

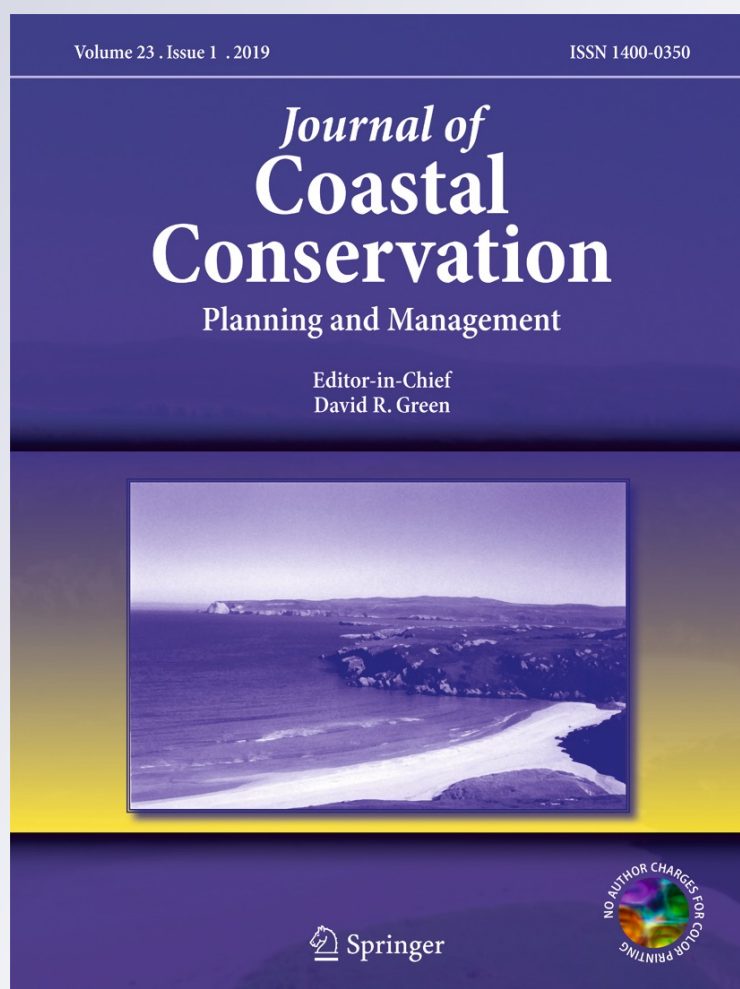
Poaching in Andaman and Nicobar coasts: insights

**R. Kiruba-Sankar, K. Lohith Kumar,
K. Saravanan & J. Praveenraj**

Journal of Coastal Conservation
Planning and Management

ISSN 1400-0350
Volume 23
Number 1

J Coast Conserv (2019) 23:95-109
DOI 10.1007/s11852-018-0640-y



Your article is protected by copyright and all rights are held exclusively by Springer Nature B.V.. This e-offprint is for personal use only and shall not be self-archived in electronic repositories. If you wish to self-archive your article, please use the accepted manuscript version for posting on your own website. You may further deposit the accepted manuscript version in any repository, provided it is only made publicly available 12 months after official publication or later and provided acknowledgement is given to the original source of publication and a link is inserted to the published article on Springer's website. The link must be accompanied by the following text: "The final publication is available at link.springer.com".



Poaching in Andaman and Nicobar coasts: insights

R. Kiruba-Sankar¹ · K. Lohith Kumar¹ · K. Saravanan¹ · J. Praveenraj¹

Received: 11 April 2018 / Revised: 17 July 2018 / Accepted: 19 July 2018 / Published online: 29 July 2018
© Springer Nature B.V. 2018

Abstract

Tropical marine Islands are home to rich and highly endemic biodiversity because of their geographical seclusion. The geographical isolation supports the biodiversity against anthropogenic activities despite being vulnerable to natural disasters. Marine Islands hosts invaluable marine resources such as coral reefs, seagrass beds, mangroves and its associated fisheries which play an important role in livelihood of the coastal communities through tourism and fishing. It is important to judiciously protect and manage these islands to conserve the rich terrestrial and marine biodiversity it hosts. Andaman and Nicobar Islands (ANI), India is a strategically located linear chain of 572 tropical Islands located in Bay of Bengal in close proximity to South East Asian (SEA) countries such as Myanmar, Thailand and Indonesia. This proximity attracts poachers from SEA countries for harvesting living marine resources in the Exclusive Economic Zone (EEZ) of ANI posing significant threat to marine biodiversity and coastal security. Prudent approaches are required to address the issue of poaching by involving various stakeholders and a science-policy interface at regional level. Implementation of efficient and reliable monitoring-reporting systems could be worthy to address the issue of poaching. Mobile apps help lines, fishermen groups, aerial vehicles, Monitoring, Control and Surveillance (MCS) system and other satellite based tools can effectively deter poaching and illegal fishing. The importance of community participation and the ways through which the modern tools and community participation could compliment in curbing the incidences of poaching were discussed. Necessary precautionary approaches are essential at this point in ANI as it was understood through the review that poachers have gone down in recent years and this period could be effectively utilized towards planning and efficient management of such incidences in future. The status of poaching and its associated activities over these years and the possibilities on implementation of suitable monitoring and reporting systems in collaboration with stakeholders were discussed.

Keywords Poachers · Sea cucumbers · Biodiversity · Conservation · Stakeholders

Introduction

With the rise in importance to the economic value of oceans and maritime industry, it is important to preserve the oceans harboring the sensitive ecosystems through balancing the use and protection (Ehlers 2016). The concept of Blue Economy emerged as powerful concept which broadly conceptualizes oceans as shared developmental space (Doyle 2018) since oceans link sellers and buyers (Smith-Godfrey 2016). Oceans being least observed part (MacCauley et al. 2016) could also potentially harbor illegal trade and transport which could harm

the ocean biodiversity and aggravate illegal activities. Some of the threats include pirates, gun running, narcotics, poaching, illegal fishing etc. (Das 2011; Doyle 2018). Fisheries, offshore oil, gas, tourism, maritime industry are already making significant contribution to economy of the countries bordering Indian Ocean (Llewellyn et al. 2016). Illegal, unregulated and unreported (IUU) fishing comprises a subset of transnational organized crime including actions such as poaching and illegal trade at the cost of economic and environmental concerns of sovereign countries (Bondaroff et al. 2015). Illegal fishing could either be internal through local fishermen or external through poachers from other countries. Poaching being a form of illegal fishing is one of the most imminent threats faced by marine ecosystems globally.

India is an important marine fishing nation as fisheries have now transformed to a commercial enterprise with 2.02 million sq. km of Exclusive Economic Zone (EEZ) NPMF (2017). Issues such as climate change, rising sea levels, marine

✉ R. Kiruba-Sankar
rkirubasankar@gmail.com

¹ ICAR-Central Inland Agricultural Research Institute, Port Blair, Andaman and Nicobar Islands 744105, India

pollution, protection of coastal ecosystems, ocean acidification, illegal and overfishing have become critical in Indian maritime outlook (Mishra 2017). India is being robbed of its precious flora and fauna to fulfill ever growing wildlife demand in other countries (WWF 2014) as illegal wildlife trade shows no signs of decline. Though the illegally traded species are protected through multi-layered conservation laws and policies, the issue remains persistent and steady. Marine species such as sea cucumber, shells, turtles, sea horse, tunas are being poached and traded illegally owing to their high value in international market. Holothurians (sea cucumber) are often highlighted in poaching/illegal trade of marine fauna of India due to their high market demand for food and pharmaceutical uses in Asia. Harvest of tropical sea cucumbers have surged in Indo-Pacific regions mainly Indonesia, Papua New Guinea, India, Solomon Islands, Kiribati and constellation of many Islands in Melanesia, Micronesia and Polynesia (Rogers et al. 2017). More than 70% population of sea cucumber is fully/over exploited or depleted (Purcell 2014; Gonzalez-Wanguemert et al. 2018). Even grim harvests of sea cucumbers are considered worth by poachers. *Trochus niloticus* commonly called as top shells are most valuable gastropods which

inhabit shallow waters and have huge demand in global market as seafood and for making artifacts.

The archipelago of Andaman and Nicobar Islands (ANI) is one of the biodiversity hotspot located in the Bay of Bengal close to South East Asian countries (Fig. 1). The maps used were prepared using QGIS, open source software and the EEZ boundaries were downloaded from Flanders Marine Institute (2018). The Islands are home to highly diverse terrestrial and marine ecosystems with a variety of habitats ranging from densely forested hills to sandy beaches and some of the intact coral reefs (Roy et al. 2017a). Coastal security and monitoring plays a vital role in securing and governing the marine resources of Andaman and Nicobar Islands (Fig. 2). Being a tropical Island, the marine ecosystems and the fisheries resources plays a significant role in livelihood, tourism and associated entrepreneurship development in the Islands. The estimated harvestable potential of marine fisheries in ANI is 1.48 lakh tonnes while the present harvest stands at 39,284 t in 2017–18 (Unpublished data, Directorate of Fisheries, Andaman and Nicobar Administration). From 0 to 12 nautical miles (nm), fishing in Andaman and Nicobar waters is regulated by the Union territory of Andaman and Nicobar as per the

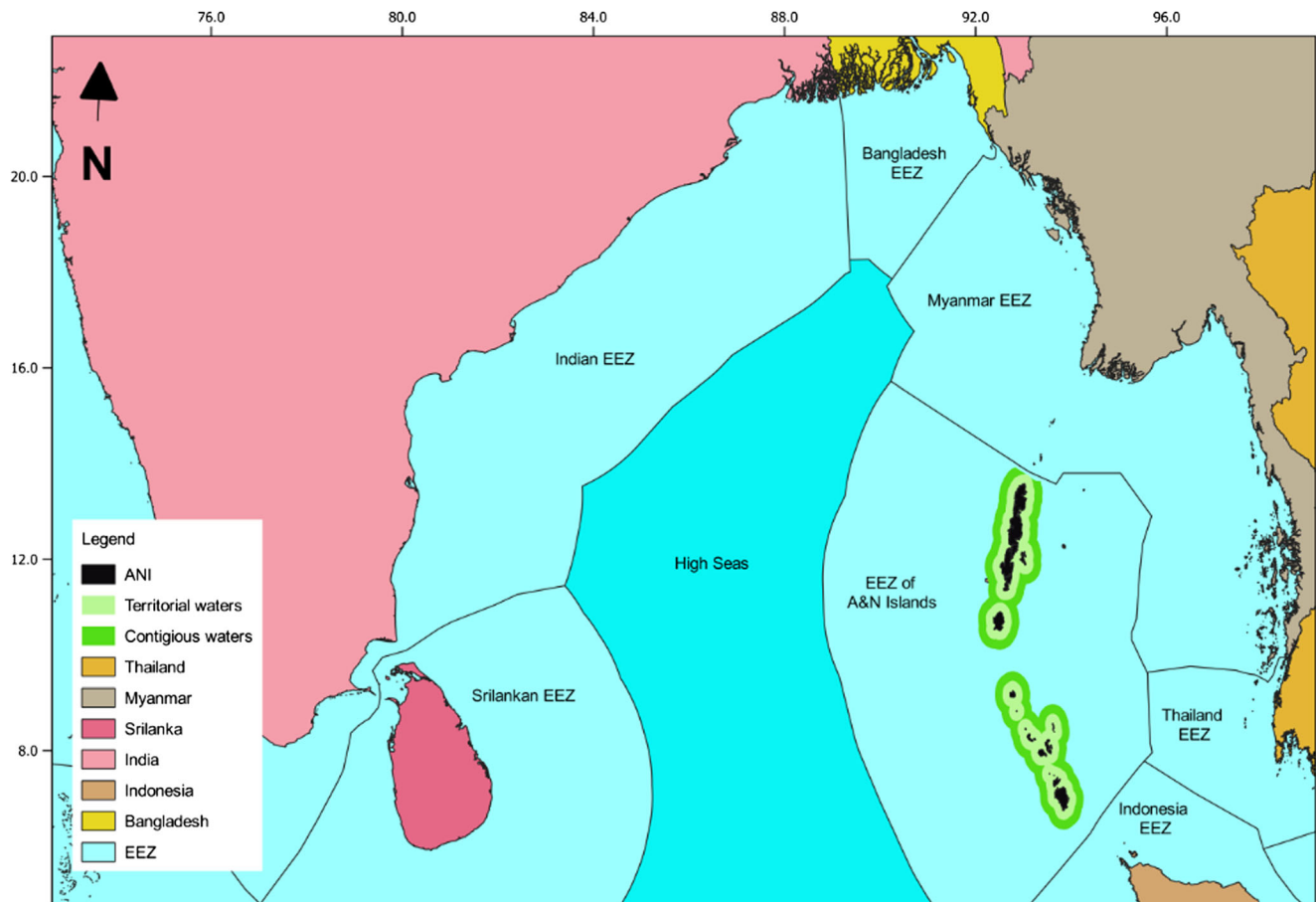
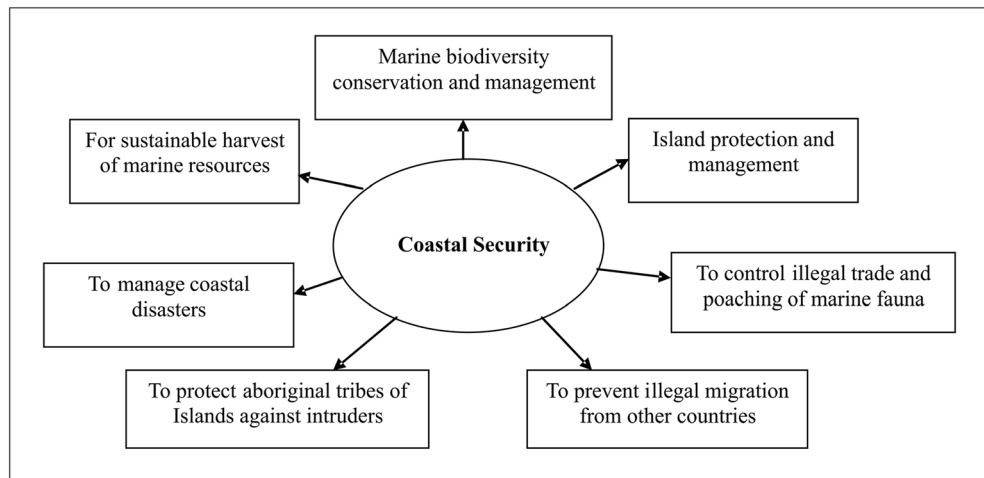


Fig. 1 Location of Andaman and Nicobar Islands, India and the EEZ of surrounding regions

Fig. 2 Importance of coastal security and governance



Andaman and Nicobar Islands marine fishing regulation being territorial waters (Unpublished data, Directorate of Fisheries). The territorial waters have been divided into fishing zones A and B as Zone A extends upto six nautical miles from high tide and vessels fitted with 30 hp. or less and non mechanized boats are permitted whereas Zone B are territorial waters beyond six nautical mile from the high tide mark and vessels with engines more than 30 hp. are permitted (Advani et al. 2013). Apart from territorial waters (12 nm), other zones and limits include contiguous zone (24 nm), Exclusive Economic Zone (200 nm) and high seas beyond 200 nm (FICCI 2017). The trend in annual marine fish production from ANI waters, categorized into pelagic, demersal and oceanic are shown in (Fig. 3) (Personal communication, Directorate of Fisheries). Some of the important fish species landed are sardines, perches, silver bellies, carangids, mackerel, seer fish, tuna, mullets, prawns and other crustaceans (Roy and George 2010). Poachers from

adjacent countries are known to frequently trespass in the ANI to poach the marine wealth. These Islands are rich in marine biodiversity (Table 1) and 220 species are known to be endemic (Hornby et al. 2015). Shells and sea cucumbers are some of the important target species for poachers in ANI waters. Andaman and Nicobar Islands, South East Asian countries and Pacific Islands forms an important distribution range for *Trochus niloticus* (Lemouellic and Chauvet 2008). Though entire Andaman and Nicobar Islands are repository for *Trochus niloticus*, illegal fishing are noticed in few localities such as North and Middle Andaman, Little Andaman and Nicobar Islands especially Kundol Island (Ramakrishna et al. 2010). Similarly, the ANI waters also harbour dense sea cucumbers resources which have high demand in international market. Abundant and widespread distribution of these commercially important species in ANI waters makes them vulnerable to poaching.

Fig. 3 Trend in marine capture fisheries of Andaman and Nicobar Islands

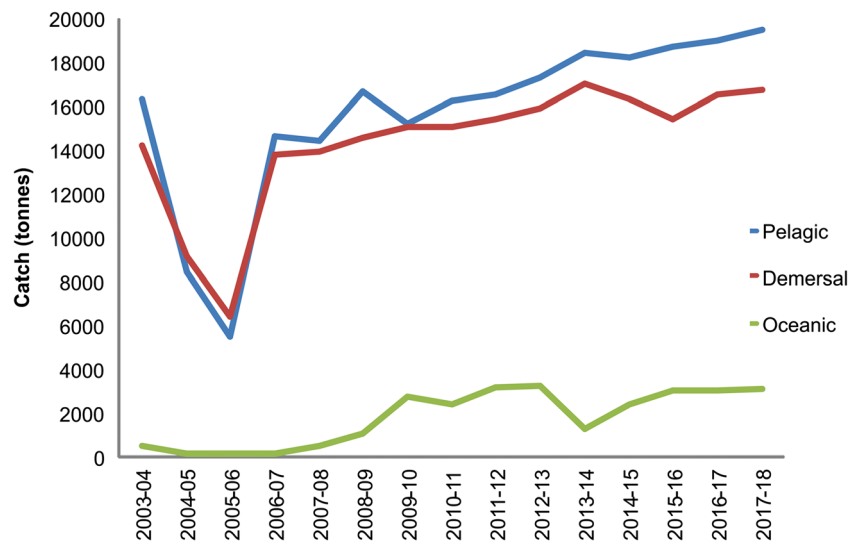


Table 1 Significant aquatic biodiversity of Andaman and Nicobar Islands

Groups	No. of species	References
Mangroves	38	Ragavan et al. (2016)
Sea grass	11	Immanuel et al. (2016)
Fishes	1434	Rajan et al. (2013)
Sponges	123	Krishnan et al. (2012a)
Echinoderms	430	Raghunathan and Venkataraman (2014)
Holothurians	98	Raghunathan and Venkataraman (2014)
Crustaceans	746	Raghunathan and Venkataraman (2014)
Marine Mollusks	1422	Sivaperuman and Raghunathan (2012)

Why poachers are intruding into Andaman and Nicobar waters

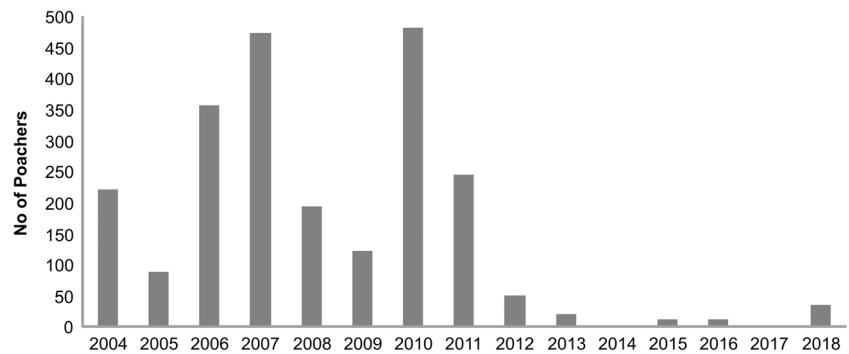
The striking characteristic of ANI fishery is the abundant yet underexploited oceanic fisheries constituted particularly by tunas and tuna like fishes. Of the total potential of 1.48 lakh tonnes, oceanic fisheries constitute about 60,000 tons of which tunas constitute 46,700 t which is about 77% of oceanic fishery potential (Roy and George 2010). The current exploitation of oceanic resources is below 10% of estimated potential as there is no organized deep sea fishing industry in ANI. The under exploited fishing grounds attracts the poachers to exploit marine species which are having high demand in South East Asian markets. Though the oceanic resources are underexploited, resources such as sea cucumber and top shells were once exploited irrationally considering their export market. Due to increased exploitation and habitat destruction, holothurians and top shells are banned for fishing since 2001 under Wild Life Protection Act, 1972 (Raghunathan and Venkataraman 2014). There were 7326 active licensed fishermen in ANI with fleet size of 2888 (Mechanized-83, Motorized- 1255, Country crafts- 1550) in 2016–17 (Unpublished data, Directorate of Fisheries). As the fishing fleet of ANI is relatively small for the vast EEZ (0.6 million sq. km), the probability of poachers being detected by the local fishing crew is low. The terrain, thick forests along the coast and many uninhabited islands (only 38 of 572 islands are inhabited) provides good hideouts in case of interception by authorities. Poachers are well aware of these facts and enter ANI water to poach the marine resources. Poachers with motorized dinghies target sea cucumbers and top shells along the coasts in shallow depths whereas mechanized vessels targets deep sea fishes. Most of the poachers apprehended in the Islands are seized with sea cucumbers, shells and fishes (MOEF 2011). Majority of the poachers caught were of Myanmar's origin. Poachers from other countries include Thailand, Indonesia, Sri Lanka, Bangladesh, China and Taiwan. The most desirable species for poachers are Sea cucumbers (Echinoderms) and shells (*Trochus niloticus*) (Abraham 2018). Sea cucumbers and top shells are easy

targets as they inhabit shallow waters and offer no resistance against hand collection. These are collected by skin divers without using Self Contained Underwater Breathing Apparatus (SCUBA) gears making it easily harvestable even for small scale traditional poachers. Apart from these targeted resources, poachers with mechanized vessels illegally fish the deep sea fish resources which include oceanic tunas, sharks, bill fishes, marlins, groupers and carangids. Das (2011) has noted that the security forces are successful in apprehending poor poachers from Myanmar and Bangladesh while trawlers with sophisticated navigation and communication equipment's were successful in dodging Indian security forces. While the number of poachers have come down in recent years post 2011, the very recent incidence in 2018 wherein Myanmarese poachers attacked and severely injured the local fishermen in Little Andaman in an desperate attempt to escape raised serious concerns on the vulnerability of the Islands to poachers (The New Indian express 2018).

Present trend in poaching

Poaching in ANI could have been a regular activity in the past. However, increased surveillances by the security forces have led to frequent apprehension of poachers in past decade. Reports from various sources available on poaching reveals that poachers caught were mainly from Myanmar, Indonesia, Thailand, Sri Lanka, Taiwan and China. The trend in poachers apprehended over the years shows that there is a constant intrusion of poachers in Island waters as shown in Fig. 4 (Source: Das (2011), MOEF (2011), Andaman Sheekha (2012a, b, 2013a, b, 2015, 2018a, b, c), Times of India (2012, 2015), Business Standard (2016), News18 (2016), The New Indian Express (2018), unpublished data, Directorate of Fisheries). However a sharp decline in poachers was observed after 2011. In 2014, a foreign fishing trawler was apprehended with 45 t of deep sea fishes mainly tunas, bill fishes, sail fishes and marlins, however the crew details were unavailable (Unpublished data, Directorate of Fisheries). The confiscated catches mostly comprised of

Fig. 4 Number of poachers reported from Andaman and Nicobar Islands



Sea cucumbers, shells, and fishes, More than 95% of the confiscated catch by weight was comprised of fishes. The considerable contribution of fishes to poached catches in our analysis was mainly due to the trawler apprehended with 45 tons of deep sea fishes in 2014 shown in Fig. 5 (Unpublished data, Directorate of Fisheries.). However the main targeted species by poachers over these years are sea cucumbers and shells owing to their demand in SEA countries. The most frequently poached areas based on published news and personal interactions with fishermen shows that the entire stretch of ANI is vulnerable to poaching. The size of the circles is not the exact representation of either poached areas or intensity and magnitude of poaching as they are only indicative (Fig. 6). There is a considerable need to identify the poaching hotspots to enforce strong monitoring mechanisms to control these incidences and conserve the marine biodiversity. The vast coastline of Myanmar lies opposite to the North and Eastern side of Andaman Islands with Andaman Sea in between. Myanmar poachers have better access to the most of the part of Islands. A report of Ministry of Environment and Forests, Govt. of India, MOEF (2011) states that western parts of the Islands are most vulnerable to poaching. This is further supported by Das (2011) who mentions that western part of the Islands are mostly reserved forests whereas more settlements are

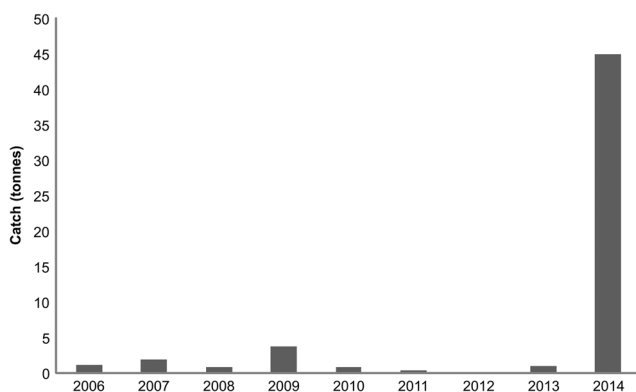
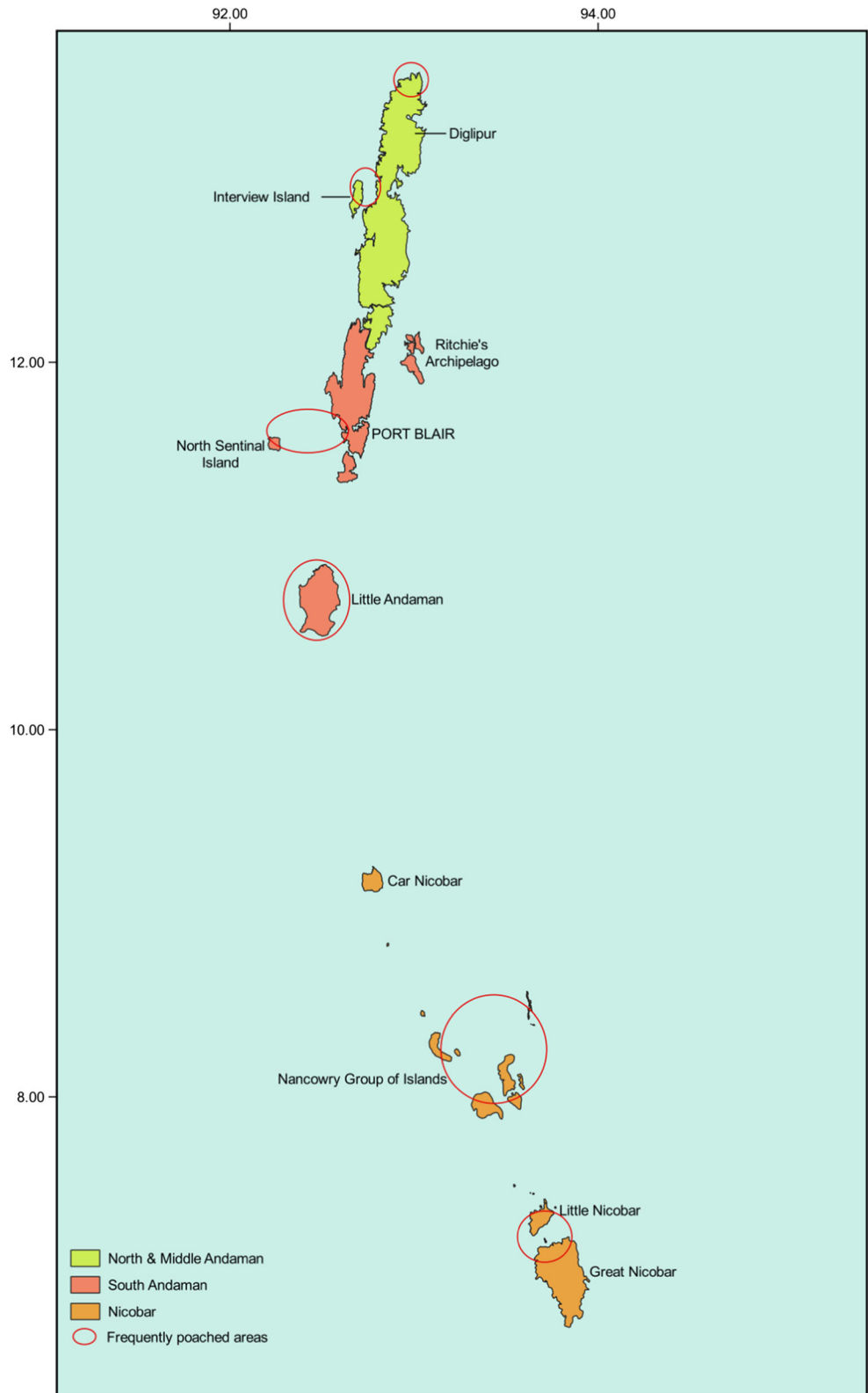


Fig. 5 Marine catches apprehended from poachers

on eastern part. The uninhabited, secluded areas and reserved forests in western part of Islands act as hideouts for the poachers. The scarce human inhabitation in Nicobar stretch also seems quite congenial for poaching activities. Poachers were also apprehended near North Sentinel Island which is home to Sentinalese tribe, one of the uncontacted tribes in the world. Incidences of poachers intruding in Jarawa reserve areas (area reserved for Jarawa tribal group) are also observed in recent years. Fishermen from Thailand, Malaysia, Myanmar and Bangladesh temporarily stay in uninhabited Islands (Das 2011). In 2018 Myanmarese poachers were been in Little Andaman for more than a month trying to find escape route that lead to attack on local fishermen (The New Indian express 2018).

The abundant wealth of marine biodiversity in Andaman and Nicobar Islands particularly sea cucumbers and shells was the main reason that guide the poachers towards these far located Islands. The diversity and abundance of marine fauna was found to differ between Andaman and Nicobar group of Islands. Nancowry group of Islands in Nicobar harbor *Trochus niloticus* at a density of 20 shells/100m³ with specimens of larger size growing up to 13.62 cm (Raghunathan et al. 2012). Little Nicobar, Katchal, Kamorta and their adjoining waters upto 500 m from shore could be declared reserves for *Trochus* and *Turbo* (Ramakrishna et al. 2010). Status studies of Ramakrishna et al. (2010) and Raghunathan et al. (2012) revealed that the density and size of *Trochus niloticus* is comparatively higher in Nicobar group of Islands than Andaman group. In case of Holothurians, the status survey reveals that overall density of 30 species (including 14 commercially important species) was abundant in Andaman group of Islands with 599 to 1179 individuals/100m² whereas the Nicobar group of Islands were less abundant with less than 503 individuals/100m² (Raghunathan and Venkataraman 2014). The high density of commercially important holothurians in Andaman group of Islands makes it convenient for poachers from Myanmar. Apart from sea cucumbers and shells, poachers also target and catch Sharks, Perches, Groupers, Marlin, Yellow fin tuna, Skip jack tuna etc. from ANI waters (Unpublished data, Directorate of Fisheries). Andaman and

Fig. 6 Most frequently poached regions reported in Andaman and Nicobar Islands



Nicobar group of Islands are also home to excellent oceanic fishing grounds. However the fishery in Nicobar group of Islands is least exploited as most of the active commercial

fishery is concentrated in Andaman group of Islands. Another major reason for low fishing activities in Nicobar Islands is that the Islands are mostly inhabited by tribal fishers

who tend to go for fishing on subsistence basis. Particularly in Islands like Car Nicobar the fisheries sector is in infant stage as their attitude towards sea is very modest, primitive and indigenous (Ravikumar et al. 2016). Inactive fishing grounds due to low levels of local fishing population could be an advantageous environment for poachers to approach and harvest these marine resources.

Currently, the surveillance of EEZ of ANI is done by Coast Guard, Marine Police, Forest department, Fishermen watch groups and a coordination committee constituted by Andaman and Nicobar Administration with a toll free helpline number (MOEF 2011). This was effective in controlling the poaching to a certain extent. The current declining trend of poaching apprehensions is of no guarantee that the poaching incidences has really come down. In 2018 till July, around 35 poachers were already caught or detected from various parts of Island raising further concerns. The report on poachers attacking and injuring local fishermen in Little Andaman in 2018 was alarming. There may be chances that the poachers are raising permanent shelters in uninhabited Islands to avoid detection of security forces. Thus, further strengthening of surveillance through involvement of all the stakeholders, sensitizing the local communities, demarking poaching hotspots, developing community based surveillance teams and use of advanced techniques such as a robust regional Monitoring, Control and Surveillance (MCS) network is essential. The fishermen watch groups can be effectively placed in the surveillance works along the linear strip of Islands. About 20 important fish landing centers along the stretch of Andaman and Nicobar Islands were mapped and used for studying the efficacy of different modes of Potential Fishing Zone advisories distribution (George et al. 2014). Sensitizing the importance on conservation of fishing grounds, through awareness programs and interactions with the local fishermen is essential. Information generated on landing centres, their fishing areas followed with interactions and awareness programs can be well utilized for spreading information on issues related to poaching. Providing necessary trainings and awareness to identify foreign fishing vessels can easily resolve the issues the future might face due to poaching.

Stakeholders' role in fight against poaching

While conservation plans are mostly made at national or local level, all countries are not equally inclined to monitor and effectively manage marine conservation areas (Levin et al. 2018). The Fishermen watch group (MOEF 2011) is an efficient surveillance method against poaching. These watch groups can pass on the reliable information on poaching to the authorized agencies leading to the apprehension of poachers. Fishermen, with vested interest and sense of responsibility in conserving the fishing grounds, can act as

an effective tool against the poaching. Koh and Sodhi (2010) have reported that tangible conversation can be achieved only through support of local communities and any conservation strategy will fail without the support of local communities. The relevance of engaging the community in fight against poaching should be emphasized. Fishermen should be sensitized on the consequences and ill effects of poaching, loss of marine biodiversity and their rights on fishing grounds through the environmental conservation programs. In Pacific countries, the protection of *Trochus* sp. and other valuable macro invertebrates such as giant clams, green snails and sea cucumbers is achieved by village based marine reserves through traditional marine reserve management (Dumas et al. 2017). Steinmetz et al. (2014) reports that conservationists in Asia tend to regard outreach and community based conservation as niche area, however the core business should be direct protection through patrolling and enforcement. Though there has been historic reliance on law enforcement and crime control to address illegal exploitation, it is recognized that a shift in governance needs to take place to address the issue (Hauck and Sweijd 1999). Creative strategies and innovative solutions are necessary to deal with poaching through involvement of all the stakeholders. Though stakeholders such as fishermen could provide reliable information on poaching through their mode of networking, the reliability only on such method will not be effective. Involving stakeholders from Government and private institutions through streamlining their mode of action to detect and control poaching could be effective. Updated technologies and tools on detecting poaching and illegally fishing vessels are to be implemented and practiced as conservatory measure to conserve the coastal ecosystems and the stakeholders dependent.

Tools to tackle poaching and some global examples

The tools used in tackling wild life poaching were discussed in this section. Though the content is not directly related to fisheries, these tools with some modification can be effectively used to control marine poaching. Tools used against poaching, its advantages, disadvantages and suitability in Andaman and Nicobar waters are given in detail in Table 2. A report of United Nations Environmental Program (UNEP 2014) advised use of various technically advanced equipment's to track poaching. Drones (Unmanned aerial vehicles), acoustic traps, mobile technology using apps to report illegal activities, microkopters, radio frequency identification tags and camera traps are some of the advanced tools currently being implemented for wildlife conservation. A mobile App called 'Wildlife Witness' was developed for the first time in South Asia helped the users to report suspicious activities with

Table 2 Tools against poaching, their advantages, disadvantages and suitability in Andaman and Nicobar Islands

S. No	Tools/methods	Advantages	Disadvantages	Suitability in ANI
1	Mobile App based	Very easy to implement, low cost and easy to access large number of fishermen as the trend of using smart phone is on rise.	Networking issues may lead to delay in passing information, uncertain monitoring as users may not be aware of status of foreign vessels (foreign vessel fishing with letter of Permission from Govt. of India), false information and low chances of locating the poachers.	In Andaman and Nicobar Islands, mobile app usage is very common and hence could be a best tool for reporting poaching and illegal activities. This is most suitable for the people residing in coastal areas as poachers targeting sea cucumbers and shells fish in shallow waters near to coast. Reporting from deep sea cannot be done due to non-availability of telephone network.
2	Satellite based monitoring, AIS, VMS	Could be a reliable mode, continuous monitoring and efficient mode of detection.	Costly and advanced tool, needs good networking support.	Though use of these tools is an efficient approach to deal with poaching/illegal fishing, the implementation is a time taking process and the present network conditions will not support quick implementation. However such systems could be a well implemented in future as there are fair chances of improving network in next 2–3 years.
3	Unmanned aerial vehicles	Modernistic tool, reliable information could be gathered on poaching, easy detection in open waters than terrestrial forest covers.	Costly and advanced tool.	This is a very costly approach and in present condition the use of such costly tool may not hold well in Islands.
4	Fishermen watch groups	Simple, cost effective and easily implementable.	Incentives, mode of engagement, authenticity of the information.	With awareness and encouragement this approach may be well suited. Existence of such groups is discussed in the report of MOEF (2011).
5	Hotlines, Toll free communications	Easy to set, could be helpful as a supplementary monitoring tool.	The reception to such toll free could be uncertain, needs a major sensitization to local stakeholders to encourage users.	Can be used as an additional tool along with mobile app based tool and fishermen watch group.
6	Aerial, water and terrestrial surveillance	A wider range of monitoring, reliable and effective to detect poachers.	Difficult to operate in rough weather conditions. Aerial surveillances can detect poachers, but naval or terrestrial assistance is needed to apprehend poachers.	Aerial, water and terrestrial surveillance by Coast Guard, Indian Navy, Marine Police, Forest Dept. and other Govt. agencies are in place.

photos and location reporting (Traffic 2014). Another app SMART (Spatial Monitoring and Reporting Tool) used by forest rangers to combat wild life poaching mainly through identification of hotspots and rapid response measures (Science Daily 2012). In India, *Hejje* (Pugmark) an indigenously developed android based app was launched in 2012 for conservation of tiger (The Hindu 2014).

Some tools to combat poaching in marine environment include *Eye on the seas* which was developed by Pew charitable trust. It uses Automatic Identification System (AIS) and Global Positioning System (GPS) based system to distinguish between non-fishing and fishing vessels (PEW 2015). The use

of Automatic Identification Systems (AIS) in marine governance and research (MacCauley et al. 2016) and Vessel Monitoring Systems (VMS) are some of the vessel tracking tools to deter illegal fishing activities. Unmanned Aerial vehicles (UAV's) are used for monitoring and surveillance of sea turtles and marine mammals besides its use in terrestrial environment (Gonzalez et al. 2016).

Apart from these tools and technologies, many countries had taken firm stand to control the incidences of poaching. For instance, Palau, an Island nation in Pacific has bought major reforms in fisheries sector to fight against the illegal fishing. Some major moves includes banning of bottom trawling,

prohibiting commercial shark fishing, observers in all tuna longliners, and declaring an area of 1,93,000 sq. miles as *No take* reserve in 2015 (NY times 2016). Palau aims to establish fully functional Monitoring Control and Surveillance (MCS) by 2021 to protect its EEZ against illegal fishing (Palau MCS plan 2015). They sent a strong response against poaching by burning a Vietnamese boat which was caught poaching sea cucumber in Palau waters (Nationalpost 2015). Indonesia fights against poaching and illegal fishing through destroying hundreds of fishing vessels used for poaching mostly from Vietnam, Philippines, Malaysia and Thailand (Pressherald 2017). South Africa has established an anti-poaching unit called marines (Sjostedt and Sundstrom 2015). In the past, Taiwanese and South Korean trawlers have been detected poaching in Maldivian waters (Sathiendrakumar and Tisdell 1986). Maldives has built strategic plan on biodiversity protection and curbing illegal fishing through identifying and effectively blocking the routes and pathways of illegal trades (MEE 2015). Some examples of Monitoring, Control and Surveillance (MCS) system implemented in various countries is given in Table 3. Taking such global examples and strengthening the monitoring and control mechanisms through innovative approaches in collaborative effort with involvement of stakeholders is necessary. The number of Thai fishermen involving in poaching has reduced during the last decade because of better coordination between Indian and Thailand Navy (Abraham 2018). An Inter-Governmental dialogue with Govt. of Myanmar was recommended in the report of MoEF (2011) to sort the issue of poaching by Myanmar fishermen. In response to the rising incidents of poaching by Myanmar fishermen, India has warned Myanmar of stronger sanctions and harsher penalties (Mmtimes 2012). Apparently, the number of poachers has reduced after 2011 as India and Myanmar has agreed to closely cooperate on maritime issues in Bay of Bengal (Pattanaik 2016). Such management actions and Inter government dialogues followed by a robust marine resource governance is essential to control the incidences of poaching and illegal fishing in Andaman and Nicobar Islands.

The need to reinforce the regional fisheries monitoring

Most of the world fisheries especially in Africa and parts of Asia have no protection of any kind (Hilborn 2016). Effective management of fisheries resources from illegal, unreported and unregulated (IUU) fishing is crucial for sustainable fisheries development. Strengthening the local fisheries monitoring and intelligence through advanced tools should be the priority for ANI. Though aerial surveillances in EEZ are continuously keeping eye on foreign vessels, the monitoring of Indian vessels on biological angle could be the missing link in illegal fishing and poaching. The chances of local traditional and mechanized

fishermen involving in illegal activities cannot be completely denied which needs monitoring. Mass sensitization to the local fishermen on the ill effects of poaching and its deleterious effects for future fishing generations needs to be advised. The fishermen can keep check on the sustainable fishing practices within their own fishing groups and can also trace the foreign fishing vessels involved in poaching. Other issues such as overfishing in case of Groupers (Kirubasankar et al. 2013), carangids (ANDFISH 2005) and the ill effect due to bottom trawling (Thomas et al. 2017) has been reported from the Islands. A common platform to address the problems in regional fisheries management needs to be exercised to resolve the scientific and managerial issues in fisheries management. Several government departments working on similar objectives but in different paths may not yield the expected results. There are various stakeholders and working groups involved in various components of the fisheries sector and there is a need for a well coordinated approach on the part of all the stakeholders starting from the individual fishermen to the administration, bankers, research bodies and exporters (Nithyanandan 2009). The science-policy interface should be strengthened at regional levels to regulate marine fishing for sustainable catches. An institute which could link science and policy could be more effective.. Some recommendations for global fisheries management such as merging various government departments responsible for conservation and fisheries management in to a single department (Hilborn 2016), setting up of new institutions for science based fisheries management, regional scientific management councils for decision making (Cao et al. 2017) are worth considering for strengthening science-policy interface. Those initiatives are also well supported in ANDFISH (2005) which also points the importance on creating an Institute for Marine Island Ecosystems for scientific backstopping and development initiatives for creating systematic databases on the resources. Such institute should have dedicated units to deal with various issues in fisheries management such as fisheries intelligence group, catch database group, policy group, extension wings and associated sections which can identify and mitigate the risks and developmental hurdles associated with the fisheries development in the Islands. Such dedicated units can well address the issue of illegal fishing and poaching through regional and international collaborations. Fisheries development action plan should reckon with the preservation of pristine condition of the Islands (Roy and George 2010). The confronting issue is that the actual fisheries potential of the Islands is not being fully utilized. Not many scientific interventions were applied and proven to augment the marine fisheries resources in the Islands. Significant interventions through dissemination of Potential Fishing Zone advisories has brought a positive attitude among marine fishermen towards fish harvest. The convenience in locating the fish shoals and the easy quick access to the fishing grounds has favored the accessibility of fishermen to harvest the resources. Integrated Potential Fishing

Table 3 Global examples and actions against illegal fishing

Country/region	Actions and outcomes	Reference
Pacific Islands Exclusive economic zones (EEZs) of Cook Islands, Federated States of Micronesia, Fiji, Kiribati, Marshall Islands, Nauru, Niue, Palau, Papua New Guinea, Samoa, Solomon Islands, Tokelau, Tonga, Tuvalu, and Vanuatu	First regional coordinated effort to reduce IUU vessels resulted in apprehension of vessels and reduction in fishery loss due to IUU	FFA (2011)
Mauritius	Full fledged MCS system All national and foreign vessels to be vessel monitoring system (VMS) compliant. Automatic identification system (AIS) transponders are also required since 2015.	COFREPECHE, NFDS, MRAG and POSEIDON (2015)
Republic of Palau (2016–21)	Fisheries protection service established in 2007 Comprehensive plan aimed at 2021 to fully establish MCS actions to prevent illegal fishing for protection of EEZ and marine biodiversity	Palau MCS plan (2015)
Peru	MCS through SMS based application developed as SISESAT to combat IUU being recognized worldwide now The app enable the accredited produce inspectors and fishermen to check the last location (latitude, longitude), speed, direction, distance to coast and reference area of their vessels	International MCS network (2014); Andina (2017) All three programme received 2 nd stop IUU fishing awards in 2016 for successful outcome to combat IUU. International MCS network.
Indian Ocean Commission (Comoros, Madagascar, Mauritius, Réunion and Seychelles)	Smart fish programme, acts on destructive fishing gear, blast fishing	
Indian Ocean Commission Tanzania	Smart fish programme, fishing vessel registration	
West Africa (Mauritania, Senegal, The Gambia, Guinea-Bissau, guinea, Sierra Leone)	MCS actions between 2009 and 16 resulted in collection of \$29 million US as sanctions	Doumbouya et al. (2017)
Namibia (Namibia national plan of action against IUU, 2007)	MCS action through fisheries patrol vessels, fisheries patrol aircrafts etc. Low degrees of illegal fishing and poaching in Namibia	Tuna transparency action in ATLAFCO zone (2015) Sjostedt and Sundstrom (2015)
Ghana (National plan of action to combat IUU, 2014)	MCS tools used were Vessel monitoring system (VMS), Automatic identification system (AIS)@24/7, catch certification, vessel registration	Tuna transparency action in ATLAFCO zone (2015)
Canada (Implemented MCS and continually seeks ways to improve)	Vessel monitoring system and Dockside monitoring system (accurate, timely and independent third party verification of fish landings) are important methods for achieving Canada's MCS objectives	Government of Canada (2005)
Malacca strait Malaysia, Singapore, Indonesia (MALSINDO programme- Eye in the sky)	Combating IUU Community based MCS in Indonesia	Poernomo et al. (2011)
Maldives	Developing monitoring, compliance and surveillance strategy, strengthening fisheries statistics and data collection, strengthening regulatory and legal framework, recover plans and measures in place for all depleted species	MEE (2015)
India	Online uniform registration and licensing system (ReALCraft). Improvement planned in phased manner through Chip based smart registration cards, log books, colour coding, biometrics, etc. Community based MCS implementation is planned. Existing mechanisms needs further strengthening.	NPMF (2017)

Zone forecasts have proved helpful in harvesting the underexploited resources. They also helped in reducing the scouting time and thereby reduce the fuel consumption by the fishing

vessel (George et al. 2011). While low exploitation rates, income and trade benefits of fisheries sector needs due attention, the sustainable and rational exploitation of fisheries needs to be

exercised at regional level. The existing fisheries database and fish catches landed needs systematic monitoring and record. The National Marine Fishery Resource Data Centre (NMFDC) developed by ICAR- CMFRI, Kochi gives detailed structure and insight on developing database on catch and effort, data combining various parameters. Such data repository structure can be effectively implemented in collaborative manner to get the actual landing scenario in the Islands. Marine resource management and governance can be achieved through improving the capabilities of the fisheries department to manage, conserve and protect the Island marine resources (Pillai and Abdussamad 2009) The stress on systematic monitoring on fishery database, fishing vessels operating in EEZ, catch quantity, species composition, area of capture, biological conditions are also pointed by Pillai and Abdussamad (2009). Addressing the above mentioned concerns existing in regional fisheries management can strengthen the regional database on fish landings, fishing vessels operating in EEZ, which can ultimately be guiding factor towards managing the issue of poaching and illegal fishing.

Discussion

South East Asia suffers the world's highest rate of wildlife declines mainly due to poaching (Steinmetz et al. 2014). With respect to fisheries, monitoring and enforcement is difficult in Asia due to large number of vessels and high level of illegal fishing such as fishing without licenses, illegal gears and fishing in protected areas (Stobutzki et al. 2006). The majority of world's sea cucumber fisheries are located in tropical countries in south where management is troubled (Bennett and Basurto 2018). The catches confiscated from the poaching vessels should be considered at minimum level as there is probability of some poaching vessels gone unnoticed or escaped from the authorities. Dolorosa et al. (2010) reports that, poachers in Philippines poaching on *Trochus* shells drop sacks of *Trochus* shells into water when detected and chased by authorities. Hence, confiscated catch may be much lesser than what is being actually harvested. The scenario in Andaman Islands might be same as many of the seized boats were chased for hours by patrolling authorities before being apprehended. This particular issue can hold many underlying meaning as poachers could have dumped many valuable poached species in sea to flee away and hence the volume being apprehended could be unrealistic.

Regulation remains the principal tenet of conserving species threatened by poaching for international trade (Challender and MacMillan 2014). Strong sanctions against offenders, including local fishermen should be imposed when any sort of illegal fishing is carried out. In Great Barrier Reef, Australia fine for fishing within green zone by recreational fisheries are considerably higher than the value of catch (Davis et al. 2004).

Over last 15 years, conservation and management of deep sea fisheries has become a global agenda (Oanta 2018) signifying the intense pressure on deep sea fisheries sector. Deep sea fishing offers high profitability with large global demand. For instance, tropical tuna fisheries are the largest worldwide (Miller et al. 2017) as in 2015 the catches of major commercial tunas were 4.8 million tons with skipjack tuna, yellowfin tuna, big eye tuna and albacore tuna contributing 58, 28, 9 and 4% respectively (ISSF 2017). Tunas are highly migratory and move between the jurisdictions of many countries emphasizing the need of multinational cooperation for their management (MSC 2017). The higher market demand for tunas globally has led to decline in catches of some tunas. Illegal fishing and poaching could severely affect the tuna resources of small tropical Islands. Poaching of tunas from ANI waters should be a matter of concern as tuna resources are highly underexploited in ANI and tuna demand is at par with sea cucumber in SEA markets. The Sea Around Us project on Andaman and Nicobar Islands reports the unreported industrial catches and bycatches by the joint venture tuna fishing representing 28% of total reconstructed catch (Hornby et al. 2015). Unreported commercial catches and by catches from tuna fishery was estimated to be over 1,00,000 t from 1950 to 2010 (Hornby et al. 2015). Tuna poaching by foreign vessels were reported in Maldives (Sathiendrakumar and Tisdell 1986), Andaman and Nicobar Islands and other parts of world.

The demand in international market particularly Asian market seems to be the driving factor for poachers approaching Andaman and Nicobar waters. Asian markets are looking for new target species mainly from, Mediterranean Sea and NE Atlantic waters (Gonzalez-Wanguemert et al. 2018). Such demand has also caused illegal fishery and exploitation of sea cucumbers in Mediterranean seas (Meloni and Esposito 2018). The issue of poaching is global and hence alternatives such as aquaculture programs can be considered to meet the rising demand of sea cucumbers in Asia. Some Pacific Island countries has successfully completed research trials on hatchery and release techniques and have capacity to scale up the aquaculture program (Rahman et al. 2015). Sea cucumber *Holothuria scabra* is produced through aquaculture in Southern China in multi-trophic polyculture ponds along with pearl oysters and groupers and a current production of over one million market sized animals was achieved annually (Purcell and Wu 2017). Such mariculture programs can cater to the market needs and help in rebuilding the natural stocks. The increasing pressure on natural stocks can also be considerable reduced through such mariculture practices.

Monitoring and reporting systems are crucial to address the growing concerns over poaching. Authorities should build the capacity of human resource through trainings and equipping them with modern gadgets. The technology in use should be regularly updated and upgraded. Vessel monitoring system (VMS), Automated identification system (AIS),

fishing vessels mapping, fishing traffic, integration environmental data and forecasts with marine intelligence data (Palau MCS 2015) are some of the technologies that can be taken up for securing ANI. Community based surveillance was discussed as the best solution to control the poaching activities. The best way to achieve effective role and participation of community in community based surveillance is by ensuring that the community is directly benefitted in the form of incentives or employment (Masse et al. 2017). Tools such as mobile apps, hotlines, fishermen groups could be used together to receive multiple feedbacks from stakeholders on issue of poaching. Mobile apps can be experimented on priority and the reception of public to such initiatives needs to be assessed. Public also needs thorough sensitization on this issue and necessary demonstrations on use of apps are to be in practice. The apprehended boats and equipments could be given as reward for providing information on the poachers. Such practices can motivate local communities for deeper involvement in management of marine ecosystem. Auctioning of fishing boats involved in illegal fishing is reported (Stop illegal fishing 2016) instead of relieving them after a period of time could be another thought to benefit local fishing community. Some benefits of auctioning the poaching vessels could be encouraging; however these are unlikely to outweigh the cost of surveillance (Sathiendrakumar and Tisdell 1986). Sensitizing the public is the key to address the issue of poaching and illegal fishing. Public may not necessarily realize the issue of poaching and the impact it might had caused to Island ecosystems unless they are sensitized. Creating awareness to common public and important stakeholders such as fishermen can be beneficial to prevent poaching. Interventions for increasing the fish catch through Potential Fishing Zone (PFZ) advisories have yielded a change in the attitude of marine fishers towards harvest over last decade. The Island fishermen have well utilized the Potential fishing zones (PFZ) advisories disseminated through digital display boards, email, text messages, radio, community network and print outs in person which were proven to be beneficial (George et al. 2011, 2013) in Andaman and Nicobar Islands. Such existing networks and linkages can be well utilized as communication modes to report and address the issue of poaching.

The Andaman and Nicobar coasts are vulnerable to climate change and several natural events such as storms, cyclones, tsunami, earthquakes etc. (Roy et al. 2017b) which has caused severe damage to marine ecosystems and livelihood dependent on these ecosystems. The sensitive ecosystems of corals and mangroves are already under threat due to climate change (Roy and George 2010). Mangroves play an important role in coastal protection (Kiruba-Sankar et al. 2018) which is very essential in tropical Islands against natural disasters. About 30–80% of mangrove stands in Andaman were affected due to the Indian ocean Tsunami that occurred in the year 2004 (Roy and

Krishnan 2005) reporting the decline in fish catches by fishermen post tsunami in mangrove areas. Mass bleaching of corals due to elevated sea surface temperature was reported in 2010 causing a significant damage to associated marine biodiversity (Krishnan et al. 2011). Krishnan et al. (2012b) reported the damage caused in coral reefs of Andaman due to the tropical storms in Myanmar. Such events seriously affect the fishermen livelihood as coral reefs and mangroves harbours a wide variety of marine fin fishes, shell fishes and other faunal groups. While ecosystem damages due to natural disasters are uncertain, most targeted fauna in poaching such as sea cucumbers are also known to play an important ecological role in marine ecosystems. They are ecologically important as suspension feeders, detritivores and prey and being suspension feeders, sea cucumbers regulate water quality (Anderson et al. 2011). Unsustainable fishing of sea cucumbers might also have ecological consequences in marine ecosystems. Sea cucumbers are important component of the food chain in coral reef ecosystems and plays important role as deposit and suspension feeders (Sadhukhan and Raghunathan 2014). Large scale depletions of sea cucumbers are likely to have indirect effects on sea grass and coral reef lagoons especially coral reefs because it is in these carbonate rich habitats that sea cucumber can most affect ocean chemistry (Purcell et al. 2016). Purcell and Eriksson (2015) also reports that appreciable number of scaleworm, crabs, shrimps on sea cucumbers shows that they can act as hosts to echinoderm and other epibiotic taxa playing important ecological roles in reef ecosystems. Hence the issue of poaching as a whole has direct and indirect negative effects to the coastal ecosystems and demands a comprehensive management approach to conserve and protect the vulnerable marine ecosystems of Andaman and Nicobar Islands.

Controlling the occurrence of natural events and the associated damages to ecosystems are not possible, however the threats and damages due to anthropogenic activities can be controlled and minimized to certain extent through strict regulations and monitoring. Illegal fishing and poaching activities could harm the marine ecosystems of Andaman and Nicobar Islands due to unsustainable and irresponsible fishing practices causing additional pressure to ecosystems that are already vulnerable to climate change events. Hence the issue of poaching and illegal fishing needs to be brought under control considering the importance of the Islands being a biodiversity hotspot. One does not have any control over the natural phenomena and no one can stop the natural calamities from occurring but we can surely control destruction of marine biodiversity happening through poaching and illegal fishing.

Acknowledgements The authors wholeheartedly thank and sincerely acknowledge the assistance rendered by The Directorate of Fisheries, Andaman and Nicobar Administration for providing the necessary data on fish landings, poachers and fish catches apprehended from poachers in past years. The authors also thank the Director, ICAR-CIARI for his encouragement in this work.

References

- Abraham I (2018) The Andamans as a “sea of islands”: reconnecting old geographies through poaching. *Inter-Asia Cult Stud* 19(1):2–20. <https://doi.org/10.1080/14649373.2018.1422344>
- Advani S, Sridhar A, Namboothri N, Chandi M, Oommam MA (2013) Emergence and transformation of marine fisheries in the Andaman Islands. Dakshin Foundation and ANET publication, p 29
- Andaman Sheekha (2012a) 16 Burmese poachers apprehended by A&N police. <http://www.andamansheekha.com/2012/02/25/16-burmese-poachers-apprehended-by-an-police/>. Accessed 30 Mar 2018
- Andaman Sheekha (2012b) Coast guard apprehends two boats along with 22 Myanmarse poachers off the Sisters Island. <http://www.andamansheekha.com/2012/05/29/coast-guard-apprehends-two-boats-along-with-22-myanmarse-poachers-off-the-sisters-island/>. Accessed 30 Mar 2018
- Andaman Sheekha (2013a) Coast Guard apprehends 11 poachers off Barren Island. <http://www.andamansheekha.com/2013/03/14/coast-guard-apprehends-11-poachers-off-barren-island/>. Accessed 30 Mar 2018
- Andaman Sheekha (2013b) Ten Myanmarse poachers apprehended. <http://www.andamansheekha.com/2013/03/12/ten-myanmarse-poachers-apprehended/>. Accessed 30 Mar 2018
- Andaman Sheekha (2015) Indian Coast Guard apprehended Myanmar poachers off Tillangchong Island. <http://www.andamansheekha.com/2015/01/19/indian-coast-guard-apprehended-myanmar-poachers-off-tillangchong-island/>. Accessed 09 July 2018
- Andaman Sheekha (2018a) Little Andaman combing operation update: two more Burmese poachers arrested by police. <https://www.andamansheekha.com/2018/06/20/little-andaman-combing-operation-update-two-more-burmese-poachers-arrested-by-police/>. Accessed 07 July 2018
- Andaman Sheekha (2018b) Six poachers arrested from Jarawa reserve area. <https://www.andamansheekha.com/2018/04/10/six-poachers-arrested-from-jarawa-reserve-area/>. Accessed 09 July 2018
- Andaman Sheekha (2018c) Police apprehended 04 Myanmarse poachers from Diglipur area. <http://www.andamansheekha.com/2018/07/08/police-apprehended-04-myanmarse-poachers-from-diglipur-area/>. Accessed 09 July 2018
- Anderson SC, Flemming JM, Watson R, Lotze HK (2011) Serial exploitation of global sea cucumber fisheries. *Fish Fish* 12:317–339. <https://doi.org/10.1111/j.1467-2979.2010.00397.x>
- ANDFISH (2005) Draft roadmap for the development of Fisheries in Andaman and Nicobar Islands. pp 87
- Andina (2017) Peruvian app to combat illegal fishing recognized worldwide. <http://www.andina.com.pe/ingles/noticia-peruvian-app-to-combat-illegal-fishing-recognized-worldwide-604293.aspx>. Accessed 06 Mar 2018
- Bennett A, Basurto X (2018) Local institutional responses to global market pressures: the sea cucumber trade in Yucatan, Mexico. *World Dev* 102:57–70. <https://doi.org/10.1016/j.worlddev.2017.09.006>
- Bondaroff TNP, Tuesday R, Werf WVD (2015) The illegal fishing and organized crime Nexus: illegal fishing as transnational organized crime. *The Global Initiative Against Transnational Organized Crime and The Black Fish*, p 84
- Business standard (2016) Myanmarse poachers arrested from Andaman Island. http://www.business-standard.com/article/pti-stories/myanmarse-poachers-arrested-from-andaman-island-116090901131_1.html. Accessed 30 Mar 2018
- Cao L, Chen Y, Dong S, Hanson A et al (2017) Opportunities for marine fisheries reform in China. *PNAS* 114(3):435–442. <https://doi.org/10.1073/pnas.1616583114>
- Challender DWS, MacMillan DC (2014) Poaching is more than an enforcement problem. *Conserv Lett* 7(5):484–494. <https://doi.org/10.1111/conl.12082>
- COFREPECHE, NFDS, MRAG and POSEIDON (2015) Ex post and ex ante evaluation of the protocol to the Fisheries Partnership Agreement between the EU and the Republic of Mauritius. (Framework contract MARE/2011/01 – Lot 3, specific contract 16) Brussels p 141
- Das P (2011) Securing the Andaman Islands. *Strateg Anal* 35(3):465–478. <https://doi.org/10.1080/09700161.2011.559988>
- Davis KLF, Russ GR, Williamson DH, Evans RD (2004) Surveillance and poaching on inshore reefs of the great barrier reef Marine Park. *Coast Manag* 32(4):373–387. <https://doi.org/10.1080/08920750490487223>
- Dolorosa R G, Songco A M, Calderon V, Magbanua R, Matillano J A (2010) Population structure and abundance of *Trochus niloticus* in Tubbataha Reefs Natural Park, Palawan, Philippines with notes on poaching effects. *SPC Trochus Information Bulletin* #15 – June 2010 17–23
- Doumbouya A, Camara OT, Mamie J, Intchama JF, Jarra A, Ceesay S, Gueye A, Ndiaye D, Beibou E, Padilla A, Belhabib D (2017) Assessing the effectiveness of monitoring control and surveillance of illegal fishing: the case of West Africa. *Front Mar Sci* 4:50. <https://doi.org/10.3389/fmars.2017.00050>
- Doyle T (2018) Blue economy and the Indian Ocean Rim. *J Indian Ocean Reg* 14(1):1–6. <https://doi.org/10.1080/19480881.2018.1421450>
- Dumas P, Ham J, Kaku R, William A, Kaltavara J, Gereva S et al (2017) Tectus (*Trochus*) niloticus search for suitable habitats can cause equivocal benefits of protection in village based marine reserves. *PLoS One* 12(5):1–16. <https://doi.org/10.1371/journal.pone.0176922>
- Ehlers P (2016) Blue growth and ocean governance—how to balance the use and the protection of the seas. *WMU J Marit Aff* 15:187–203. <https://doi.org/10.1007/s13437-016-0104-x>
- FFA (2011) Region’s biggest maritime surveillance operation acts to stop illegal fishing. <https://www.ffa.int/node/565>. Accessed 04 Mar 2018
- FICCI (2017) Smart border management: Indian coastal and maritime security. pp 1–44
- Flanders Marine Institute (2018) Maritime boundaries geodatabase: maritime boundaries and exclusive economic zones (200NM), version 10. <http://www.marineregions.org/> <https://doi.org/10.14284/312>
- George G, Krishnan P, Kamal-Sarma, Kirubasankar R, Goutham-Bharathi MP, Kaliyamoorthy M, Krishnamurthy V, Kumar TS (2011) Integrated potential fishing zone(IPFZ) forecasts: a promising information and communication technology tool for promoting green fishing in the islands. *Indian J Agric Econ* 66(3):513–519
- George G, Krishnan P, Roy SD, Sarma K, Bharathi MPG, Kaliyamoorthy M, Krishnamurthy V, Kumar TS (2013) Validation of potential fishing zone (PFZ) forecasts from Andaman and Nicobar Islands. *Fish Technol* 50:1–5
- George G, Sarma K, Bharathi G, Kaliyamoorthy M, Krishnan P, Kirubasankar R (2014) Efficacy of different modes in disseminating potential fishing zone (PFZ) forecasts- a case study from Andaman and Nicobar Islands. *Indian J Fish* 61(1):84–87
- Gonzalez LF, Montes GA, Puig E, Johnson S, Mengersen K, Gaston KJ (2016) Unmanned aerial vehicles (UAVs) and artificial intelligence revolutionizing wildlife monitoring and conservation. *Sensors* 16: 97. <https://doi.org/10.3390/s16010097>
- Gonzalez-Wanguemert M, Dominguez-Godino JA, Canovas F (2018) The fast development of sea cucumber fisheries in the Mediterranean and NE Atlantic waters: from a new marine resource to its over exploitation. *Ocean Coast Manag* 151:165–177
- Government of Canada (2005) Canada’s national plan of action to prevent, deter and eliminate illegal, unreported, unregulated fishing. Published by Communications branch. ISBN 0-662-68828-7. 28pp. http://www.dfo-mpo.gc.ca/npoa-pan/npoa-iuu/npoa-iuu_e.pdf
- Hauck M, Sweijd NA (1999) A case study of abalone poaching in South Africa and its impact on fisheries management. *ICES J Mar Sci* 56: 1024–1032

- Hilborn R (2016) Marine biodiversity needs more than protection. *Nature* 535:224–226
- Hornby C, Kumar MA, Bhathal B, Pauly D, Zeller D (2015) Reconstruction of the Andaman and Nicobar Islands (India) marine fish catch from 1950–2010. Working Paper Series #2015 – 75. Fisheries Centre, University of British Columbia, Vancouver
- Immanuel T, Goutham-Bharathi MP, Sawhney S, Ragavan R, Sankar RK (2016) New record of the pantropical seagrass *Halophila decipiens* Ostenfeld (Hydrocharitaceae) from the Andaman and Nicobar Islands, India. *Bot Mar* 59(1):79–83. <https://doi.org/10.1515/bot-2015-0090>
- International MCS network (2014) International Monitoring, Control and Surveillance (MCS) network for fisheries-related activities. <http://imcsnet.org/2ndstopiuufishingaward/>. Accessed 07 Mar 2018
- ISSF (2017) Status of world fisheries for tuna. ISSF technical report. International sea food sustainability foundation, Washington, p 98
- Kirubasankar R, Roy SD, Grinson-George SK, Krishnan P, Kumar SR, Kaliyamoorthy M, Goutham-Bharathi MP (2013) Fishery and exploitation of *Epinephelus malabaricus* from Andaman Islands. *Asian Fish Sci* 26:167–175
- Kiruba-Sankar R, Krishnan P, Roy SD et al (2018) Structural complexity and tree species composition of mangrove forests of Andaman Islands. *J Coast Conserv* 22(2):217–234. <https://doi.org/10.1007/s11852-017-0588-3>
- Koh LP, Sodhi NS (2010) Conserving Southeast Asia's imperiled biodiversity: scientific, management, and policy challenges. *Biodivers Conserv* 19:913–917. <https://doi.org/10.1007/s10531-010-9818-9>
- Krishnan P, Roy SD, George G, Anand A, Murugesan S, Kaliyamoorthy M, Vikas N, Soundararajan R (2011) Elevated sea surface temperature (SST) induces mass bleaching of corals in Andaman. *Curr Sci* 100(1):1800–1804
- Krishnan P, Immanuel T, Raghunathan C, Sankar K, Roy SD (2012a) Sponge diversity in the Andaman and Nicobar Islands: status and issues. In: National seminar on innovative technologies for conservation and sustainable utilization of island biodiversity. CARI, Port Blair, pp 102–109
- Krishnan P, George G, Vikas N, Immanuel T, Goutham-Bharathi MP, Anand A, Kumar KV, Kumar SS (2012b) Tropical storm off Myanmar coast sweeps reefs in Ritchie's archipelago, Andaman. *Environ Monit Assess* 185(6):5327–5338
- Lemouellic S, Chauvet C (2008) *Trochus niloticus* (Linnae 1767) growth in Wallis Island. *SPC Trochus Information Bulletin* 14:2–6
- Levin N, Begger M, Maina J, McClanahan T, Kark S (2018) Evaluating the potential for transboundary management of marine biodiversity in the Western Indian Ocean. *Australasian J Environmental Management* 25(1):62–85. <https://doi.org/10.1080/14486563.2017.1417167>
- Llewellyn LE, English S, Bamwell S (2016) A roadmap to a sustainable Indian Ocean blue economy. *J Indian Ocean Reg* 12(1):52–66. <https://doi.org/10.1080/19480881.2016.1138713>
- MacCauley DJ, Woods P, Sullivan B, Bergman B, Jablonicky C, Roan A, Hirshfield M, Boerder K, Worm B (2016) Ending hide and seek at sea. *Science* 351(6278):1148–1150
- Marine Stewardship Council (2017) Global impacts report. MSC, London, p 44. ISSN 2052-8876
- Masse F, Gardiner A, Lubilo R, Themba MN (2017) Inclusive anti poaching? Exploring the potential and challenges of community based anti poaching SA crime quarterly no 60. June 2017 19–27
- MEE (2015) National biodiversity strategy and action plan 2016–2025, vol 102. Ministry of Environment and Energy, Maldives
- Meloni D, Esposito G (2018) Hygienic and commercial issues related to the illegal fishing and processing of sea cucumbers in the Mediterranean: a case study on over-exploitation in Italy between 2015 and 2017. *Reg Stud Marine Science* 19:43–46. <https://doi.org/10.1016/j.rsma.2018.03.009>
- Miller KL, Nadheeh I, Jauharee AR, Anderson RC, Adam MS (2017) Bycatch in Maldivian pole and line tuna fishery. *PLoS One* 12(5): e0177391. <https://doi.org/10.1371/journal.pone.0177391>
- Mishra V (2017) India's emerging concept of regional maritime security, maritime affairs. *J Natl Marit Found India* 1–10. <https://doi.org/10.1080/09733159.2017.1410933>
- Mmtimes (2012) India repeats warning on illegal fishing. Myanmar Times. <https://www.mmtimes.com/business/610-india-repeats-warning-on-illegal-fishing.html>. Accessed 27 Mar 2018
- MOEF (2011) Committee constituted to holistically address the issue of poaching in the Andaman and Nicobar Islands. Government of India. Ministry of Environment and Forests, p 29
- Nationalpost (2015) Tiny island nation of Palau very publicly burns Vietnamese boats caught fishing illegally. <http://nationalpost.com/news/world/tiny-island-nation-of-palau-very-publicly-burns-vietnamese-boats-caught-fishing-illegally>. Accessed 27 Mar 2018
- News18 (2016) Coast guard apprehends Myanmar boat in Andaman. <https://www.news18.com/news/india/coast-guard-apprehends-myanmar-boat-in-andaman-1271314.html>. Accessed 30 Mar 2018
- Newyork Times (2016) Palau vs the poachers. <https://www.nytimes.com/2016/02/21/magazine/palau-vs-the-poachers.html>. Accessed 27 Mar 2018
- Nithyanandan R (2009) Development of fisheries in Andaman and Nicobar Islands: a case of the potential going Abegging. In: Roy SD (ed) Proceedings of brainstorming session on development of island fisheries. Central Agricultural Research Institute, Port Blair, pp 1–3
- NPMF (2017) National policy on Marine fisheries notification. Department of Agriculture and Farmers welfare, pp 22. Available online <http://dahd.nic.in/news/notification-national-policy-marine-fisheries-2017>
- Oanta GA (2018) International organizations and deep-sea fisheries: current status and future prospects. *Mar Policy* 87:51–59
- Palau MCS plan (2015) The republic of Palau exclusive economic zone monitoring, control and surveillance. The next five years 2016–21. http://palaugov.pw/wp-content/uploads/2016/05/palau_mcs_strategic_plan_final.pdf
- Pattanaik S (2016) Indian Ocean in the emerging geo-strategic context: examining India's relations with its maritime South Asian neighbors. *J Indian Ocean Reg* 12(2):126–142. <https://doi.org/10.1080/19480881.2016.1226750>
- PEW (2015) Project Eyes on the Seas. <http://www.pewtrusts.org/en/research-and-analysis/issue-briefs/2015/03/project-eyes-on-the-seas>. Accessed 31 Mar 2018
- Pillai NGK, Abdussamad EM (2009) Development of tuna fisheries in Andaman and Nicobar Islands. In: Roy SD (ed) Proceedings of brainstorming session on development of island fisheries. Port Blair, Central Agricultural Research Institute, pp 23–34
- Poernomo A, Purwanto, Ahmadi (2011) Combating illegal, unreported, unregulated (IUU) fishing to attain food security and alleviate poverty. *Fish for the People, SEAFDEC* 9(2): 79–85
- Pressherald (2017) Indonesian official blows up poachers' boats to save fisheries. <https://www.pressherald.com/2017/05/13/indonesian-official-goes-full-blast-for-fisheries-conservation/>. Accessed 27 Mar 2018
- Purcell SW (2014) Value, market preferences and trade of Beche-De-Mer from Pacific Island sea cucumbers. *PLoS One* 9(4):e95075. <https://doi.org/10.1371/journal.pone.0095075>
- Purcell SW, Eriksson H (2015) Echinoderms piggybacking on sea cucumbers: benign effects on sediment turnover and movement of hosts. *Marine Biology Res* 11(6):666–670. <https://doi.org/10.1080/17451000.2014.962544>
- Purcell SW, Wu M (2017) Large scale sandfish (*Holothuriacabra*) aquaculture in multitrophic polyculture ponds in southern China. *SPC Beche-de-mer Information Bulletin* 37:51–52

- Purcell SW, Conand C, Uthicke S, Byrne M (2016) Ecological roles of exploited sea cucumbers. *Oceanogr Mar Biol* 54:367–386
- Ragavan P, Mohan PM, Saxena A, Jayaraj RSC, Ravichandran K, Saxena M (2016) Mangrove floristics of the Andaman and Nicobar Islands: critical review and current scenario. *Mar Biodivers*. <https://doi.org/10.1007/s12526-016-0581-3>
- Raghunathan C, Venkataraman, K (2014) Status survey of Holothurians (Sea cucumber) in the territorial waters of Andaman and Nicobar Islands. *Zoological survey of India*, pp 96
- Raghunathan C, Sivaperuman C, Venkataraman (2012) Status and distribution of *Trochus niloticus* (Linnaeus 1767) in Andaman and Nicobar Islands. In: Venkataraman K et al (eds) *Ecology of faunal communities on the Andaman and Nicobar Islands*. Springer, pp 85–102
- Rahman MA, Yusoff FM, Arshad A (2015) Sea cucumber fisheries: global status, culture, management and extinction risks. *Int J Chem Environ Biol Sci* 3(4):344–348
- Rajan PT, Sreeraj CR, Immanuel T (2013) Fishes of Andaman and Nicobar Islands: a checklist. *J Andaman Science Association* 18(1):47–87
- Ramakrishna, Raghunathan C, Sivaperuman C (2010) Status survey on *Trochus niloticus* (Linnaeus, 1767) in Andaman and Nicobar Islands. Status survey of endangered species. *Zoological Survey of India, Kolkata*, pp 1–80
- Ravikumar T, Ram N, Krishnan P, Sankar RK, Sachithanandam V, Roy SD (2016) Subsistence fishing methods of Nicobari tribes using traditional knowledge. *J Mar Isl Cult* 5:79–87. <https://doi.org/10.1016/j.imic.2016.05.002>
- Rogers A, Hamel J, Mercier A (2017) From life sustaining to life threatening: the case of the sea cucumber fishery in Nicaragua. *SPC Beche-de-mer Information Bulletin* 37:48–50
- Roy SD, George G (2010) Marine resources of islands: status and approaches for sustainable exploitation/conservation with special emphasis to Andaman and Nicobar. *Indian J Animal Sci* 80(4):57–62
- Roy SD, Krishnan P (2005) Mangrove stands of Andamans Vis-à-Vis tsunami. *Curr Sci* 89(11):1800–1804
- Roy SD, Krishnan P, Patro S, George G, Velmurugan A, Sankar RK, Ramachandran P (2017a) Wetlands of small island nations in South Asia Vis-a- Vis the mainland and island groups in India: status and conservation strategies. In: BAK P (ed) *Wetland science, perspective from South Asia*, pp 31–48
- Roy SD, Krishnan P, Velmurugan A, Anand A, George G, Sankar RK, Swarnam TP (2017b) Wetlands of Tropical Islands under changing climate: a case from Nicobar group of islands, India. In: BAK P (ed) *Wetland science, perspective from South Asia*, pp 205–224
- Sadhukhan K, Raghunathan C (2014) Status of edible holothurians on the fringing reef flats of Nicobar Islands, India. *Rec Zool Surv India* 114(3):503–507
- Sathiendrakumar R, Tisdell C (1986) Fisheries resources and policies in Maldives, trends and issues for an island developing country. *Mar Policy* 10(4):279–293
- Science Daily (2012) Powerful tool to fight wildlife crime unveiled. <https://www.sciencedaily.com/releases/2012/09/120911111628.html>. Accessed 31 Mar 2018
- Sivaperuman C, Raghunathan C (2012) Fauna of the protected areas of Andaman and Nicobar Islands. *Zoological survey of India, Kolkata*, pp 1–26
- Sjostedt M, Sundstrom A (2015) Coping with illegal fishing: an institutional account of success and failure in Namibia and South Africa. *Biol Conserv* 189:78–85
- Smith-Godfrey S (2016) Defining the blue economy. *Maritime Affairs: J Natl Marit Found India* 12(1):58–64. <https://doi.org/10.1080/09733159.2016.1175131>
- Steinmetz R, Srirattaporn S, Mor-Tip J, Seuaturien N (2014) Can community outreach alleviate poaching pressure and recover wildlife in south-east Asian protected areas? *J Appl Ecol* 51:1469–1478. <https://doi.org/10.1111/1365-2664.12239>
- Stobutzki IC, Silvestre GT, Garces LR (2006) Key issues in coastal fisheries in south and Southeast Asia, outcomes of a regional initiative. *Fish Res* 78:109–118
- Stop Illegal Fishing (2016) FISH-i Africa: issues, investigations and impacts. Gaborone, Botswana, pp 48
- The Hindu (2014) ‘Hejje’, mobile application for tracking tigers launched. <http://www.thehindu.com/news/national/karnataka/hejje-mobile-application-for-tracking-tigers-launched/article5649714.ece>. Accessed 31 Mar 2018
- The New Indian Express (2018) Myanmarese poachers attack villagers at Little Andaman; Five injured. <http://www.newindianexpress.com/nation/2018/jul/12/myanmarese-poachers-attack-villagers-at-little-andaman-five-injured-1842155.html>. Accessed 12 July 2018
- Thomas L, Venu S, Malakar B, Nagesh R, Basumatary G (2017) An assessment on the impact of bottom trawling to the demersal fisheries and benthic diversity of Andaman Islands, India. *Reg Stud Marine Science* 10:20–26. <https://doi.org/10.1016/j.rsma.2016.12.009>
- Times of India (2012) 7 Myanmarese poachers held. <https://timesofindia.indiatimes.com/home/environment/flora-fauna/7-Myanmarese-poachers-held/articleshow/12556838.cms>. Accessed 30 Mar 2018
- Times of India (2015) Coast Guard nabs 12 Myanmarese poachers. <https://timesofindia.indiatimes.com/india/Coast-Guard-nabs-12-Myanmarese-poachers/articleshow/45948003.cms>. Accessed 30 Mar 2018
- Traffic (2014) New app to build awareness and information on illegal wildlife trade in South East Asia. <http://www.traffic.org/home/2014/4/9/new-app-to-build-awareness-and-information-on-illegal-wildli.html>. Accessed 31 Mar 2018
- Tuna transparency initiative (TTI) in ATLAFCO zone (2015) Report of the workshop Monitoring, Control and Surveillance (MCS) an effective tool to fight against IUU fishing. Morocco, pp 65
- UNEP (2014) Emerging technologies: smarter ways to fight wildlife crime. https://na.unep.net/geas/getUNEPPageWithArticleIDScript.php?article_id=113. Accessed 31 March 2018
- WWF (2014) Illegal wildlife trade in India. Special issue, pp 48