AJES
ASIAN JOURNAL OF ENVIRONMENTAL SCIENCE
DOI: 10.15740/HAS/AJES/12.2/129-134
VOLUME 12 | ISSUE 2 | DECEMBER, 2017 | 129-134 e ISSN-0976-8947 Visit us : *www.researchjournal.co.in*

A REVIEW

Impacts of climate change on marine fisheries sector

M. M. GIRKAR, S. S. GHATGE, S. N. KUNJIR, A. T. TANDALE AND B. BOPANNA

Article Chronicle :
***Received* :**
26.07.2017;
***Accepted* :**
27.11.2017

ABSTRACT : The biodiversity is under threat due to overfishing, pollution, habitat destruction/ degradation, exotic species invasion global warming, variation in sea surface temperature and climate change. Of these only immediate non-mitigable factor is climate change and can be a major concern for fisheries and aquaculture production worldwide. The authors have made an effort to review the impacts of climate change on marine ecosystem and its resources which will affect capture fisheries with respect to following points: species distribution shift, species extinction, competitors and pathogens, productivity, ocean acidification, mangroves and coral reefs.

HOW TO CITE THIS ARTICLE : Girkar, M.M., Ghatge, S.S., Kunjir, S.N., Tandale, A.T. and Bopanna, B. (2017). Impacts of climate change on marine fisheries sector. *Asian J. Environ. Sci.,* **12**(2): 129-134, **DOI: 10.15740/HAS/AJES/12.2/129-134.**

Key Words :
Climate change, Marine fisheries, Ocean acidification, Mangroves, Coral reefs

Author for correspondence :
M.M. GIRKAR
Department of Aquatic Environment Management, College of Fishery Science, Udgir, LATUR (M.S.) INDIA

See end of the article for **Coopted authors'**

The term 'fisheries sector' in broader sense encompasses capture fisheries and aquaculture. The contribution from fisheries sector to the total supply of food increased from 4 million tonnes in 1900 to 167.2 million tonnes in 2014 and valued US$148 billion. The significant growth in fisheries and aquaculture production in the past 50 years, especially in the last two decades, has enhanced the world's capacity to consume diversified and nutritious food. While the world capture fisheries continue to dominate in overall production, the capture fishery data across the globe indicates that significant hike in production levels are not possible in near future (FAO, 2016). Similarly, India bestowed with a varied potential fisheries resource but the catches from the marine capture fishery have been stagnated in the past decade. In addition to this inland capture fisheries from the rivers, estuaries, backwaters, lagoons, etc., have witnessed wanton exploitation and have already shown a declining trend in production.

The capture fisheries sector is totally dependent on the biodiversity of fishes available in the waters of world oceans and rivers. Presently aquaculture is also in need of species diversification at regional level to increase the nutritional security of consumers and increased income of the fish farmers. Hence, biodiversity needs to be properly conserved and managed as it incorporates invaluable resources from educational, cultural, economic, aesthetic and scientific point of view (Dudgeon *et al.,* 2006).

The biodiversity is under threat due to overfishing, pollution, habitat destruction/ degradation, exotic species invasion global warming, variation in sea surface temperature and climate change. Of these only immediate non-mitigable factor is climate change and can be a major concern for fisheries and aquaculture production worldwide.

Climate change in a nut shell is the change in average global temperature. The U.S. Global Change Research Act of 1990

(GCRA), defines climate change as "changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry and ecological systems) that may alter the capacity of the Earth to sustain life". Whereas, the intergovernmental panel on climate change (IPCC) established by the world meteorological organization (WMO) and the united nations environment programme (UNEP) in 1988 as a lead agency to investigate climate change issues define climate change as follows.

"A change in the state of the climate that can be identified (e.g. using statistical tests) by changes in the mean and/or the variability of its properties and that persists for an extended period, typically decades or longer". Referring to any change in climate over time, whether due to natural variability or as a result of human activity.

Further, the united nations framework convention on climate change (UNFCCC), defines climate change as "change of climate that is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and that is in addition to natural climate variability observed over comparable time periods".

Whatsoever is the definition of climate change the climate change with its multiple components *i.e.*, temperature, rainfall, extreme events, CO_2 concentrations and ocean dynamics is expected to affect biodiversity. This will be reflected at molecular, species and ecosystem level too (Parmesan, 2006). The authors have made an effort to review the impacts of climate change on marine ecosystem and its resources which will affect capture fisheries. The impacts of climate change are discussed below under different aspects.

Species distribution shift:

Climate change has both direct and indirect impacts on fish biology and physiology. Direct effects act on physiology and behaviour alter growth, development, reproductive capacity, mortality altering and distribution. Regarding distribution as fishes are piokilothermic chordates their spatial as well as vertical distribution is governed by temperatures. Indirect effects alter the productivity, structure and composition of the ecosystems on which fish depend for food and shelter. Fish stocks may compensate for annual temperature variations by changing location to maintain a desired temperature range (Mountain and Murawski, 1992 and Overholtz *et al.*, 2011). The effects of increasing temperature on marine and freshwater ecosystems are already evident, with rapid pole ward shifts in distributions of fish and plankton in regions such as the North East Atlantic, where temperature changes has been rapid (Beaugrand *et al.*, 2002; Brander *et al.*, 2003 and ICES, 2006). Many species ranges have moved pole wards and upward in elevation in the last century and this is likely not to cease. Local communities of fishes are disaggregating and encompassing the niche of more warm-adapted species (Parmesan and Yohe, 2003 and Heller and Zavaleta, 2009). Several instances of warm-water species being caught north of their expected ranges including the following: Pacific bonito (*Sarda chiliensis*) in Eureka, California, skipjack tuna (*Katsuwonus pelamis*) off cape blanco in oregon, swordfish (*Xiphias gladius*) in Monterey Bay and dolphinfishes (*Coryphaena* spp.) as far north as Grays Harbor, Washington (Radovich, 1961). Similarly, in India, Indian oil sardine (*Sardinella longiceps*) whose distribution has shifted from its known distribution of Malabar upwelling zones (Karnataka and Kerala) since 1985 and is still continuing. With warming of sea surface, the oil sardine is able to find temperature of its preference especially in the northern and eastern longitudes, thereby extending the distributional boundaries and establishing fisheries over a larger coastal reach. It was further postulated that its future distribution may extend till Gujarat and West Bengal on the east coast (Vivekanandan *et al.*, 2009a). This postulation came true in Gujarat in the year 2013-14 when the oil sardine landings peaked to 21 tonnes of (CMFRI, 2014). Similarly Indian mackerel *Rastrelliger kanagurta* besides exploring northern waters along the Indian coast, has been descending deeper as well during the last two decades (CMFRI, 2008). In another study it was found that *Nemipterus japonicus* and *N. mesoprion* off Chennai have changed their spawning seasonality and are adapted to shift the spawning activity to seasons when the temperature is around the preferred optima. (Vivekanandan *et al.*, 2009).

Species extinction:

Anthropogenic climate change may be a major driver of species extinction in the next 100 years, but the possible impacts of climate change on species survival remain highly uncertain (Thomas *et al.*, 2004; Bellard *et al.*, 2012 and Urban, 2015). Global mean annual temperatures increased by ~0.85°C between 1880 and 2012 and are likely to rise by an additional 1°C to 4°C by 2100 (Stocker *et al.*, 2013). Although a certain variation of climate is compatible with the ecosystem survival and its function, the very rapid shift is detrimental to the variety of life forms (Thomas *et al.*, 2004). Fishes have evolved physiologically to live within a specific range of environmental variation, and existence outside of that range can be stressful or fatal (Barton *et al.*, 2002). These ranges can coincide for fishes that evolved in similar habitats (Attrill, 2002). Local extinctions are occurring at the edges of current ranges, particularly in freshwater and diadromous species such as salmons and sturgeons (Friedland *et al.*, 2003 and Reynolds *et al.*, 2005). The amount of energy allocated toward growth and reproduction in fish usually declines as temperatures approach the extreme ends of species-specific tolerance ranges (Roessig *et al.*, 2004). The migratory species of fishes and shellfishes that inhabit a variety of environments at different life stages, like *Anguilla bengalensis* (adults- freshwater, spawning and larvae – seawater, juveniles – estuaries) are likely to be affected by all round climate-related changes that affect both marine and estuarine habitat as well as freshwater habitat. In addition to changes in averages of temperature, precipitation will lead to failure of reproduction in many aquatic species.

Competitors and pathogens:

Alteration in the trophic level interactions, cause decrease (or increase) in abundance of valued species as well as of their predators and competitors. Competitions between species and pathogen attacks are two important biotic factors governing the productivity of a particular species in a given area. Lesser the competition and predation more the production. Climate change can enable both competitive species and pathogenic species to spread to newer areas. Climate change has been implicated in mass mortalities of many aquatic species, including plants, fish, corals and mammals, although lack of adequate data makes it difficult to attribute and pinpoint the causes (Harvell *et al.*, 1999 and Diederich *et al.*, 2005). Increasing temperature might alter the importance of grazing as an increase in temperature strengthens predator-prey interactions (Hoekman, 2010). In recent years jellyfish, in particular, have increased in abundance dramatically in many regions including Indian waters, where they eat larvae of important fish and shellfish, compete with them for food and clog fishermen's gear.

Productivity:

Changes in temperature are related to alterations in oceanic circulation patterns that are affected by changes in the direction and speed of the winds that drive ocean currents and mix surface waters with deeper nutrient rich waters (Kennedy *et al.*, 2002). These meteorologically induced oceanographical processes in turn affect the distribution and abundance of plankton which are primary producers in the oceanic realm. Further changes in distribution and productivity are expected due to continuing warming and freshening of the Polar ice (Drinkwater, 2005). Some of the changes are expected to have positive consequences for fish production, but in other cases reproductive capacity is reduced and stocks become vulnerable to levels of fishing that had previously been sustainable (Brander and Mohn, 2004 and Arctic Council, 2005). The laboratory experiments carried out by CMFRI demonstrated that the rise in water temperature leads to faster growth of phytoplankton (microalgae) at temperature of 29°C, but simultaneously the decay set-in earlier than at lower temperature (24°C). A shift in the food web structure was observed in the Baltic Sea towards more microbial, less energy-efficient food webs consisting of lower food quality and smaller sized organisms, which in combination with warming may lead to decreased availability of energy for grazing zooplankton and fish (Suikkanen *et al.*, 2013). The oceanographic effects of climate change may directly affect the abundance and distribution of marine fishes by affecting the availability food resources.

Ocean acidification:

Few studies have been conducted in temperate marine ecosystems to investigate the effect of ocean acidification on fishes (Ishimatsu *et al.*, 2004). However, research suggests that ocean acidification causes a wide range of deleterious physiological responses in marine fishes and shellfishes. It has been observed that elevated levels of ambient CO_2 is associated with a condition in fish known as "hypercapnia," which causes disturbances that limit the function of the respiratory, circulatory and nervous systems in fish and impair the olfactory discrimination and homing ability. The long-term effects of hypercapnia may inhibit important life functions by reducing growth, reproduction and calcification (Ishimatsu *et al.*, 2004 and Doving, 2009). In tropical ecosystems ocean acidification has been found to affect the development of sensory mechanisms. It is reported that exposure to acidified seawater may impair the ability of these fish to recognize olfactory clues necessary for predator avoidance in tropical reefs (Munday *et al.*, 2009; Devine *et al.*, 2012 and Dixson *et al.*, 2010). The effects of exposure to elevated CO_2 levels is greatest in fish eggs, larvae, and juveniles, suggesting that fish in early developmental stages may be the most vulnerable to the impacts of ocean acidification (Kikkawa *et al.*, 2003 and Ishimatsu *et al.*, 2004). Although the precise effect of acidification on local fish populations is uncertain, it's likely that ocean acidification would reduce marine biodiversity through the loss of pH and CO_2-sensitive species (Widdicombe and Spicer, 2008).

Mangroves:

Coastal ecosystems are most productive and highly threatened ecosystems in the world. The rapid increases in population density and economic activities near coastal areas significantly increase their vulnerability. The estuarine habitats which harbor the mangrove sites are refereed to as nursery and breeding ground of many commercially important finfishes, shellfishes and birds (Alongi, 2015). The availability of such high quality estuarine habitat, may be threatened by climate change induced sea level rise. Scientists have not yet determined whether sand flat and mudflat elevations relative to tidal levels will be able to keep pace with sea level rise. The ongoing climate change is a looming danger for the pivotal Indian coastal mangrove ecosystems, which are highly vulnerable to climate change. Mangroves are the marginal ecosystems which share the resources with the adjoining ecosystem like coral reef and sea grass bed. Hence adverse effects on mangroves will extend and spill its serious consequences to these adjoining fragile and important ecosystems (Vannucci, 2001). Moreover, the ecological and socioeconomic values offered by the mangroves are innumerable, immeasurable and incomparable. So conserving mangroves might be a vital agenda in any nation's conservation programs. Practically conserving the mangroves from ongoing climate change is not an easy task and on the other hand it is high time to adopt a road map to minimize the damages. natural conditions, coastal wetlands have the ability to adjust the rising seas and changes in local storm patterns, but unfortunately combination of climate changes and human activities jointly alter natural conditions and disrupt coastal wetland hydrology, biogeochemical cycling and other processes (Morris *et al.*, 2002). Alongi (2015) critically reviewed the impact of climate change on mangrove ecosystems and concluded that there will be more negative impacts on mangroves. Further mangroves have shown signs of latitudinal expansion pole and concluded that greatest current threat to mangrove survival, however, is deforestation and such continuing losses must be considered in tandem with the impact of climate change.

Coral reefs:

Coral reefs are highly sensitive to climatic influences and are among the most sensitive of all ecosystems to temperature changes exhibiting the phenomenon known as coral bleaching when stressed by higher than normal sea temperatures. Corals usually recover from bleaching, but die in extreme cases. In past decades the extent, severity and rates of consequent coral mortality due to coral bleaching are increasing in the world's largest Great Barrier Reef (Glynn,1996 and Hoegh-Guldberg, 1999). Additionally, more acidic ocean conditions will reduce the ability of corals to produce their calcium carbonate skeletons (calcify) which is essential to forming the structure of reefs. Hughes *et al.* (2017) reports that the world's longest ever global bleaching event, begun in 2014 is still continuing in 2017 and with repeated bleaching of the Great Barrier Reef and other reefs worldwide offering no reprieve. Climate projections for the future indicate that the extreme ocean temperatures that caused the most recent bleaching could occur every two years by the mid-2030s (CoECCS, 2016). Given the implication that reefs will not be able to sustain catastrophic events more than three times a decade, reef building corals are likely to disappear as dominant organisms on coral reefs between 2020 and 2040 and the reefs are likely to become remnant between 2030 and 2040 in the Lakshadweep sea and between 2050 and 2060 in other regions in the Indian seas (Vivekanandan *et al.*, 2009b).

Given their central importance in the marine ecosystem, the loss of coral reefs is likely to have several impacts on marine fisheries.

Conclusion:

Climate change is predicted to have a wide range of impacts on marine fisheries and its resources and those who depend on them. There should be detailed studies initiated at local level to assess the impacts of climate change in the Indian scenario.

Coopted Authors' :

S.S. GHATGE, S.N. KUNJIR, A.T. TANDALE AND B. BOPANNA, College of Fishery Science, Udgir, LATUR (M.S.) INDIA

REFERENCESReferences:

Alongi, D.M. (2015). The impact of climate change on mangrove forests. *Curr. Clim. Chang. Rep.*,**1**: 30 - 39.

Attrill, M.J. (2002). Community level indicator of stress in aquatic ecosystems. In: Adams, S.M. (Ed.). Biological indicators of Aquatic Ecosystem Stress. Bethesda MD. American Fisheries Society.

Barton, B.A., Morgan, J.D. and Vijayan, M.M. (2002). Physiological and condition-related 8 indicators of environmental stress in fish. In: Adams, S.M., *Biological Indicators of Ecosystem 9 Stress*, American Fisheries Society, Bethesda, MD, 111-148pp.

Beaugrand, G., Reid, P.C., Ibanez, F., Lindley, J.A. and Edwards, M. (2002). Reorganization of North Atlantic marine copepod biodiversity and climate. *Sci.,* **296** :1692–1694.

Bellard, C., Bertelsmeier, C., Leadley, P., Thuiller, W. and Courchamp, F. (2012). Impacts of climate change on the future of biodiversity. *Ecol Lett*., **15** : 365–377.

Brander, K.M., Blom, G., Borges, M.F., Erzini, K., Henderson, G., MacKenzie, B.R., Mendes, H., Ribeiro, J., Santos, A.M.P. and Toresen, R. (2003). In *Hydrobiological Variability in the ICES Area, 1990–1999*, Eds Turrell W, Lavin A, Drinkwater KF, St John MA, Watson J (Intl Council for the Exploration of the Sea, Copenhagen), pp. 261–270.

Brander, K. and Mohn, R. (2004). Effect of north atlantic oscillation on recruitment of Atlantic cod (*Gadus morhua*). *Canadian J. Fish. Aquat. Sci.,* **61** : 1558 - 1564.

CMFRI (2008). Research Highlights 2007-2008. Central Marine Fisheries Research Institute, Cochin, India, pp. 36.

CMFRI (2014). Annual Report 2013-14. Central Marine Fisheries Research Institute, Cochin, 274 p

Devine, B.M., Munday, P. L. and Jones, G. P. (2012). Homing ability of adult cardinal fish is affected by elevated carbon dioxide. *Oecologia,* **168** (1) : 269-276.

Dixson, D.L., Munday, P.L. and Jones, G. P. (2010). Ocean acidification disrupts the innate ability of fish to detect predator olfactory cues. *Ecology Letters,* **13**(1) : 68-75.

Doving, K.B. (2009). Ocean acidification impairs olfactory discrimination and homing ability of a marine fish. *Proc. National Acad. Sci.,* **106** (6) : 1848-1852.

Drinkwater, K.F. (2005). The response of cod (*Gadus morhua*) to future climate change. *ICES J. Mar. Sci.,* **62** : 1327–1337.

Dudgeon, D., Arthington, A.H., Gessner, M.O., Kawabata, Z.I., Knowler, D.J., Lévêque,C., Naiman, R.J., Prieur-Richard, A.-H., Soto, D., Stiassny, M.L.J. and Sullivan, C.A. (2006). Freshwater biodiversity: importance, threats, status and conservation challenges. *Biol. Rev.,* **81** : 163–182.

FAO (2016). The state of world fisheries and acquaculture.

Friedland, K.D., Reddin, D. G., McMenemy, J. R. and Drinkwater, K.F. (2003). Multidecadal trends in North American Atlantic salmon (*Salmo salar*) stocks and climate trends relevant to juvenile survival. *Can. J. Fish. Aquat. Sci*., **60** : 563–583.

Glynn, P.W. (1996). Coral reef bleaching: facts, hypotheses and implications. *Global Change Biology,* **2**: 495-509.

Harvell, C.D., Kim, K., Burkholder, J.M., Colwell, R.R., Epstein, P.R., Grimes, D.J., Hofmann, E.E., Lipp, E.K., Osterhaus, A.D., Overstreet, R.M., Porter, J.W., Smith, G.W. and Vasta, G.R. (1999). Emerging marine diseases--climate links and anthropogenic factors. *Sci.,* **285**:1505–1510.

Heller, N.E. and Zavaleta, E.S. (2009). Biodiversity management in the face of climate change: A review of 22 years of recommendations. *Biol. Conserv.,* **142** : 14–32.

Hoegh-Guldberg, O. (1999). Climate change, coral bleaching and the future of the world's coral reefs. *Marine & Freshwater Research,* **50**: 839-866.

Hoekman, D. (2010). Turning up the heat: temperature influences the relative importance of top–down and bottom-up effects. *Ecology,* **91**: 2819-2825.

Hughes, L., Steffen, W., Alexander, D. and Rice, M. (2017). Climate change: A deadly threat to coral reefs climate council of Australia Ltd. pp.28.

ICES (2006). International Council for the Exploration of the Sea *Report on Ocean Climate 2005*, eds Hughes SL, Holliday NP (Intl Council for the Exploration of the Sea, Copenhagen). ICES Co-operative Research Report No 280.

Ishimatsu, A., Kikkawa, T., Hayashi, M., Lee, K.S. and Kita, J. (2004). Effects of CO_2 on marine fish: larvae and adults. *J. Oceanography,* **60** (4) : 731-741.

Kennedy, V. S., Twilley, R.R., Kleypas, J. A., Cowan, Jr., J. H. and Hare, S.R. (2002). Coastal and marine ecosystems and global climate change. Potential effects on U S resources. Pew Center on Global Climate Change, Arlington, USA, pp. 52.

Kikkawa, T., Ishimatsu, A. and Kita, J. (2003). Acute CO_2 tolerance during the early developmental stages of four marine teleosts. *Environ. Toxicol.,* **18**(6) : 375-382.

Morris, J.T., Sundareshwar, P.V., Nietch, C.T., Kjerfve, B. and Cahoon, D.R. (2002). Response of coastal wetlands to rising sea level. *Ecology,* **83**: 2869-2877.

Mountain, D.G. and Murawski, S.A. (1992). Variation in the distribution of fish stocks on the northeast continental shelf in relation to their environment, 1980–1989. ICES Marine *Science Symposia,* **195**: 424–432.

Munday, P. L., Dixson, D. L., Donelson, J. M., Jones, G. P., Pratchett, M. S., Devitsina, G. V., Overholtz, W. J., Hare, J. A., and Keith, C. M. (2011). Impacts of interannual environmental forcing and climate change on the distribution of Atlantic mackerel on the U.S. Northeast Continental Shelf. Marine and Coastal Fisheries: *Dynamics Mgmt. & Ecosyst. Sci.,* **3**: 219–232.

Parmesan, C. and Yohe, G. (2003). A globally coherent finger print of climate change impacts across natural systems. *Nature,* **421** : 37–42.

Parmesan, C. (2006). Ecological and evolutionary responses to recent climate change.*Annu. Rev. Ecol. Evol. Syst.,* **37**: 637–669.

Radovich, J. (1961). Relationships of some marine organisms of the northeast pacific to water temperatures, particularly during 1957 through 1959. *Fish Bull.,* **112** (62) : 18-30.

Reynolds, J.D., Webb, T.J. and Hawkins, L.A. (2005). Life history and ecological correlates of extinction risk in European freshwater fishes. *Can. J. Fish Aquat. Sci.,* **62** : 854–862, DOI, http://dx.doi.org/10.1139/FO5-066.

Roessig, J. M., Woodley, C. M., Cech Jr, J. J. and Hansen, L.J. (2004). Effects of global climate change on marine and estuarine fishes and fisheries. *Reviews in Fish Biology & Fisheries,* **14** (2) : 251-275.

Stocker, T.F., Qin, D., Plattner, G.K., Tignor, M., Allen, S.K., Boschung, J. , Nauels, A., Xia, Y., Suikkanen, V., Pulina, S., Engstrom-Ost, J., Lehtiniemi, M. and Lehtinen, S. (2013). Climate change and eutrophication induced shifts in northern summer plankton communities. *PLoS ONE,* **8**(6): e66475.

Suikkanen, S., Pulina, S., Engström-Öst J., Lehtiniemi, M., Lehtinen, S. and Brutemark, A. (2013). Climate change and eutrophication induced shifts in northern summer plankton communities. *PLoS ONE,* **8**(6): e66475. *https://doi.org/10.1371/journal.pone.0066475.*

Thomas, C.D., Cameron, A., Green, R.E., Bakkenes, M., Beaumont, L.J. and Collingham, Y.C. (2004). Extinction risk from climate change. *Nature,* **427**:145–148.

Urban, M.C. (2015). Accelerating extinction risk from climate change. *Science,* **348** : 571–573.

Vannucci, M. (2001). What is so special about mangroves? *Braz. J. Biol.,* **61**: 599 -603.

Vivekanandan, E. and Rajagopalan, M. (2009). *Impact of rise in seawater temperature on the spawning of threadfin Breams. In: Global Climate Change and Indian Agriculture.* Indian Council of Agricultural Research, New Delhi, India, pp. 93-96.

Vivekanandan, E., Rajagopalan, M. and Pillai, N.G.K. (2009a). *Recent trends in sea surface temperature and its impact on oil sardine.* In: Global Climate Change and Indian Agriculture. Indian Council of Agricultural Research, New Delhi, India pp. 89-92.

Vivekanandan, E., Hussain Ali, M. and Rajagopalan, M. (2009b). Vulnerability of corals to seawater warming, In: Impact, adaptation and vulnerability of Indian agriculture to climate change (Aggarwal, P.K., Ed.), Indian Council of Agricultural Research, NEW DELHI, INDIA.

Widdicombe, S. and Spicer, J.I. (2008). Predicting the impact of ocean acidification on benthic biodiversity: what can animal physiology tell us?. *J. Exp. Marine Biol. & Ecol.,* **366**(1) : 187-197.

WEBLIOGRAPHY

CoECSS (2016). Extreme coral bleaching may be new normal by 2034. Accessed at *https://www.climatescience. org.au/content/978-extreme-coral-bleaching-may-be-new-normal-2034.*