ABC (acceptable biological catch) 141
adaptation of Wshing communities 59–63
Ahmed, M. vii
Ålesund 40
Alheit, J. 238, 297
Alston, J. 221
alternative occupations of fishers 59, 112, 123–4
see also supplementary occupations of fishers
anchovy see South African pilchard/anchovy fishery model
aquaculture
as alternative occupation for fishers 59, 123
as source of demand for fish product 139–41, 262, 265
Arctic Climate Assessment study 5
Arminton, P. 221
Arnason, R. vii, 72, 74, 76, 78
Asche, F. 273
Asian fisheries
catch levels 216–17
climate change 218–20
climate change impact model approaches 220
conclusions 231–2
numerical implementation 221–3
results 223–31
structure 220–21
overview 215
species 232–3
stocks 217–18
Askøy 38
Astthorsson, O.S. 108
Atlantic–Pacific correlations 120–22
Atlanto-Scandian herring see Norwegian spring-spawning herring
Bakun, A. 237, 262, 265
Barange, M. vii–viii, xv
Barnett, T.P. 237
Barreteau, O. 268
Barrowman, N.J. 152
Baumgartner, T.R. 128, 135, 155, 237, 238, 302
Beamish, R.J. 297
Beaugrand, G. 299, 302
behaviour, migratory
Norwegian spring-spawning herring 67–9, 101–8
Pacific sardine 126
Belkin, I.M. 108
Bellman, R. 21
Bergen 37, 40
Beverton, R.J.H. 272
big herring fishery 36–7, 39
bioeconomic models 268
Bjørkvik, E. 114
Bjørndal, T. 17, 76, 98, 238, 239, 273
Bomlo 60–61
Botsford, L. 219
Boyer, D.C. 205, 206, 207, 208, 299
Briones, R.M. viii, 268
Butterworth, D.S. 152, 155, 156, 157, 164, 195, 200, 202, 206, 208, 210
capelin see winter capelin fishery
catch rate per unit effort (cpue) 201
Chavez, F.P. 128, 218, 219
Chinese fisheries 263, 292
Cisneros-Mata, M.A. 263
Clark, C.W. 6, 12, 236, 268
Clark, F.N. 126, 129, 147, 149
climatic change impacts abrupt changes 297–8
Asian fisheries 218–20
empirical evidence for 237–8
marine ecosystems 263–5
modelling
competitive fishery 15–18, 29–30
considerations 5–8
optimal fishery 9–15, 27–8
stochastic case 18–25
Namibian pilchard 208
Norwegian spring-spawning herring 85–8
Pacific Northwest sardine fishery 146–7
Pacific sardine 128, 129–31
predictions 1–5, 25–7, 296–7

Clupea harengus L. see Norwegian spring-spawning herring
Cochrane, K.L. 163
cod 238
Collie, J.S. 152
Conser, R.J. 136
CPS (coastal pelagic species) 126
cpue (catch rate per unit effort) 201
Cram, D.L. 208
Crawford, R.J.M. 209
Cripe, G. viii, 240
Csirke, J. 262
Cushman, R.M. 262
Dalzell, P. 217, 219
de Leiva Moreno, I. 263
De Oliveira, J.A.A. xii, 152, 155, 156, 157, 163, 164, 170, 193, 195, 200, 202
DeAngelis, D.L. 262
Delgado, C.L. 220, 268
demand for fish product 265
see also aquaculture, as source of demand for fish product; Japan, demand for sardine; supply-demand models
Devaraj, M. 216
Dey, M. 217, 220, 268
Dickson, R.R. 108, 238
Diffenbaugh, N.S. 265
Duffy, J. 268
Durand, M.-H. 262

East Iceland Current, cooling of 69
eel see sand eel fishery
EEZs (exclusive economic zones) 66–7
empirical evidence for climate change phenomena 237–8

Engesæter, S. 66, 67, 98
EU–Norway fishing agreements 67
exclusive economic zones (EEZs) 66–7

Failler, P. 268
Färe, R. 148
Farrell, M.J. 148
Fasting, K. 48, 114
fat herring fishery 36–7
Fedje 60–63
Finney, B.P. 237
fisheries management 292, 302
fisheries management plan (FMP)
see PFMC fishery management plan
fishery collapses 298–300
fishing vessel categories 196–7
Floro 40
Floros, C. 268
FMP see PFMC fishery management plan
Francis, R.C. 219, 237
Fréon, P. viii–ix, 262, 278, 292
Frey, H.W. 129
fuel per trip-hour 200
Gammelsrod, T. 208
Garces, L. ix
Garcia, S.M. 263
Gislason, A. 108
global warming 301, 303
Golubtsov, P. ix, 240, 255, 258
Gordon, H.S. 236
Gréboval, D. 262
Hagen, E. 238, 297
hake see Namibian hake
Hamilton, L.C. x, 109, 122, 123
Hampton, I. 205, 206, 207, 208
Hamre, J. 67
Hannesson, R. x, 6, 16, 67, 300
Hardin, G. 58
Hare, S.R. 237, 299, 302
Hart, J.L. 126
harvest formula see maximum sustainable yield
Haugesund 40
Hedgecock, D. 126
Herrick, S.F., Jr x
Herring Era Museum 109
herring game see Norwegian spring-spawning herring, game theory biomass model
herring girls 109
herring stock fluctuation causes, Norwegian fisheries 47–8
herring towns
erise and fall 100–101, 122–4
see also Fedje; Neskaupstaður; Rákvåg; Seyðisfjörður; Siglufjörður
herring types 36–7
Hilborn, R. 152, 272
Hill, K.T. x–xi, 135
Hollowed, A.B. 237
Holmes, B. 262
Holt, S.J. 272
Hordaland county 37–44, 49, 51–2
horse mackerel 213
Hull, J.C. 20
Hurrell, J.W. 108, 238
Iceland
herring fishery 36–7
see also Neskaupstaður; Seyðisfjörður; Siglufjörður
IMR (Institute of Marine Research) 48, 50
India
climate change model results 223–7
see also Asian fisheries
Indo–Pacific mackerel 216–17
see also Pacific mackerel
Institute of Marine Research (IMR) 48, 50
interdecadal variability 151
see also Pacific Decadal Oscillation
Intergovernmental Panel on Climate Change (IPCC) 1, 301
IPCC (Intergovernmental Panel on Climate Change) 1, 301
Isaacs, J.D. 155
jack mackerel 128, 136
Jacobson, L.D. 129
Janssen, J.F., Jr 126, 149
Japan, demand for sardine 143–4
Johansen, E.K. 39, 40, 41, 42, 45, 48, 49, 52, 53
Mendelssohn, R. 265
Merton, R.C. 18, 21
migratory behaviour
Norwegian spring-spawning herring 67–9, 101–8
Pacific sardine 126
Miller, K. xi, 237, 258
Mirman, L.J. 236, 258
Misund, O.A. 262
mixed fisheries 302–3
models see Asian fisheries, climate change impact model; climate change impacts, modelling; Norwegian spring-spawning herring, game theory biomass model; South African pilchard/anchovy fishery model; Split Stream Harvest Model; worldwide system of small pelagic fisheries model, prototype
Moreno, I. de Leiva see de Leiva Moreno, I.
Mote, P.W. 265
MP (management procedure) approach 152
MSY (maximum sustainable yield) control rule 135–6
Mueller, D. 274
Mullon, C. xi–xii
Munro, G.R. 237
Myers, R.A. 152
Nagurney, A. 292
Namibian hake 211–13
Namibian pilchard biomass 205–6
consequences of decline 209–11
landings 205–6
reasons for decline 206–8, 213
NAO (North Atlantic Oscillation) 108, 238, 297
Neskaupstaður 101, 111, 113–14
North Atlantic Oscillation (NAO) 108, 238, 297
North Sea herring fishery 41, 50
migration dependent upon abundance 67
North Sea mackerel 36, 51–2, 55, 57, 61, 63
Norton, G. 221
Norway see Askøy; Bømlo; Fedje; Råkvåg
Norwegian pout fishery 58
Norway–EU fishing agreements 67
Norwegian fisheries 1919–1940 interwar period 37–42
1940–1960 postwar 43–4
1961+ crisis adaptation 48–52
causes 47–8
consequences 44–7, 52–3
expansion in new fisheries 58–9
government response 53–4
regulation introduction 55–7
technology changes 54–5
and herring 34–6
Norwegian spring-spawning herring climate change impacts 85–8
data sources 78
definitions 36
game theory biomass model competitive solution, 81–4
cooperative solution 84–5
model 77–81
game theory literature 72–7
migratory behaviour 67–9, 101–8
Norway’s share 69–72
surplus growth model v. multi-year-class 88–98
NPV (net present value) calculation 201
NSSH see Norwegian spring-spawning herring
O’Brien, C. 297
Ocean Loop 67
ocean temperature changes as cause of Norwegian fisheries crisis 47–8
and collapse of Pacific sardine fishery 128
gradual 297–8
observed 33, 299
predictions 3, 300
see also East Iceland Current, cooling of; North Atlantic Oscillation; Pacific Decadal Oscillation
Ögmundardóttir, H. xii
optimum harvest policy
Pacific sardine fishery
  catch allocation for full harvest utilization 139–44
  harvesting capacity goal 138–9
  limited entry 136–9
  MSY control rule 135–6
  policy considerations 144–7
Østvedt, O.J. 239
Ottersen, G. 238
Otterstad, O. xii–xiii, 118

Pacific Decadal Oscillation (PDO)
  see also interdecadal variability
Pacific Fishery Management Council (PFMC) 128, 134, 145
Pacific mackerel 128, 132, 136, 219
  see also Indo–Pacific mackerel
Pacific Northwest sardine fishery, climate change impacts 146–7
Pacific sardine (*Sardinops sagax*)
  climate change impacts 128, 129–31
  Japanese demand 143–4
  migratory behaviour 126
  overview 126–8
Pacific sardine fishery
  historical collapse 129–33
  optimum harvest policy
  catch allocation for full harvest utilization 139–44
  harvesting capacity goal 138–9
  limited entry 136–9
  MSY control rule 135–6
  policy considerations 144–7
  renewal 133–5
 Pacific–Atlantic correlations 120–22
Pardey, P. 221
Parma, A.M. 151, 152
Parsons, L.S. 238
Pascoe, S. 8
Pauly, D. 219, 263, 267, 292
PDO (Pacific Decadal Oscillation)
  237–8
  see also interdecadal variability
PFMC (US Pacific Fishery Management Council) 128, 134, 145
PFMC fishery management plan 128, 134

Philippines
  climate change model results 227–9
  see also Asian fisheries
pilchard 205
  see also Namibian pilchard; South African pilchard/anchovy fishery model
Pindyck, R.S. 18, 21, 23, 24, 31
Plourde, C.G. 12
Pontryagin, L.S. 22
pout see Norway pout fishery
Prato, T. 8
profitability, as feedback on fish stocks 36
Punt, A.E. 152
purse-seining 40, 45, 117, 132
Radovich, J. 126, 129, 131, 148
Råkvåg 114–20
regime shifts 151–2
Reiss, C. xiii
resource depletion, reactions to 122–4
Roemmich, D. 237
Rogers, J.C. 238
Rosamond, N. 262
Roth, A.E. 268
saithe fishery 58–9
sand eel fishery 58
Sandal, L.K. 259
sardine see Pacific sardine; pilchard
*Sardinops sagax* see Pacific sardine
Schwartz, N.L. 18, 21
Schwartzlose, R.A. xvi
Schwing, F.B. 265
sea-net fishing gear 42
seine groups 40
seining see land-seining; purse-seining
Seyðisfjörður 101–2, 111, 113–14
Shannon, L.J. 205
Shoven, B.J. 268
Siglufjörður 101–2, 108–12
Sigurðsson, B. 102, 109
Silvestre, G.T. 216, 218
Sissener, E.H. 76
Sjurseth, K. 114
small herring fishery 36–7, 41
Smith, A.D.M. 152
Snyder, M.A. 265
Soutar, A. 155
South African pilchard/anchovy
fishery model
discussion 193–6
interannual catch variability 187–92
management procedures
alternatives 163–4
estimators 157–63
sources of 156
NPV v. loss
results 177–87
submodel 196–201
operating models 152–5
preliminary investigations 165–70
without Total Allowable Catch
constraints 192–3
summary performance statistics
155–6
Sparre, P.J. 196
Split Stream Harvest Model
examples of output 243–53
further advances 255–9
information structure of game 242–3
overview 239–40
sprat fishery 41–2, 49, 58
spring herring fishery 36–7, 39
Stavanger 40
Steinshamn, S.I. 211, 259
Stenevik, E.K. 33, 48, 300
Stenseth, N.C. 237, 238
Stephanus, K. xiii
Storsildfiske see big herring fishery
Sumaila, U.R. xiii–xiv, 211
Sundby, S. 33, 48, 300
Supongpan, M. 217
supplementary occupations of fishers
42
see also alternative occupations of
fishers
supply-demand models 268–9
Sutinen, J.G. 302

Tacon, A.G.J. 273
technology changes 36, 54–5, 61–2, 63
teleconnections see Atlantic–Pacific
correlations
Thailand
climate change model results 229–31
see also Asian fisheries
Toresen, R. 239
Trinidad, A. 217, 218
Troade, J.-P. 263
Tsai, C.-F. 219
Tufteland, J. 114
tuna fishery off Norway, disappearance
of 50
Tvetetaras, R. 273
Uber, E. 128, 129, 132, 147
US Pacific Fishery Management
Council (PFMC) 128, 134, 145
Van Loon, H. 238
Vários dfiske see spring herring fishery
Vasconcellos, M. 211
Vilhjálmsson, H. 86, 98, 101, 103, 108
Vivekanandan, E. 217
Vollan, O. 114
Vrooman, A.M. 126
Walden, J.B. 138
Walters, C.J. 151, 152, 272
Watson, R. 263, 267, 292
Weeks, S.J. 262
Welch, D.W. 297
Whalley, J. 268
Wilen, J.E. 16
Willmann, R. 196
winter capelin fishery 57–8
winter herring fishery 36–7, 39–40, 41,
43–4
see also big herring fishery; spring
herring fishery
worldwide system of small pelagic
fisheries model, prototype
data collection 278
discussion 290–92
entities, scales and mechanisms
269–74
modelling principles 267–9
overview 262–7
parameters 274–6
results 281–6
role-playing game 276–7
scenarios 276
‘black’ 281–6
‘pink’ 286
sensitivity analysis 276, 286
zonal attachment 66–7