32 VULNERABILITY ASSESSMENT OF BIODIVERSITY – CASE STUDIES FROM AN ECOSYSTEM PERSPECTIVE

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Assessing the vulnerability of biodiversity can be done on an ecosystem perspective with the help of various vulnerability assessment tools. These tools vary from numerical models, satellite remote sensing data, *insitu* observations and related mechanisms. A description of vulnerability assessments for marine resources carried out in Indian context is explained in this chapter. Suggested readings are also indicated.

1. IDENTIFYING VULNERABLE FISH HABITATS USING NUMERICAL MODELS

The Cushing's triangle on fish migration (Fig.1) explains various life cycle activities from recruitment to fishing as governed by physical oceanographic processes. The role of currents in a closed area such as Gulf of Kachchh (GoK) and geological structures such as mounts in an open area such as Mangalore coast is explored to see the role of fish aggregation creating fishing and nursery grounds. Numerical and particle transport models was used for generating hydrodynamics and further for identifying areas of fish aggregation. Validations of the models were done with *insitu* observations. Likelihood retention areas of larval aggregations indicated formation of nursery grounds. A case study is described in section 2 of this chapter. Oceanographic processes such as fronts, eddies, meanders, rings and primary productivity linked to them are keys to identification of Potential Fishing Zones (PFZ). Altimeter satellite remote sensing data could identify mesoscale features (Eddies). Such data products can supplement the SST-Ocean color based PFZ and provide information in cloudy conditions too. Productive habitats and their vulnerability can also be assessed using the satellite data based oceanographic processes.

2. ROLE OF HYDRODYNAMICS IN ASSESSING FISHING GROUNDS

Knowledge of local hydrodynamics is a pre-requisite to modelling coastal processes,given that physical drivers such as tides and currents control them (Fig. 2). There is a major role of diffusion and related physical processes in dispersal and recruitment of marine populations (Okubo, 1994). Tidal flows can move larvae passively in peak tidal velocities (Levin, 1990; Gross *et al.*1992). Physical processes influence the distribution of larval fish on a variety of scales, ranging from few meters to thousands of kilometers (Bruce *et al.* 2001; Hare *et al.* 2002). The basic idea in fish larval transport studies is to characterise the passive movement of larvae during the planktonic larval duration (PLD) phase of the species studied(Fig.2). During the pelagic larval phase, the larvae may be dispersed or retained in passive response to physical forcing (Cowen and Sponaugle, 2009).It is a phase that larvae are considered as "poorswimmers" (Leis *et al.* 2006)because the hydrodynamic (HD) forcing on them exceeds their swimming ability.

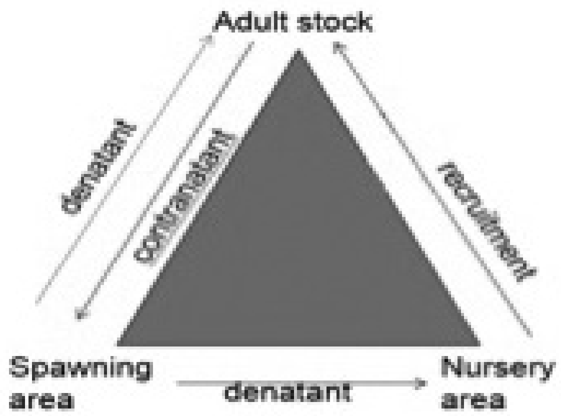

Fig.1 Triangle of fish migration

Biological processes such as fish larval transport can be modelled based on a clear understanding of the physics of a water body. There are few larval transport studies in the coastal waters in particular regions (Moser and Smith, 1993; Oliver and Shelton, 1993; Grothues and Cowen, 1999; Hare *et al.* 2001). A study combining observational data

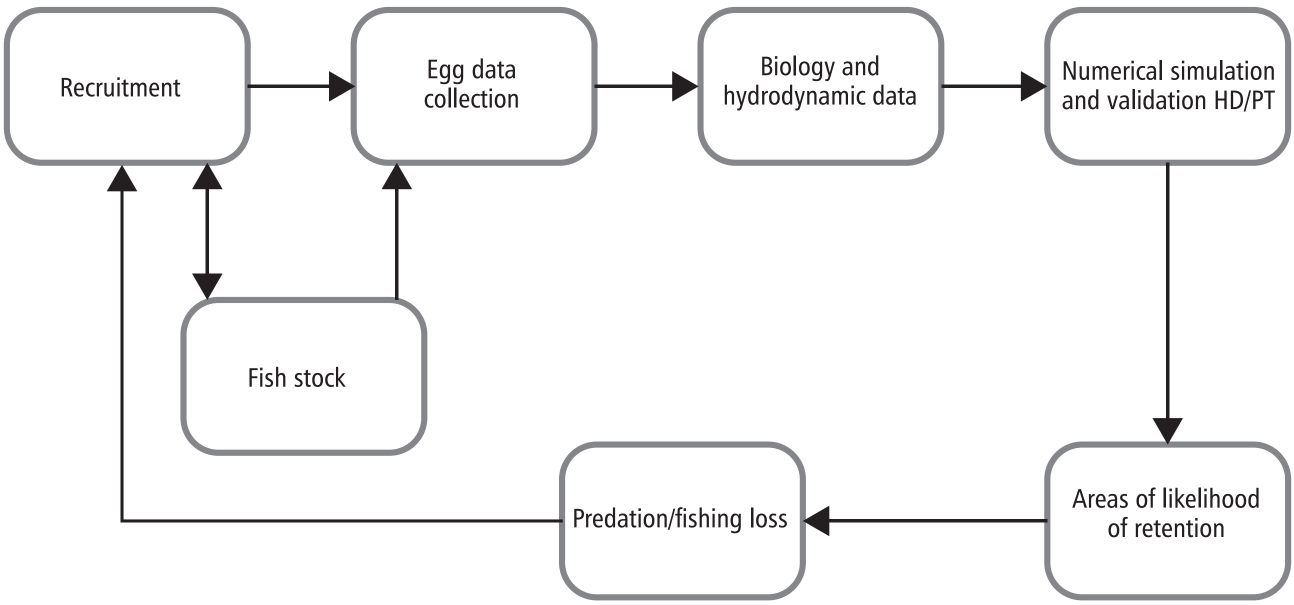

Fig.2 Role of hydrodynamics in assessing fishing grounds

with a two-dimensional numerical model product has been carried out to determinethe fate of fish eggs released in a semi enclosed basin (Grinson *et al.* 2011). Fish eggs were treated as passive particles in the model, and were released from probablespawning sites identified duringexploratory surveys(Fig.3).

Numerical modelling of fish egg dispersion at the Patos Lagoon estuary in Brazil was carried out by Martins *et al.* (2007). There are various HD models to provide the spatial and temporal current patterns. Digitized bathymetry maps are used for defining the study domain. Inputs such as tide and wind are given inthe model as the major physical forcings driving the current.Simulation will produce the HD variables as output at every grid point for the time interval required. The currents generated in these models can be validated using observed data at certain grid points to ascertain the model accuracy. Areas with retention of larvae above 30% were demarcated as nursery areas. Model simulation of eggs from different spawning sites showed varying dispersal patterns. About 80% of the particles were retained in the basin for allthe three seasons studied (Fig. 4).

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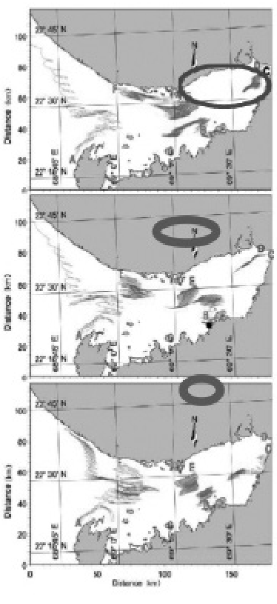

Table 5.1 Fish egg abundance (in numbers) and site ecology as observed during exploratory surveys during April and Novemeber, 2002

Site	Place	Fish egg abundance April 2002	Fish egg abundance November 2002	Site ecology	Geographical barrier	Remarks
A	off Okha	0	114	uneven topography with strong currents.	free flushing in and out with ebb and flood.	less commercial fishing operations.
B	off Bedi	60	3177	scattered reef and mangrove areas along the coast	small islands and reefs in the Marine National Park; weak currents	commercial fishing operations active.
C	off Navalakhi	454	60	closer to the land area and depth gradually reduces to the minimum	extreme SE boundary with a tide variation of 7.31 m	only port in Rajkot district with some fishing activities
D	off Kandla	35	0	alluvial marshy tidal flats with a major creek system	high tidal movements and unusually strong currents	less fishing except shore based hand and gill net
E	off Kukadsar	0	0	4 streams, 2 shoals and a couple of islands visited by flamingoes	presence of tapering land and shoals restrict flood and ebb flows	fishing by trawlers
F	off Mandvi	140	8	river Rukmanathi joins this site	river run-off less	fishing grounds with increasing efforts

Fig.3 Identification of spawning site

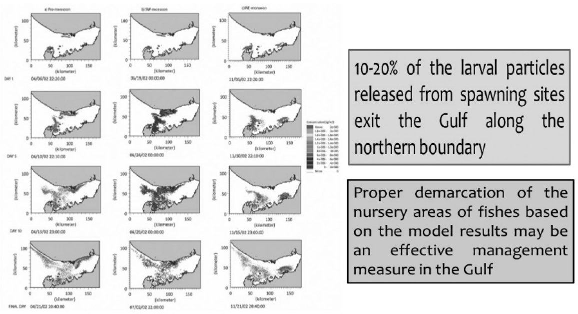

Fig.4 Larval dispersal pattern

as output at every grid point for the time interval required. The currents generated in these models can be validated using observed data at certain grid points to ascertain the model accuracy. This HD input, along with the physical forcings, is applied to larval transport models to deduce the dispersion pattern of larvae

3. VULNERABILITY DUE TO EXTREME EVENTS

The reefs in some islands of Andaman and Nicobar suffered severe damage following a tropical Storm in the Bay of Bengal off Myanmar coast during 13–17 March 2011. Surveys were conducted at eight sites in Andaman, of which five were located in the Ritchie's Archipelago where maximum wind speeds of 11 ms-1 was observed; and three around Port Blair which lay on the leeward side of the storm and had not experienced wind speeds of more than 9 ms-1. Corals in the shallow inshore reefs were broken and dislodged by the thrust of the waves. Significant damage in the deeper regions and offshore reefs were caused by the settlement of debris and sand brought down from the shallower regions. The fragile branching corals (*Acropora* sp.) were reduced to rubbles and the larger boulder corals (Porites sp.) were toppled over or scarred by falling debris (Fig. 5). The reefs on the windward side and directly in the path of the storm winds were the worst affected. The investigation exposes the vulnerability of the reefs in Andaman to the oceanographic features which generally remain unnoticed unless the damage is caused to the coastal habitats.

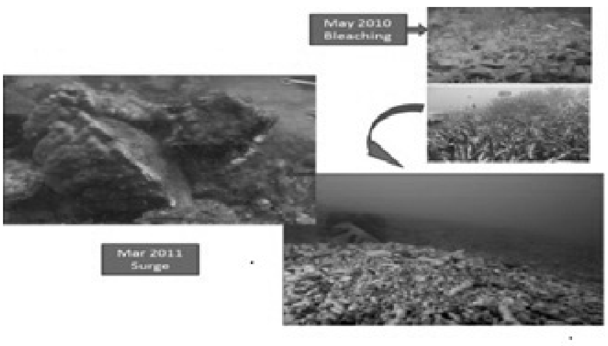

Fig.5 Damages to reef after cyclone in South Button

Fast currents generated by eddies, tidal and ocean currents and gyres, quite close to coral islands are considered as physical factors that induce local water movements, flush toxins and remove thermal stratification in coral reef locations and hence are assumed as high reliability factors of resistance to coral bleaching (West and Salm 2003). Physical damage to the coral reef structures due to eddies is not yet documented. The EKE computed for the present eddy shows high kinetic energy in the area of Ritchie's Archipelago. Although eddies with high kinetic energy alone

Mesoscale eddies are quite common in the seas surrounding the Andaman and Nicobar Islands, however their presence in such close proximity to the coast as observed in this event has not yet been recorded. Eddies occurring in coral reef areas are known to cause thermal stress related bleaching due to the upwelling associated with the eddy circulation (Jokiel and Coles 1990). Models evaluating the hydrographic effects of eddy on island waters (Farmer and Berg 1989) have explained the dispersal of larvae due to high-velocity shear currents generated by the approaching eddy. Cross-frontal advection has been documented for cold core and warm core eddies (Wroblewski and Cheney 1984). Fast currents generated by eddies, tidal and ocean currents and gyres, quite close to coral islands are considered as physical factors that induce local water movements, flush toxins and remove thermal stratification in coral reef locations and hence are assumed as high reliability factors of resistance to coral bleaching (West and Salm 2003). Physical damage to the coral reef structures due to eddies is not yet documented.

Conclusion

Vulnerability assessment is crucial in biodiversity studies. The present chapter is illustrating various vulnerability assessment techniques with the help of case studies. Instead of analyzing species independently, it is important to visualize the vulnerability from an ecosystem perspective. Independent data sets on biodiversity are important but collective analysis will provide a better picture.

Suggested reading

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