UNDERWATER REEF FISH CENSUS PROTOCOL

1. Background

Reef fish play a pivotal role in maintaining healthy reef trophodynamics by performing several ecosystem functions. They are involved in ecosystem processes such as macroalgae and detritus removal, plankton harvesting and sediment dynamics. Reef fish populations globally have been increasingly threatened by overfishing, warming seas, and ocean acidification. Local factors such as increased tourism and targeted fishing of meso- and apex predators can have disproportionate impacts on fish biodiversity and ecosystem function. It is therefore integral that reef fish diversity is monitored, and their functional roles are understood.

To try and do this, we have divided the reef fish community broadly into four categories:

1. **Pelagic species**: This will include planktivores and roving predators, monitoring this group allows us to include species that generally stay higher up in the water column.
2. **Bentho-pelagic species**: Species that are found in the water column but stay close to the substrate. This group will include all the common reef associated herbivores/invertivores like surgeonfish, corallivores like parrotfish and predators like groupers etc.
3. **Territorial herbivores:** This group will include species that maintain territories and therefore stay close to the substrate, to defend their territories such as damselfish.
4. **Crypto-benthic:** This group will include species that tend to stay very close to the substrate, hide in crevices or species that tend to blend in with the substrate like gobies, blennies, scorpionfish etc.

Monitoring these groups in addition to benthic surveys, and algal biomass estimation will give us insights into the biodiversity and reef trophodynamics at these sites in the ANI. Monitoring of mixed-species groups (MSGs) of reef fish has also been included. This is because shoaling groups of herbivorous reef fish keep turf and macroalgae populations in check. Their roles as browsers and grazers are of immense importance in warming seas where coral reefs are increasingly being dominated by macro and turf algae.

2. Objectives

1. To characterize of the diversity and abundance in reef fish groups across selected sites of the ANI.
2. To understanding the factors that drive the formation of shoaling aggregations of mixed species groups in reef fishes.
3. To assess reef health and trophodynamics across sites that differ in fundamental ways (viz. fishing intensity, tourist influx, remoteness, and management regimes).

3. Methods

3.1. Visual census of fish groups

Monitoring of the following groups of interest (Size classes in cm: 5-10, 10-20. 20-30, 30-50, 50-80, >80; for all biomass calculations).

1. Bentho-pelagic fish: species that are found in the water column but stay close to the substrate.
2. Pelagic fish: water column specialists.
3. Crypto-benthic fish: stay very close to the substrate/hide in crevices.
4. Territorial herbivores: reef fish that maintain territories.
5. Mixed-species groups.
6. Benthic cover, algal biomass estimation.

Personnel and roles

1. Diver 1: tape coordinator
2. Diver 2: fish ID specialist
3. Diver 3: fish ID specialist

Dive Plan

Dive 1 = 2 * 50 m transects. Bottom time: 75 minutes, data collection: 60 minutes.

Dive 2 = Random walk + rugosity estimates. Bottom time: 85 minutes, data collection: 60 minutes.

Belt transects: The bentho-pelagic species, pelagic, crypto-benthic and territorial species will be sampled using a 50 meter belt transect.

1. **Onward Transect:**
    a. Diver 1 – secures tape measure and points in direction to begin transect
    b. Diver 2 – calibrates 5 m distance on either side of tape, then begins benthopelagic fish count within 5 m belt for 50 m
    c. Diver 1 – starts unrolling tape
    d. Diver 3 – counts pelagic species for 50 m

2. **Return Transect:**
    a. Diver 2 – count all territorial damselfish within 1m belt
    b. Diver 3 – 1m * 1m photo-quadrat every 5m - benthic cover, algal biomass
    c. Diver 1 – rolling tape

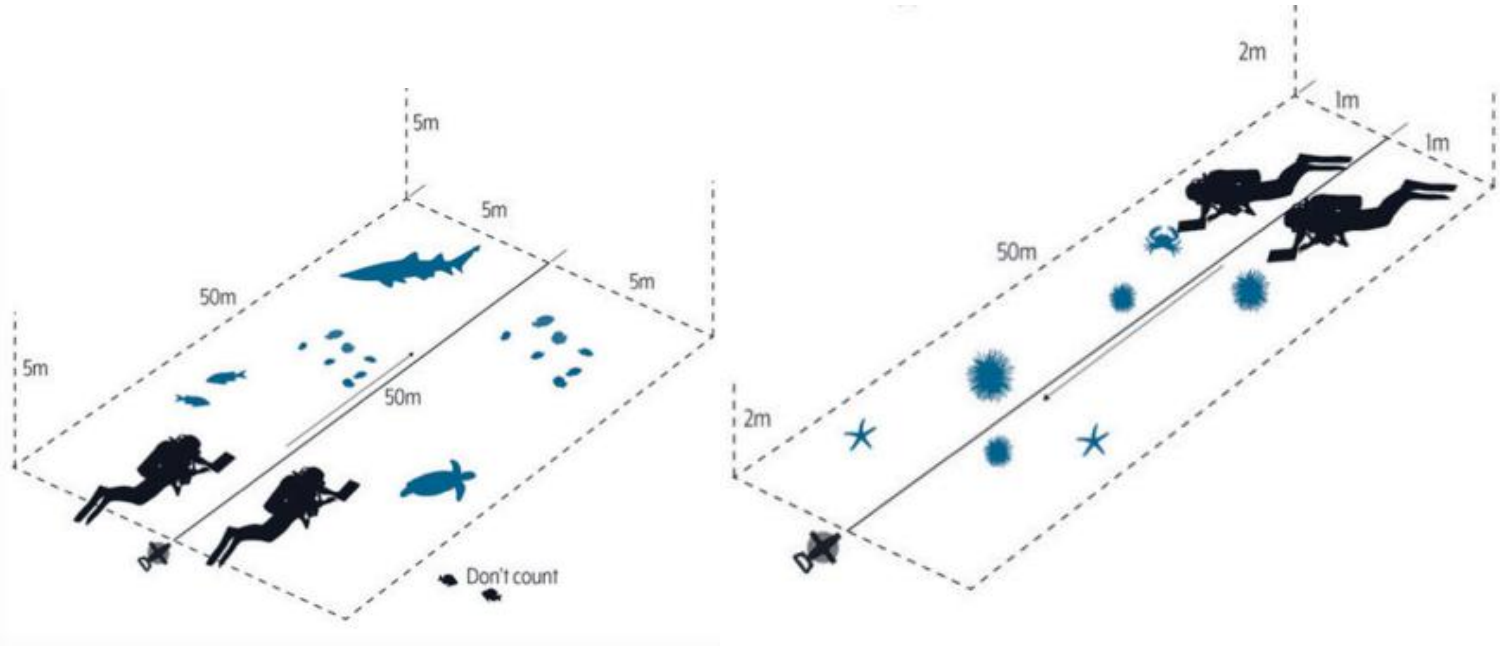

Fig: Diagrammatic depiction of Onward and return transects

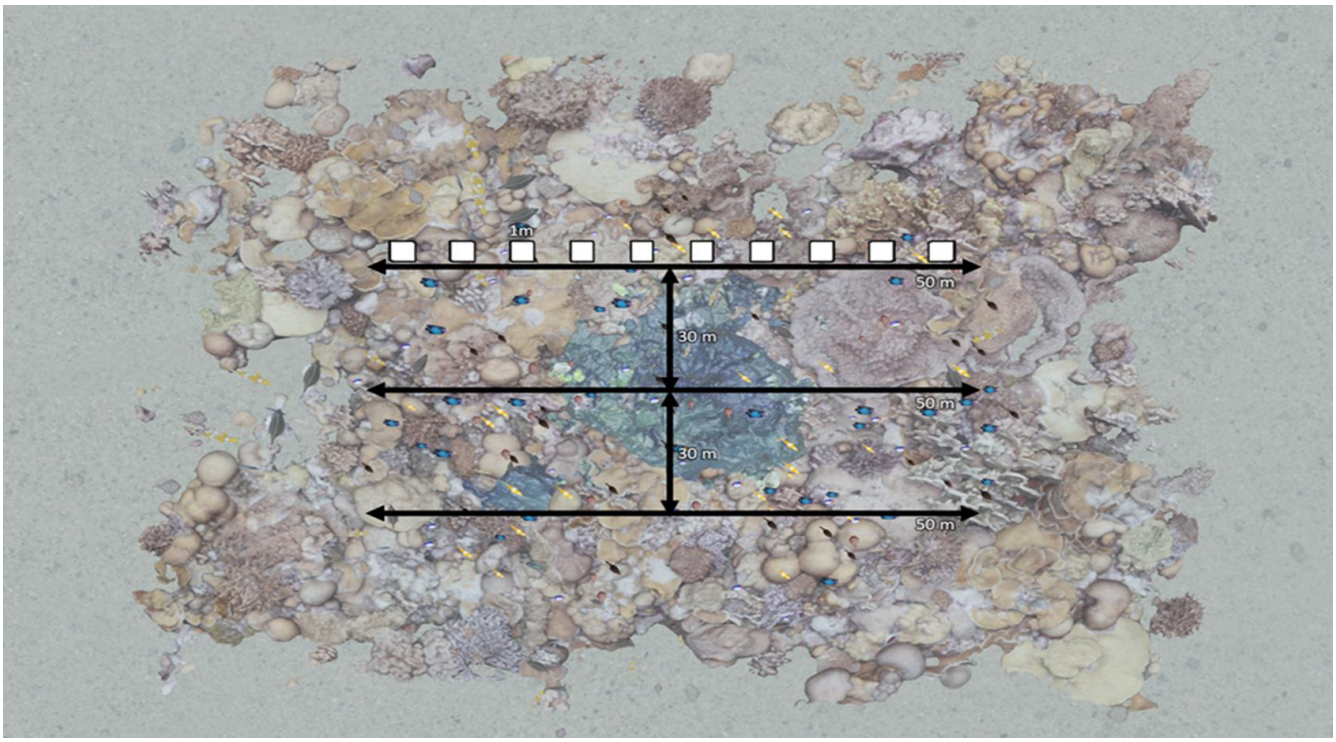

Fig: Study design depicted on a reef

Dive 2: Random Walk + Rugosity estimates

Mixed-species groups: Mixed-species groups will be sampled using a timed random walk (50-60 minutes) - on a separate dive after the belt transect is carried out at the same site. This is a two-diver protocol where one diver collects information on herbivores that form shoaling groups by following these groups and recording them videographically. The data extracted from these videos will pertain to group composition, time spent in group, feeding activity and antagonistic interactions (if any). The second diver records the same species of interest which are present outside mixed-species groups. This gives us an idea of grouping propensity. Observations on attendant groups and predators sighted are recorded at the reef by both divers on this dive. There is scope for a third diver to join on this dive and carry out rugosity estimates, algal sampling etc.

3.2 Baited Remote Underwater Video Stations (BRUVS)

BRUVS are a globally standardized, non-invasive, low-cost technique to study species habitat occupancy in-situ. A video camera in underwater housing is mounted on a trapezoidal structure with a bait arm attached perpendicularly, in the camera's field of view. A mesh bait bag is filled with ~500g of oily bait fish (E.g. *Sardinella* sp.). This entire structure is then lowered from a vessel on to the seafloor for benthic deployments between 10 and 20m depth. The videos record 60 minutes of underwater footage. During video analysis, metrics of presence and relative abundance of species belonging to different trophic groups will be used as indicators of the health of predator fish species populations and reef ecosystem functioning. BRUVS can be deployed either before or between dives at a different dive site – no counts measuring diversity and abundance should be carried out at a site where BRUVS has been deployed.

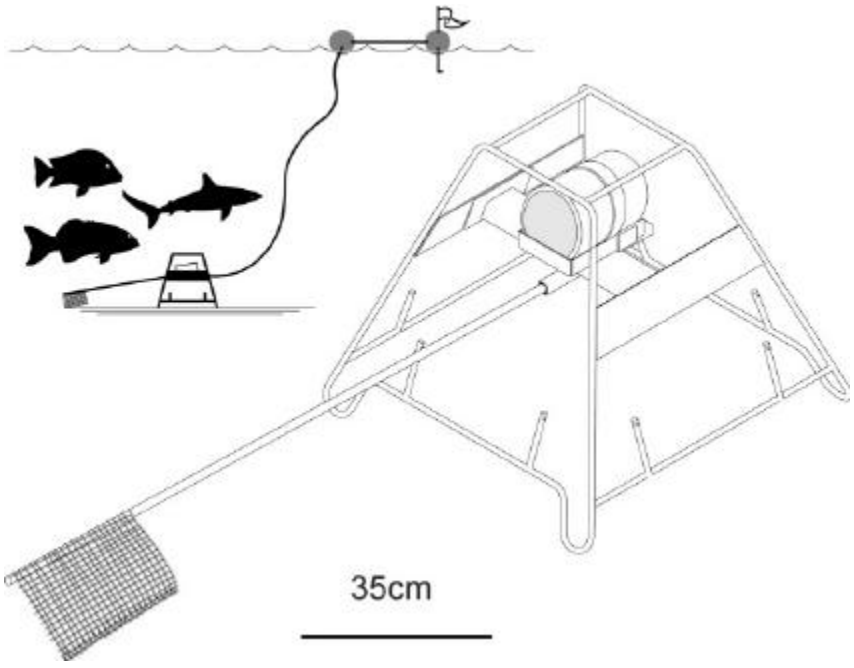

Fig: Diagram depicting BRUVS set up and function