117, 137, 169, 235, 244, 264, 276-277, 279, 315, 320, 336, 339-341, 406, 420-422, 432, 436, 438, 442, 446, 463
- San Joaquin River, CA (near San Francisco) 339
- Santa Barbara Harbor 274-275
- Santa Cruz, CA (between San Francisco and Monterey) 75, 256
- Santa Cruz Mountains 75
- Santa Monica 275, 437
- sardines 292, 305, 488
- Sargasso Sea 188-189, 294, 299, 301, 343, 382, 408-409, 415-416
- sargassumfish (*Histrio histrio*) 408
- Sargassum* sp. 294, 299, 408-409, 415-416
- Saronikos Gulf, Greece (central Aegean Sea) 331
- satellites 16, 19-20, 28, 35-36, 39, 41, 55-57, 79, 82, 90, 107, 111, 119-120, 142, 159, 166, 172-173, 180-181, 188-189, 201, 211, 217, 225, 243, 248, 250, 259, 274-275, 293-294, 321-322, 325, 335, 341, 454
- saturation pressure 143-144, 170, 172
- saturation solubility 97-98, 113, 295, 313, 422
- Saudi Arabia (see Arabian Peninsula) 29
- saw blade shrimp (*Tozeuma armatum*) 388
- scale worms 385, 388, 413
- scallops 352, 368
- Scandinavia 84, 162, 259
- scarps 264-265, 278
- Scarus gibbus* (black-headed parrotfish) 367
- scattering, of light in water 107
- scavengers 306, 407-408, 412, 415
- scavenging 350
- schooling 301, 305, 370-371, 390-391
- scientific (exponential) notation 5, 10-12
- Scorpaenopsis macrochir* (flasher scorpionfish) 384
- Scorpaenopsis venosa* (raggy scorpionfish) 362
- scorpionfishes 362, 368, 373, 376
- flasher (*Scorpaenopsis macrochir*) 384
- raggy (*Scorpaenopsis venosa*) 362
- Scotch Cap, AK 223
- Scotland 193
- scuba divers 1, 19, 24, 29, 35, 52-53, 57, 107, 109, 112, 205, 213-214, 307, 374-376, 383, 389-390, 400
- Sea Beam multibeam sonar 40
- seabirds 16, 158, 310-312, 323, 333, 375, 403, 427, 430, 443
- sea cucumbers 304, 313, 351, 355-356, 368, 380, 388, 398-399, 408, 411, 416, 489
- creeping (*Cucumaria* sp.) 356
- Thelenota rubralineata* 380
- Sea Empress 429
- sea fans gorginians
- Melithaea* sp. 355
- sea fans (gorgonians) 355, 357, 362, 370, 385, 396, 400
- seafloor
- mining of 21-22, 27-28, 32, 116, 124, 317
- /seafloor
- as habitat 25, 29, 50-52, 57, 122, 292-293, 296-298, 301, 304, 306, 308, 312-314, 318, 320, 331-332, 342-344, 348, 350-352, 356-358, 376-377, 381, 388-392, 397-398, 410, 415-416, 421-422, 430, 432, 434, 437-439, 442-444
- drilling of 19-20, 26-27, 32, 43, 57, 62, 67, 127, 134, 139, 225, 431, 445
- interaction of waves and 31, 106, 112, 155, 205-207, 209, 213, 219-223, 228-229, 246, 248, 260, 264-266, 273, 275, 279-280, 297, 404, 428
- sampling of 18, 42-45, 52, 57, 257, 274
- slope of 26-27, 32, 61, 83, 86, 126-129, 133, 137, 139, 414, 438
- topography of 7, 14, 36-41, 44, 56-57, 61, 83, 86, 113, 195, 200-201, 218, 223, 250, 262, 302, 409
- seafood 23-24, 330, 345, 423, 438, 440-441, 443, 489
- sea grasses, turtle grass (*Thalassia* sp.) 357-358, 362
- seagrass filefish (*Acreichthys tomentosus*) 358
- seagulls 311-312
- seahorses 362, 375, 377
- pygmy (*Hippocampus bargibanti*) 362
- spotted (*Hippocampus kuda*) 362
- sea-level change 2, 6, 22, 30, 36, 56, 59, 61, 74, 77, 80-84, 86-87, 115-117, 126, 130-131, 135, 138-139, 147-148, 151, 157-158, 167, 223-224, 231, 251, 253, 256-257, 259-260, 265, 270-273, 276-280, 334-336, 344, 397, 410, 419, 447, 450, 452-455, 464, 467
- eustatic 83-84, 86-87, 257-259, 280, 450, 452-453
- isostatic 77, 83-84, 86-87, 257-260, 272, 279-280, 450, 452-454
- sea lion, California (*Zalophus californianus*) 24, 309-310, 313, 403, 425, 437
- seals 24, 52, 143, 277, 291, 309-310, 313, 345, 403, 407, 410, 425, 439
- elephant (*Mirounga angustirostris*) 24, 309-310, 425
- harbor (*Phoca vitulina*) 309
- seamounts 41, 78-80, 85-86, 126, 130, 133, 297, 325
- Sea of Japan 331, 441, 444
- Sea of Okhotsk 195
- sea otter (*Enhydra lutris*) 310, 403-404, 415
- sea pens (Pennatulacea) 351-352, 366, 388, 398, 402
- Seasat satellite 41
- sea snakes
- banded (*Laticauda colubrine*) 310
- seasonal variation 111, 149-153, 155, 161-163, 178-179, 191, 194-195, 251, 269, 288, 293-294, 317-319, 323-329, 331-332, 343-345, 383, 391, 409, 415, 421, 464
- in beaches 269
- in climate 111, 149, 155, 251, 288, 294, 324, 326, 329
- in coastal oceans, 326, 343, 345
- in primary production 326, 328-329, 343-345
- sea stars
- Linckia laevigata 384
- rhinoceros (*Protoreaster nodosus*) 399
- sea star shrimp (*Periclimenes soror*) 388
- sea turtles 248, 310-311, 313, 357-358, 383, 390
- green (*Chelonia mydas*) 310, 357-358
- hawksbill (*Eretmochelys imbricata*) 310-311
- sea urchin 368, 403-404, 415
- sea urchins 304, 313, 357, 366, 368, 403, 408, 415-416, 430, 489
- Astropyga radiata 389, 399
- fire (*Asthenosoma intermedium*) 366
- fire (*Asthenosoma varium*) 388
- heart (*Echinocardium* sp.) 359
- long-spined (*Diadema savignyi*) 357
- red (*Strongylocentrotus* sp.) 403

- Sea urchins 368, 403, 415
 Sea Urchins 403
 seawalls 220, 227, 273, 278-279
 seawater 89, 98
 density of 95, 102-104, 112, 141, 180, 190, 459-460
 dissolved organic matter in 97, 284, 287, 296, 312, 324, 349, 443, 468
 oxygen in 47, 97, 124, 126, 135, 290, 295, 312, 314, 331-332, 344-345, 348, 412-413, 420-422, 430, 432, 435, 443-444
 pH of 47, 99, 113, 123-124, 126, 404, 408, 412, 415
 trace elements in 95, 97, 112, 287
 upwelling of 122, 156, 169, 186, 201-202, 287, 291, 293, 321-325, 328, 332, 342-345
Sebastes caurinus (copper rockfish) 402
Sebastes maliger (quill-backed rockfish) 402
 secondary production 283-284
 sedimentary arcs 69, 84-86, 93, 256
 sedimentary mud 18, 32, 36, 38, 41-42, 116-117, 129, 131, 133, 276-277, 296-297, 312, 358, 364, 367, 423, 458
 sedimentary rocks 3, 67-68, 72, 93, 116, 118, 124, 134, 139, 260
 sediment, sedimentation 3, 14, 18, 27, 29, 31, 36-38, 42-45, 50, 52-53, 56-59, 61, 67-70, 80-81, 83-86, 93-94, 97, 107, 113, 115-125, 127-138, 167, 195, 202, 256-257, 259, 263-264, 268-269, 271, 275-278, 283, 285, 288-289, 297-298, 302-303, 310, 313, 318, 320, 328, 334, 336, 340, 345, 347-349, 351, 356-359, 370, 383, 390-392, 396, 398, 411, 413, 415, 420-424, 428-430, 432, 434, 437-438, 440, 442, 444, 451-452, 456-458, 462-463, 494
 accumulation rates of 126, 129-130, 132, 138
 age dating of 134
 as habitat 25, 29, 50-52, 57, 122, 292-293, 296-298, 301, 304, 306, 308, 312-314, 318, 320, 331-332, 342-344, 348, 350-352, 356-358, 376-377, 381, 388-392, 397-398, 410, 415-416, 421-422, 430, 432, 434, 437-439, 442-444
 as historical (stratigraphic) record 43, 59, 67, 87, 89, 114-115, 134, 139, 175, 203, 447, 460-461
 biogenous 116, 120-124, 126, 129-131, 133-138
 biogeochemical cycles and 93-94, 97, 112-116, 124, 138, 288, 295, 427, 440, 444, 462
 classification of 116, 137
 coastal formation by 253, 256, 277-278
 cohesiveness of 127, 138-139, 280, 456-457
 cosmogenous 116, 126, 130, 137-138
 graded beds in 123, 127-130, 136-138
 hydrogenous 116, 124, 126-127, 130, 137-138
 ice-rafted 133
 in back-arc basins 70-71, 85-86
 in continental margins 80, 130-131, 138, 257
 in estuaries 339
 lithogenous (terrigenous) 81, 116-120, 123-124, 126, 128-133, 137-138, 287, 296, 329
 relict 130-131, 138, 257
 resuspension of 115, 127, 139, 141, 172, 253, 276, 280-281, 314, 320, 447, 456-457
 sampling of 42-45, 52, 57, 257
 settling velocity of 457
 sorting 87, 116, 130, 138-139, 172, 216-217, 227, 267-268, 278-279, 448, 458
 surface 42, 123, 131-133, 135, 138, 283, 390, 411
 suspended 45, 56-57, 81, 107, 113, 117, 119, 128, 135, 138, 175, 202, 275-277, 285, 298, 320, 328, 340, 345, 396, 398, 421-424, 428, 437-438, 442, 444, 456-458
 thickness of 126, 129-130, 138
 topographic smoothing by 79
 transport of 29, 32, 116, 119-120, 127-129, 133, 137-138, 209, 256-257, 269, 411, 420, 423-424, 456, 458
 seffloor
 spreading of 22, 43, 60, 63, 65-67, 70, 72-76, 79-81, 84-86, 93, 123-125, 129, 133, 135, 138-139, 195, 241, 256, 276, 283, 412-414, 416, 452-453
 seiches 226
 seismic profiling 43-44
 seismic tomography 62
 selenium 96, 100
 Sellafield, Great Britain 441
 semidiurnal tides 235-238, 240, 242-246, 250-251
 sensible heat 100, 102, 113, 146, 167, 172
Sepia latimanus (broadclub cuttlefish) 307
Sepioteuthis lessoniana (common reef squid) 307, 380
 Serbia (Balkans) 71
 sergeant fish (*Abudefduf* sp.) 371, 380
 ses stars
 basket 355-356
 setae 349
 settling velocity, of sediments 457
 sewage 23, 31, 33, 98, 253, 275, 288, 295, 329-331, 336, 339-340, 344-345, 420-425, 427, 431, 433-436, 438, 443-445, 494
 Seychelle Islands 22, 429
 shadow zone 110-111
 shallow-water waves 218-219, 223, 228, 241, 243, 246, 250-251
 sharks 1, 24, 51-52, 116, 125, 127, 305-306, 308, 313, 360, 373, 375-377, 380, 388-391, 400, 403, 411
 gray reef (*Carcharhinus amblyrhynchos*) 306-307, 373
 great white (*Carcharodon carcharias*) 24, 306-307
 nurse (*Nebrius concolor*) 306, 308
 reef whitetip (*Triaenodon obesus*) 306-307
 whale (*Rhincodon typus*) 306, 308
 shear stress, see also friction 209, 225, 228
 shelf break 61, 86, 297, 313, 317, 344
 shelf valleys 83-84
 shellfish 2, 13, 23, 29, 276, 309-310, 314, 328, 330-331, 343-344, 423, 432, 434-435, 437-438, 443-444
 Shemya Island 403
 Sheridan, WY 163
 ships, shipping 1, 10, 15-20, 25, 32, 36-41, 43-44, 46-58, 63, 112-113, 116, 148, 189, 200, 207, 209, 211-212, 215, 221-223, 225, 228-229, 231, 304, 317, 352, 427, 440, 442, 444, 449
 shoals 17, 326, 340, 344
 shore 29, 31, 48, 52, 55, 115, 119, 130, 137-138, 176, 183, 186, 205-207, 209, 213, 216-224, 227, 231, 253, 255, 260-261, 263-267, 269, 275, 278-279, 311, 323, 325, 344, 400, 404, 407-408, 421, 424, 428-430, 432, 443
 shoreline 29, 56, 115, 120, 131, 138, 209-210, 212, 218, 220, 224, 229, 256, 266, 271-276, 278-279, 320, 344, 405, 422, 424, 428, 438
 shrimp 24, 112, 330, 349-350, 352, 360-362, 364, 366, 368, 383, 385, 388-390, 395, 402-403, 408, 413
 Allopontonia sp. 362, 388
 banded coral (*Stenopus hispidus*) 349
 Coleman's (*Periclimenes colemani*) 388

- coral (*Dasycaris zanzibarica*) 362
 coral (*Vir philippinensis*) 388
 crinoid (*Periclimenes amboinensis*) 362
 emperor (*Periclimenes imperator*) 388
 harlequin (*Hymenocera elegans*) 349
 humpbacked (*Hippolyte commensalis*) 388
Periclimenes cf. tosaensis 388
Periclimenes cf. venustis 388
 pistol (*Synalpheus*) 389
 saw blade (*Tozeuma armatum*), sea star (*Periclimenes soror*),
 tiger pistol (*Alpheus bellulus*) 388
 urchin (*Gnathophylloides mineri*) 388
 Siberia, Russia 84
 Sierra Nevada mountains 117, 155, 170
 silica, silicates 93, 121-122, 126, 135, 139, 265, 287, 289-290,
 300-301, 303, 312-313, 324, 328-330, 343, 409
 siliceous organisms 121-122, 131
 silicon 61, 90, 96-97, 116, 287, 289, 329
 sills 73, 126, 193, 202, 258-259, 336, 339, 344
 silt 38, 116, 133, 137, 262, 457
 silver 27, 96, 124, 135, 364, 381
 sinks 24, 42, 48, 54, 62-63, 67-68, 70, 72, 74, 77-80, 84, 86-87,
 93, 97-99, 102, 105-106, 113-115, 120, 123-124, 127, 139,
 144-145, 147-148, 161, 164, 169, 172, 175, 190-195, 199-202,
 256-257, 276-278, 280, 286, 289-290, 296, 299-300, 314, 318-
 320, 325, 340, 342-344, 348, 373, 376, 411-412, 422, 427-428,
 433, 447-450, 452-457
 SI units 11-12, 100
 skates 377
 slack water 245-247, 249-250
 slope
 of beaches 266, 269, 278
 of ocean surfaces 180-181, 202
 of seafloor 26-27, 32, 61, 83, 86, 126-129, 133, 137, 139, 414,
 438
 Slovenia (Balkans) 71
 sludge, sewage 432, 435, 444
 slumps 120, 138, 208, 223-224, 257, 261-262
 slurp guns 52
 slurries 31, 33
 snails 303-304, 350, 367, 380, 383-384, 392, 395, 403-404, 406-
 408, 413, 415
 black turban (*Tegula funebris*) 406
 Epitonium billeeanum 380
 mud (*Nassarius papillosus*) 367
 parasitic (*Thyca crystallina*) 384
 sodium 91, 93-96, 113, 126, 462
 sodium chloride 93, 126
 soft corals 353, 355, 362, 364, 388, 395, 400, 415-416
 solar energy 119, 146-147, 162, 167, 171, 397, 458, 463-464,
 466
Solenostomus paradoxus (ghost pipefish) 362
 sole, peacock (*Pardachirus pavoninus*) 362
 Solomon Islands 305, 364, 371
 solstices 146, 149, 151, 172
 solubility, see also saturation solubility 97-98, 113, 123, 126,
 135, 137, 295, 313, 422, 425, 429
 Somalia 21, 224
 sonar 39-41, 43, 52, 57, 73, 109-113, 257, 442-444
 sorting, in sedimentation 266-267
 sound channels 109-111
 sounders 38-40, 56, 302
 soundings, difficulties of, echo 16, 18, 33, 37-42, 57, 109, 113
 sound, underwater transmission of 50, 109-111, 113
 South Africa 244, 429
 South America 10, 12, 17-18, 20, 63, 65, 69, 72, 84, 117, 132,
 155, 158, 162, 169-170, 182, 195, 298, 321
 South Carolina 166
 South China Sea 22, 85, 117
 South Equatorial Current 182
 Southern Ocean 132-133, 143, 194, 289, 293, 315, 326, 345,
 410, 417
 South Pole 7-8, 11, 134, 143, 148, 473-474, 479-480
 South Sandwich Trench 84
 Soviet Union 21, 43, 199, 441, 444
 Spain 15, 429
Spartina sp. (marsh grass) 357-358
 Spawning 248, 329, 343, 370-371, 376, 380-383, 391-392, 442
 species 2, 4-5, 11, 13-14, 17-19, 23-25, 28-29, 32-35, 50-53,
 57-59, 80, 90, 95-96, 98-99, 106, 111-112, 115-116, 120-122,
 134-139, 143, 161, 189, 231, 248, 270, 276, 278, 280-287, 289,
 291-293, 295-315, 320, 322-331, 333-334, 336, 341-347, 349-
 353, 355-360, 362, 364, 366-377, 380-385, 388-392, 395-398,
 400-405, 407-417, 419-423, 425, 430-431, 434, 437-440, 442-
 445, 447, 462, 467-472, 485-486, 488-494
 classification of 281, 396, 415
 nonindigenous 33, 423, 442, 444
 species succession 328-329, 343-344
 speckled sandperch (*Parapercis hexoptalma*) 374
 spectrum
 absorption 465
 emission 465
 speed
 in hunting and defense 360
Sphyræna putnamiae (chevron barracuda) 371
 spider crab (*Xenocarcinus* sp.) 362, 388
 spinecheek anemonefish (*Premnas biaculeatus*) 369
 spines 106, 286, 348, 360, 364, 367-368, 373-374, 388-389, 391
 spiny oyster 352-353
 Pacific (*Spondylus varians*) 353
 spiral, Ekman 177-178, 200, 202
Spirobranchus giganteus (Christmas tree worm) 356, 360, 368
 spits 261, 271, 274-275, 279, 335-336, 345
 Spitsbergen 84
Spondylus varians (Pacific spiny oyster) 353
 sponges 5, 11, 25, 311, 314, 357, 362, 364, 368, 370, 377, 380,
 385, 388, 390, 392, 395, 408
 burrowing (*Oceanapia sagittaria*) 380
 spores 325, 343, 403, 409, 415-416
 spotted boxfish 367
 spotted seahorse (*Hippocampus kuda*) 362
 Spratly Islands 22
 spreading 43, 63, 65, 67, 70-75, 83-84, 86-87, 111, 123, 212,
 217-218, 258, 298, 353, 412, 453
 spreading cycles 63, 65, 71, 83, 86-87, 258, 298, 453
 spring tides 237, 239-240, 248, 250-251, 265, 376, 380, 398,
 407
 squid 52, 305, 307-309, 313, 348, 360, 368, 370, 377, 380, 411,
 489
 common reef (*Sepioteuthis lessoniana*) 307, 380

- Sri Lanka 223-224
 stacks 262
 staghorn coral (*Acropora* sp.) 355
 standing stock, CC see also biomass 293, 314, 327-328, 345, 489
 standing waves 206, 208, 226-228, 241, 244-247, 250
 steady state 4, 12, 94, 112-113, 115, 138, 462
 steepness 206-207, 209, 211, 213, 217-220, 227-228, 265, 483-485
 steering forces, currents and 176-177
Stenopus hispidus (banded coral shrimp) 349
 St. Helens, Mount, OR 68-69, 120
Stichodactyla haddoni (Haddon's sea anemone) 369
 stonefishes 368, 373
 storm front 212-213
 storm(s) 1, 29-31, 55-56, 145, 148-149, 152, 158, 160-161, 164-165, 167, 170-171, 182, 209-211, 213, 216-217, 227-229, 260, 263-265, 268-271, 273, 275, 278, 325-329, 343, 398, 407, 409, 415, 459
 stratigraphy 134
 stratosphere 142-143
 striated frogfish (*Antennarius striatus*) 361
 striped bass 23, 343, 442
Strongylocentrotus sp. (red urchin) 403
 strontium 96
 sturgeon 442
 subduction 63, 65-73, 75-76, 83-86, 93, 117, 123, 129, 223-224, 256, 283, 336, 412, 414
 subduction zones 63, 65-73, 76, 83-86, 93, 117, 123, 129, 223-224, 283, 336, 412, 414
 sublittoral zone 297, 313-314
 submarine canyons 41, 83-84, 120, 129, 138, 256, 267, 278-279
 submarines 19, 25, 32, 36, 39, 41, 53-54, 83-84, 107, 109-110, 112, 120, 129, 138, 225, 256, 267, 278-279, 370-371, 375, 397, 441, 444
 submersibles 19, 33, 36, 41, 45, 52-57, 73, 410, 412
 subpolar (high-latitude) gyres 177, 182
 subtropical gyres 153, 177, 182-185, 187-188, 202, 289, 294, 312, 382, 408, 439-440
 Suez Canal, Egypt 462
 Sulawesi, Indonesia 224
 sulfides 4, 99, 124, 135, 158, 283, 295, 312, 331, 339, 344, 348, 412-414, 416, 420, 422
 sulfur 29, 94-96, 98-100, 137, 283, 287
 Sumatra, Indonesia 71, 223-224
 superplumes 63, 72, 74, 76, 86
 supersaturation 122, 144, 171-172, 295, 312
 supralittoral zone 31, 297, 314, 404, 407, 415-416
 surface, ocean
 microlayer of 46, 106, 348-349
 sloping of 180-181, 202
 surface sediments 42, 123, 131-133, 135, 138, 283, 390, 411
 surface tension 92, 105-106, 112-113, 176, 202, 207-208, 227-228, 348
 surfers 207, 216, 220-221, 246
 surf, surf zone 29, 31, 205, 207, 220-223, 228, 248, 264-265, 273, 275, 279-280
 surgeonfish, mimic (*Acanthurus pyroferus*) 364
 surges from 166-167, 172, 223, 228, 269, 276-277, 279, 297, 404
 survival niches 396, 415-416
 suspension feeder 351, 392
 suspension feeders 349-352, 355-356, 390, 392, 398, 407, 411, 416
 benthic 351
 pelagic 350
 Suspension feeders 349, 351, 390
 Suspension Feeders 350-351
 suspension, of sediment 107, 112-113, 126, 139, 172, 187-188, 276, 280, 294, 296, 312, 314, 320, 326, 340, 350-352, 355, 392, 414, 416, 421, 456
 Swallow floats 48
 Swallow, John 48
 swamps, mangrove 2, 97, 255-256, 276, 395, 422, 443
 swash 266, 269, 279
 sweetlips 364, 375
 Celebes (*Plectorhinchus celebicus*) 364
 Goldman's (*Plectorhinchus goldmanni*) 375
 swells 63, 209, 213, 217, 227-229, 318, 368
 swim bladders 112, 307, 313-314, 373, 376, 390-392
 swimming, adaptations in 371-372
 swordfish 372
 symbiosis 383, 391-392
Synalpheus sp. (pistol shrimp) 389
Synchiropus splendidus (mandarinfish) 380
Synodus binotatus (twospot lizardfish) 361
 synoptic observation 55, 57, 188, 202
 Syria 15, 172
Taeniura lymma (blue-spotted ray) 306
 Tahiti 15, 17
 Taiwan 15, 22
 Tambora, Indonesia 71, 120
 Tampa Bay, FL 442
 taxonomy 282
Tealia lineata (rose anemone) 402
 tectonic estuaries 334-336, 344
 tectonic plates, see plates, lithospheric 60-63, 65, 75, 77-78, 81, 85-86, 256, 450-452, 472
Tegula funebris (black turban snails) 406
 tektites 136-137
Tellina sp. (clam) 358
 temperature
 and carbon dioxide solubility in seawater 123
 and solubility of gases 98
 as conservative property 198, 201
 diurnal cycles in 161, 167
 greenhouse effect and 1-3, 12-13, 33, 56, 82-84, 87, 89, 98-99, 102, 111, 114-115, 134, 136, 139, 141-142, 145-146, 172-173, 175, 189, 195, 203, 205, 212, 229, 249, 258, 271, 314, 395, 417, 447, 453, 463-464, 466-468
 in coastal oceans 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108, 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
 in rocky intertidal communities 31, 297, 312-314, 395, 404-

- 408, 415-416
land and sea breezes and 161, 167, 169, 171
ocean surface 56, 143, 152, 161, 164, 188, 212
water density and 35, 46, 58, 89, 95, 102-103, 105, 112, 114-115, 139, 141, 175, 179-181, 185, 190-191, 200-203, 207, 290, 447, 449-450, 454, 459-460
temporal variation 45, 55, 97, 111, 113, 163, 245, 301, 464
teratogens 424, 443, 493-494
tereally
rainbow runner (*Elagatis bipinnulata*) 364
terrace, low-tide 265, 278
terranes, exotic 69-70, 84, 86, 93
terrestrial climate zones 162-163
terrigenous (lithogenous) sediment 81, 116-120, 123-124, 126, 128-133, 137-138, 287, 296, 329
territorial seas 20-21, 32-33
Texas (TX) 26, 129, 235, 255, 258, 272, 332, 339, 429, 435
Thailand 27, 158, 223-224
Thalassia sp. (turtle grass) 357-358, 362
Thalassoma lunare (moon wrasse) 374
Thames River 432
Tharp, Marie 19, 40, 56, 58
Thelenota rubralineata (sea cucumber) 380
thermoclines 5, 31, 157, 179, 186, 191, 202, 288-291, 294-295, 312, 319, 321-329, 331-332, 343-345, 396, 408-409
seasonal 179, 191, 319, 325-329, 331, 343-344
thermohaline circulation 176, 190, 200-202, 225
thermometers 46-47, 111
reversing 46-47
thermometry, acoustic 111
threadfin anthias (*Pseudanthias huchtii*) 372
Three Mile Island, PA 441
Thresher USS 225
Thunnus sp. (tuna) 370
Thyca crystallina (parasitic snail) 384
tidal bores 246, 249, 251, 264, 312
tidal curves 235
tidal ranges 29, 231, 235, 237, 239-240, 242-251, 255, 262-263, 265, 279, 334, 336, 380, 407
tide pools 320, 368, 375, 404, 408, 415
tides
amphidromic systems and 241-244, 250-251
and gravity 234, 250
as waves 208-209, 235, 240-241, 244-245, 250
Coriolis effect and 235
currents and 29, 190, 201, 231, 244-251, 320, 326, 336-337, 339-341, 344, 438
distribution of force in, 234, 250
diurnal 235-236, 238, 244, 250
ebb 231, 245-247, 250-251, 320, 336-337, 344
energy from, equilibrium 32, 248, 250
flood 246, 251
high 205, 231, 235, 238-240, 242, 244-245, 248, 263, 265, 278, 297, 380, 404, 415
landmasses and 240-241
latitudinal variation in 241
low 205, 231, 235, 238-240, 242, 245-246, 250-251, 259, 264-265, 276, 348, 351, 398, 404, 408
marine organisms affected by 248, 380
mixed 235-236, 238, 244-245, 250-251, 380
nutrient transport by 237, 239-240, 250-251, 380
open-ocean 244-245, 250
partial 240, 243, 250
predicting 240
range of 29, 231, 235, 237, 239-240, 242-251, 255, 262-263, 265, 279, 334, 336, 380, 407
tables for 235, 245-246, 248, 251
wave speed of 240-241
Tierra del Fuego 17
tiger pistol shrimp (*Alpheus bellulus*) 389
timing, in reproduction 380
Titanic 38, 54
Tokyo, Japan 8, 202
tomato anemonefish (*Amphiprion frenatus*) 369
tomography 50, 57, 62-63
acoustic 50
computer 63
seismic 62
Tonicella lineata (lined chiton) 406
TOPEX/Poseidon satellite 55, 211
topographic maps 6
topography, dynamic 180-181
toxicity 89, 114, 324, 330, 391, 395, 417, 419-420, 424-425, 429, 431, 440, 443-445, 447, 492-493
chronic 431, 444, 492
dinoflagellate 330-331, 344-345
effects on marine organisms of 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108, 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
in estuaries 341, 492
in hunting and defense 368
in industrial waste 99, 422, 436, 443
in sewage 432
non point sources (urban and agricultural) 435-436, 443
of antifouling paints 32, 427, 440, 444
synthetic vs. natural 425, 492
toxins 281, 303, 330-331, 344, 368, 423, 425, 494
Toxuma armatum (saw blade shrimp) 388
trace elements
importance to life of, 37, 45, 58, 95, 97, 198, 287, 324, 423, 425, 427, 431-433, 445, 493
in seawater 95, 97, 112, 287
tracers, in water masses 47, 57, 198-203, 440
tracing 47, 57, 109, 114, 198-203, 440
trade winds 148-150, 152, 154-158, 161, 164, 170-172, 182-186, 201-202, 210, 323
trains, wave 214-216, 227-228
transform faults 69, 75-76, 81, 85-87, 256, 336
transport
Ekman 178-187, 190, 200-202, 265, 321-322, 336, 343-344, 439
of heat latitudinally by ocean currents 147
of nutrients 289

- of sediment 22, 83-84, 116, 118, 167, 221, 261-263, 273-274, 278
- onshore-offshore 323
- Transport 3, 13-14, 23, 25, 29, 54, 83, 90, 92, 102, 112, 116-120, 127, 137, 139, 147, 155, 171, 175-187, 189-190, 198, 200-202, 213, 222, 227, 253, 256, 262-263, 265-274, 288-289, 295, 318, 321-323, 325, 336, 339-340, 343-344, 420, 423-424, 431, 439, 445, 455, 468
- transport by winds 119
- traps 51-52, 57, 76, 81, 137, 267, 307, 368, 439
- trash, pollution from, 31-32, 116, 420, 427, 439-440, 444
- trawl nets 18, 24, 27, 51-52, 57
- trenches 63, 66-67, 69, 75-76, 84-85, 132, 137, 241, 296, 298, 314
- trevally 364, 371-373
 bluefin (*Caranx melampygus*) 364
Carangoides sp. 371, 373
Triaenodon obesus (reef whitetip shark) 306
- tributyltin 425, 440, 444
- Trichechus manatus* (manatee) 357
- Tridacna gigas* (giant clam) 388-389
- Trieste bathyscaphe 54
- triggerfishes 368, 372-374
 clown (*Balistoides conspicillum*) 374
- triple junctions 67
- Tristan da Cunha 78
- tritium 199-200, 440
- trochoidal shape, of waves 206, 209
- trophic efficiency 292, 332-333, 344, 488
- trophic levels 291-293, 296, 303, 312, 314, 333, 345, 425, 443, 488-489, 494
- tropical regions 80, 104, 147, 158, 164, 171-172, 184, 201, 287, 303, 319, 326, 343, 345, 351, 422, 425, 445, 458
- Tropic of Cancer 149
- Tropic of Capricorn 149
- troposphere 142-144, 147-148, 159, 170, 172
- troughs, of waves 206-209, 213, 215, 220, 222-224, 226-228, 241, 245, 250, 263, 265, 267-268
- Trout, rainbow (*Oncorhynchus mykiss*) 375
- Truman, Harry S. 20, 32
- Truman Proclamation 20
- truncate caudal fins 372, 391
- trunkfishes see boxfishes
- TS diagrams 197-198
- tsunamis 1-2, 32, 70, 129, 136-137, 205, 208-209, 219, 222-225, 228, 257, 297
- Tubastrea* sp. (hard coral) 355
- tube worms
Riftia pachyptila 413-414
 Sabellidae 352
- tuna 24, 292, 305, 370-372, 376, 393, 488-489
 dogtooth (*Gymnosarda unicolor*) 305
Thunnus sp. 370
- tuned oscillation 227
- tunicates 120, 304, 314, 350-351, 355, 357, 368, 390, 395
Didemnum molle 355
 lightbulb, (*Clavelina* sp.) 355, 465
Rhopalaea sp. 355
Botryllus sp. 355
- turbidites, turbidite layers 123, 127-130, 136-138
- turbidity 32, 47, 81, 113, 120, 127-129, 133, 137-138, 168, 209, 222, 256-257, 275-276, 278-279, 285-286, 317, 320, 326-327, 341-345, 396, 398, 408, 411, 415, 421-422, 437, 442-443, 456, 458
- turbidity currents 32, 120, 127-129, 133, 137-138, 209, 256-257, 411, 456, 458
- Turbulence 116-118, 128, 138, 183, 202, 209, 213, 248, 286, 291, 297, 320, 325-326, 336-337, 339, 345, 350, 370, 404, 407-409, 454-458
- Turkey 71, 334, 429
- Turnagain Arm, Cook Inlet, AK 246, 255
- turtle grass (*Thalassia testudinum*) 311, 357-358, 362
- turtles 24, 52, 248, 310-311, 313, 357-358, 362, 383, 390, 400, 439
 green (*Chelonia mydas*) 310, 357-358
 hawksbill (*Eretmochelys imbricata*) 310-311
- Tuscarora, USS 38
- twospot lizardfish (*Synodus binotatus*) 361
- typhoons 166
- United Kingdom 43, 217, 429, 435, 441
- United Nations 20-21, 23, 32, 419
- United States 2, 20-23, 25-26, 32, 38, 40, 43, 84, 86, 117, 130, 138, 148, 158-160, 166-167, 169, 172, 225, 229, 235, 253, 255, 258, 267, 269, 272, 276-277, 280, 285, 318, 330-331, 334, 343, 368, 420, 423, 425, 427-428, 431-437, 442, 445, 454, 467, 469
- units of measurement 5, 10-12, 20, 29, 95, 143, 235, 460
- Upeneus tragula* (blackstriped goatfish) 359
- upwelling 63, 67, 71-72, 74, 86-87, 122, 126, 131-133, 138, 148-149, 152-158, 169, 171-172, 182-183, 185-187, 190-191, 195, 201-202, 287, 289, 291, 293-294, 312, 314, 318, 321-328, 331-333, 342-345, 380, 401, 408-409, 412, 415, 454-456
 coastal 122, 156, 169, 186, 201-202, 287, 291, 293, 321-325, 328, 332, 342-345
- Ural Mountains, Russia 71
- urchins see sea urchins
- urchin shrimp (*Gnathophyllodes mineri*) 388
- Urechis caupo* (innkeeper worm) 358-359
- Valdez, AK 426, 428-431, 443
- valleys, in continental shelves 83-84
- van der Waals force 92-93, 99, 102, 106, 113
- Vanuatu 371, 375, 380, 388
- vaporization, latent heat of 33, 92, 100-102, 112-114, 144, 146-147, 171-173, 458-459
- vapor, water see water vapor
- Vasco da Gama 16
- vectors 473
- vegetation 6, 145, 162, 260, 263-264, 271, 276, 278, 309, 317, 400, 430, 442, 466
- vegetative reproduction 377
- velocity, of sound in water 50, 109-111, 113
- venom 368, 373, 391
- vents hydrothermal, see hydrothermal vent
- Venus 41, 90, 107
- vertebrates 282, 304-305, 314, 330-331, 344-345, 375-376, 392
- vertical exaggeration 7, 12
- vertical movement of 176, 190, 200-202, 225
- Vietnam 22
- Vikings 16
- viperfish 411
- Virginia (VA) 235, 255, 275

- Virgin Islands, U.S. 22
- Vir philippinensis* (coral shrimp) 388
- viruses 51, 285, 296, 298-299, 313, 331, 368, 424, 431, 434
- viscosity 105-106, 112-113, 202, 212, 227-228, 286, 349, 377, 456
- viviparous species 380, 392, 404
- volcanic islands 69-71, 77-78, 80, 84-86, 224, 256-257, 265, 276, 280, 416
- volcanic rocks 43, 62, 77, 120, 124, 129, 260, 266, 412
- volcanoes, volcanism 2, 59, 67-78, 80-81, 85-87, 93, 97-99, 119-120, 124, 136, 170, 223, 256-257, 266, 276, 278, 283, 412, 416, 452
- as source of lithogenous particles 119
- coastal formation by 63, 65-73, 76, 83-86, 93, 117, 123, 129, 223-224, 256, 283, 336, 412, 414
- extinctions and 136-137, 224
- in hot spots 62-63, 66, 76-80, 84, 86, 124, 256, 276, 280, 452
- in magmatic arcs 69-71, 84-86, 256
- in oceanic ridges 22, 60, 63, 65-67, 70, 72-76, 79-81, 84-86, 93, 123-125, 129, 133, 135, 138-139, 195, 241, 256, 276, 283, 412-414, 416, 452-453
- in rift zones 65, 67, 71-74, 81, 85-86
- in subduction zones 63, 65-73, 76, 83-86, 93, 117, 123, 129, 223-224, 283, 336, 412, 414
- sedimentary (stratigraphic) record of 133, 138
- water released by 90, 112
- walrus (*Odobenus rosmarus*) 309-310, 410
- waste
- industrial 23, 330, 424, 427, 433, 436
- waste disposal 23, 31-32, 253, 317-318, 339-341, 359, 420, 423-425, 427, 431-433, 435, 437-439, 444-446
- wastes
- nuclear 441
- water
- as necessary for life 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108, 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
- density of 35, 46, 58, 89, 95, 102-103, 105, 112, 114-115, 139, 141, 175, 179-181, 185, 190-191, 200-203, 207, 290, 447, 449-450, 454, 459-460
- dissolving power of 90, 93, 112
- distribution of 90, 112
- Earth's budget of 144-146
- fresh, see freshwater 23, 27, 29, 32, 37, 61, 80, 84-85, 90, 92, 98, 104-106, 113, 116, 146, 153, 155, 161, 171, 179, 186, 191, 194, 196, 198, 201, 245-246, 275, 277-278, 312, 314, 317-319, 321, 325-326, 330-331, 334, 336-337, 339, 341-344, 375-376, 381-382, 391, 398, 409, 423-425, 435, 442, 444
- heat properties of 33, 89, 92, 99-102, 105, 112-114, 142, 145-147, 150-151, 161-162, 164, 167-168, 171-173, 213, 229, 345, 458-459
- molecules of 4, 90-93, 99-100, 102-107, 112-113, 135, 143-144, 176, 191, 199, 207-208, 212-214, 217, 219, 375, 440, 456, 459, 483, 487
- origin of 9, 12, 19, 26-28, 30-31, 34, 41, 45, 47, 57-58, 66, 69, 74, 82-83, 85-86, 88, 92, 101, 108, 113-114, 125, 130-131, 137-138, 140, 153, 165, 173, 178, 181-182, 184, 186, 192, 197, 203, 215, 225, 228-229, 235-236, 238, 241-242, 244, 247, 249-251, 254-255, 264, 280, 294-296, 301, 304, 306, 315, 319, 323, 329, 335, 343, 346, 350-351, 354, 356-357, 361, 363-365, 367, 369, 374, 378-379, 384, 386-387, 392-394, 399-402, 405-406, 408, 415, 417, 419, 423, 426, 435, 438, 441, 443-446, 457-459, 472, 474-475, 478-479, 481-482, 485, 488, 491, 494
- phases of 99-100, 112-113
- pore (interstitial) 27, 135, 138, 296, 358, 390, 414
- transmission of light in 106, 108, 112
- transmission of sound in 50, 109-111, 113
- water column
- aphotic zone in 108, 284, 286, 290, 302, 313, 348, 411, 416
- compensation depth in 123-124, 133, 137, 202, 286-287, 296, 298, 312-313
- Ekman spiral in 177-178, 200, 202
- photic zone in 24, 27, 97, 108, 113, 123-124, 133, 137, 202, 284-291, 293-300, 302, 308, 312-314, 318, 320-321, 325-331, 343-345, 348, 351, 356, 364, 381, 390, 395-397, 409, 411-412, 415-416, 422
- stratification of 157, 172, 178-179, 184-186, 190-193, 200-202, 225, 228, 295, 314, 319-320, 343-344, 447, 449-450
- wind-driven layer of 178-179, 182, 185
- water masses
- anoxic 295, 331-332, 344-345, 420-422, 432, 435, 443
- water vapor 33, 90, 92, 99, 101-103, 114, 135, 141-148, 162, 164, 167-173, 450, 454, 458-459, 465, 468, 483
- wavelengths 106-108, 110, 112, 145-146, 188, 207-210, 214, 216-217, 220, 223, 225, 227-229, 242, 267-268, 366, 458, 463-465, 485
- of electromagnetic radiation 33, 36, 55-57, 90, 106-109, 112-113, 145, 464-465
- of heat energy 145-146
- of oceanic waves 206, 208-209, 211, 215, 217, 223, 225-229, 235, 241, 245-246, 250, 326-327
- tsunamis 1-2, 32, 70, 129, 136-137, 205, 208-209, 219, 222-225, 228, 257, 297
- wave rays (orthogonals) 218-219, 228-229
- waves
- amplitude of 206
- and Coriolis effect 225, 228
- beach sand sorting by 267, 269
- breaking 31, 106, 112, 155, 205-207, 209, 213, 217, 219-223, 227-229, 246, 248, 260, 264-266, 273, 275, 279-280, 297, 404, 428
- capillary 208-209, 213, 227
- celerity (speed of) 206-207, 214-215, 217-218, 227-228, 241
- coastal modification by 260, 262
- complexity of 205, 227
- creation of 208-211, 223, 225, 229, 241, 326-327
- crests of 76, 170, 206-209, 211-213, 215, 218-224, 227-228, 241-245, 250, 267-269
- currents and 211
- deep-water 209, 213-214, 216, 218, 227-228
- depth of no motion in 180-181, 214
- dispersion of 209, 216-217, 227-228
- dissipation of 212
- energy from 29-31, 127, 136, 206-210, 212-213, 215, 217-

- 221, 224, 227, 255, 260-263, 268-269, 273, 275, 278-279, 398-400, 428
energy of 207
erosion by 22, 83-84, 118, 167, 221, 261-263, 273-274, 278
frequency of 206
gravity 208-209, 227
heights of 56, 164, 205-213, 215-216, 218-220, 222-223, 225, 227-229, 235, 242, 248, 265, 268
horizontal pressure gradients in 208
interference 206, 215, 227-228
intermediate 217-218, 228
internal 195, 225, 228-229, 320, 325, 336, 339, 343, 345
Kelvin 225, 228
movement of water in 207, 213, 217
nutrient transport by 325
periods of 205-206, 214, 218, 220, 227-228, 235, 265, 325
progressive 206-208, 226-228, 235, 244-246, 250
refraction of 218-219, 225, 262
restoring forces in 176, 207-208
Rossby 148, 225, 228-229
shallow-water 218-219, 223, 228, 241, 243, 246, 250-251
speed (celerity) of 206-207, 214-215, 217-218, 227-228, 241
standing 206, 208, 226-228, 241, 244-247, 250
steepness of 206-207, 209, 211, 213, 217-220, 227-228, 265, 483-485
surface tension and 208-209, 213, 227
tides as 208, 235
trains of 214-216, 227-228
trochoidal shape of 206, 209
troughs of 206-209, 213, 215, 220, 222-224, 227-228, 241, 245, 250, 265, 267-268
wavelengths of 206, 208, 226-228, 235, 245-246, 250
winds and 208-209, 211, 223, 225, 229, 241, 326-327
weathering 116, 134, 136-137, 288
weather maps 6, 225, 229, 484
weather, weather systems 1-3, 6, 13, 26, 37-38, 49, 56, 89, 102, 141-143, 145, 147-149, 151-152, 157, 159, 161, 163-169, 171-173, 187-189, 212, 223, 225, 228-229, 251, 263, 272, 279, 294, 317, 320, 328, 334, 409, 459, 464, 467-469, 472, 484
and Coriolis effect 1-2, 56, 141, 145, 147-148, 157, 159, 161, 163-168, 171-172, 212, 223, 228, 272, 279, 294, 459, 467, 469
coastal modification by 263
Weddell Sea E 193-195, 201
weed cardinalfish (*Foa brachygramma*) 388
Wegener, Alfred 19
well-mixed estuaries 336-337, 339-340, 344
westerlies 30, 148, 183, 185, 201-202
western boundary currents 167, 172, 182-184, 186, 188-189, 194, 201-203, 321, 396
West Papua, Indonesia 224
wetlands 2, 32, 127, 130, 138, 263, 276-279, 336, 340, 342-345, 358, 421-422, 424, 429-430, 442-444
whales 24, 51-52, 111-112, 116, 143, 209, 291-292, 299, 302, 306, 308-309, 313, 315, 345, 383, 390, 403, 410, 414, 442, 489
baleen 292, 302, 308-309, 313, 383, 410, 489
California gray 309, 383
humpback (*Megaptera novaenglia*) 308, 383
killer (*Orcinus orca*) 292, 308-309, 403
whale shark (*Rhincodon typus*) 306
whip corals 362, 388
whip goby (*Bryaninops yongei*) 384
wide-area echo sounders 40
willy willys 166
windrows 190
winds
coastal modification by 263
fetch of 30, 164, 210, 217, 227-228
in wave creation 208-209, 211, 223, 225, 229, 241, 326-327
trade 148-150, 152, 154-158, 161, 164, 170-172, 182-186, 201-202, 210, 323
westerly 30, 148-149, 155, 159, 161-162, 167, 171-172, 182-185, 195, 201-202, 210, 294
windward 170-172, 209, 400
World Glory 211, 429
worms
annelid 358-359
Christmas tree (*Spirobranchus giganteus*) 356, 360, 368
fan 356, 360, 368
innkeeper (*Urechis caupo*), 358-359
lugworm (*Arenicola brasiliensis*), 359
plume 413
marine 383
scale 385, 388, 413
tube 351-352, 412-414, 416
wrasses 359, 364, 370-371, 373-374
cheeklined (*Oxycheilinus digramma*) 371
cleaner (*Labroides phthirophagus*) 364
moon (*Thalassoma lunare*) 374
redbreasted Maori (*Cheilinus fasciatus*) 373
xanthophylls 486
Xenia sp. (soft coral) 355
Xenocarcinus sp. (spider crab) 362, 388
Yangtze (Chang) River 117
year class strength 329
Yellow (Huang) River 117
Yellow Sea 117
yellow shrimp goby (*Cryptocentrus cinctus*) 389
Yellowstone Park 76
yellowstreak fusilier (*Pterocaesio lativittata*) 371
Younger Dryas period 196, 198
Yucatán Peninsula, Mexico 136, 166
Zalophus californianus (California sea lion) 309
zebra lionfish (*Dendrochirus zebra*) 374
zinc 27, 58, 96-97, 124, 135, 287, 420, 436, 493
zooanthids 353, 355
zooplankton 51, 57, 109, 116, 122, 138, 287, 290-293, 296, 298-303, 313-314, 323-329, 331, 333, 342-343, 345, 348-351, 353, 370, 390, 392, 397, 410, 421, 439, 489
zooxanthellae 275-276, 278, 320, 327, 343, 388, 392, 396-397, 400, 414-416