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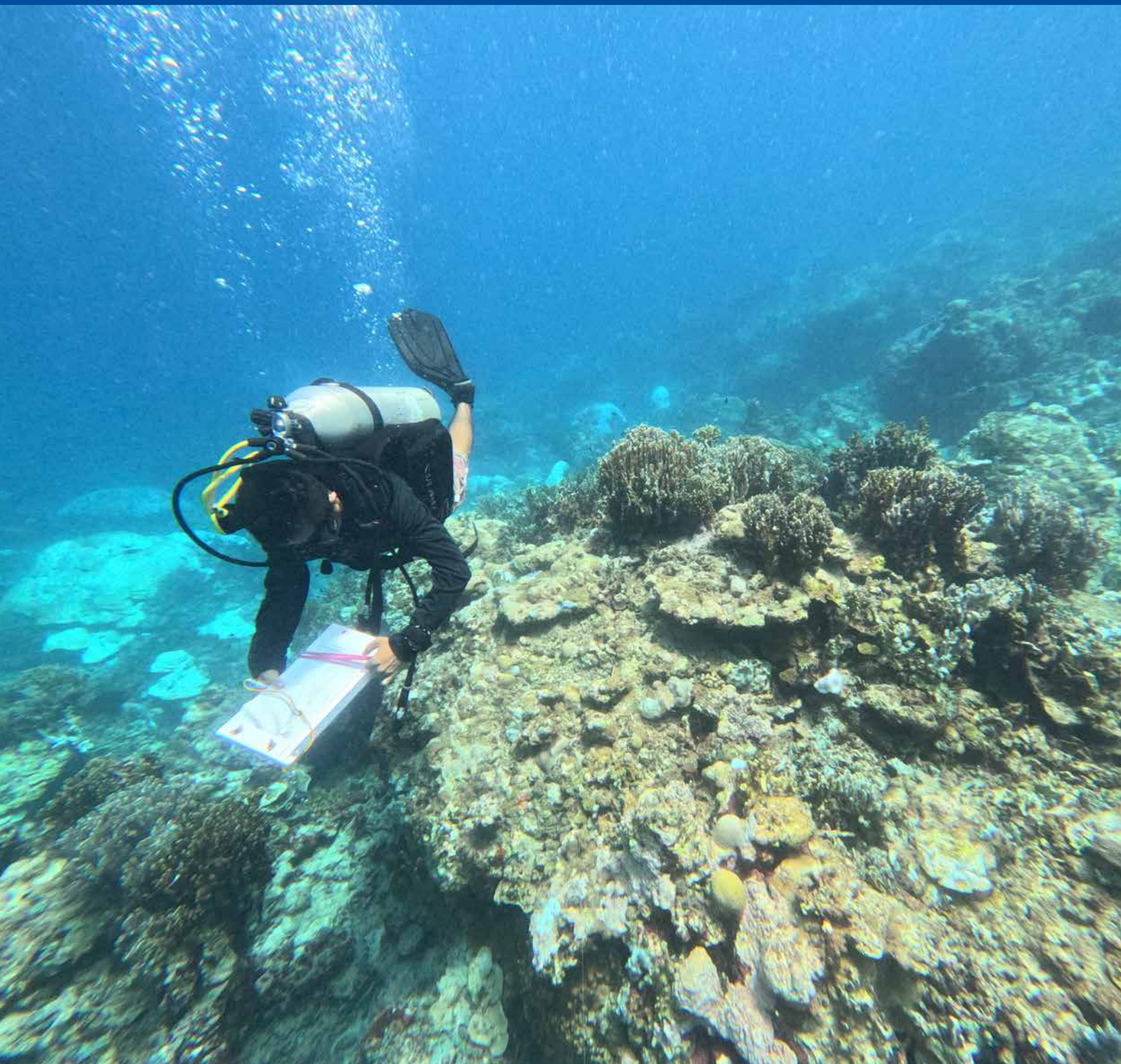
Assessment of *Rochia nilotica* status in Kosrae, Federated States of Micronesia



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Assessment of *Rochia nilotica* status in Kosrae, Federated States of Micronesia

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Pacific Community
Communauté du Pacifique

Noumea, New Caledonia, 2025

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Disclaimer

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Summary

Rochia nilotica, or trochus, is an important source of income for Kosrae, FSM. The last harvest took place in 2013, bringing in almost 22 tonnes of dry trochus valued at ~USD 57,000. Kosrae Department of Fisheries and Marine Resources (DFMR) requested support from SPC in 2023 to undertake a stock assessment of trochus to decide whether stock levels would support another harvest.

Reef benthos transects were carried out at 20 stations around Kosrae, where trochus was counted and basal diameter measured with a ruler to the nearest millimetre. These data were analysed to produce a stock estimate, length-frequency distribution and draw conclusions about where trochus is mostly found around the island. Data were compared with similar surveys conducted in 2008.

Trochus is found at 19 out of 20 of the survey stations. Mean density for all stations is 411 trochus/ha ±170, ranging from 0 at Hiroshi Point in the southeast, to 1979 trochus/ha at Trochus Sanctuary in the west. The highest densities of trochus were found in the west and northeast.

Total stock of trochus in Kosrae in 2024 is 229,732 trochus ±95,217, this is comparable with the 2008 area-adjusted stock estimate of 206,801 trochus ±40,511.

It is surprising that stock numbers are similar between 2008 and 2024, especially given that 2024 is 11 years after a harvest, and 2008 is only one year after a harvest. The reasons behind the slow recovery of the stock may be due to changes in habitat, poaching or potentially the large extent of harvests in 2012 and 2013, which removed a total of 43.58 tonnes in dry weight across two harvest instances (compared with 26 tonnes in 2007).

The recommended minimum density of trochus to open the fishery is 500 trochus/ha. As mean density across all areas in 2024 is 411 trochus/ha, we recommend that the fishery remain closed for another 3–5 years until another survey can be done to confirm further stock recovery.

Introduction

Trochus (*Rochia nilotica)* is a large herbivorous gastropod snail naturally found in southeast Asia and the western-central Pacific. It has been widely fished throughout its range for both subsistence, and also for its shell, which is used to make buttons (Gillett et al. 2020; Nash 1993; Purcell and Ceccarelli 2021). The species is easy to fish due to its shallow habitat, but it tends to be resilient to fishing because of its fast growing nature, and the difficulty in finding juveniles on the reef flat (Bell et al. 2005). As a result, trochus was the subject of many translocations throughout the western-central Pacific to develop new fisheries (Gillett 2002).

In 1959, Kosrae state, Federated States of Micronesia, received 500 live trochus from Pohnpei that were released at 13 locations following previously unsuccessful translocation attempts in the 1940s and 50s (Gawel 1982; Gillett 2002). Since then, trochus has become an important source of income for the state. The most recent export of trochus was in 2013, where 21.76 tonnes (dry weight) were harvested valued at just over USD 57,000, before that there were harvests of 21.82 tonnes in 2012 (Kosrae DREA 2013) and 26 tonnes in 2007 (Tardy et al. 2009).

Kosrae State Trochus (Tukasungai) Regulations (2013) manage harvesting, selling, buying, stockpiling and/or processing of trochus. Management rules include open and closed harvesting seasons and restrictions to harvest sizes between 3 and 4 inches (76 mm and 102 mm). Furthermore, all harvesting for commercial activities can only be made under an official permit, and all commercial buyers must have a licence issued by the Kosrae Island Resources Management Authority. Finally, Kosrae has a reserve – "Trochus Sanctuary" – where all fishing for trochus is banned, even during harvest periods.

In late 2023, 10 years after the last harvest, Kosrae DFMR requested SPC to assist in training fisheries officers in conducting a trochus assessment around the island to understand whether the stock had recovered enough to open the fishery again. The training and survey work was carried out in October 2024. This report presents a rapid analysis of results and some recommendations to Kosrae DREA concerning the trochus fishery.

Methodology

Location

Surveys were carried out over two weeks in October 2024 at stations surveyed previously in 2008. One station was added (Mutunlik), following informal feedback that fishers tend to look for trochus at that location (Figure 1). A full list of survey stations with latitudes and longitudes for their start points can be found in Appendix I.

Survey methods

Underwater visual census methods were used as specified in Pakoa et al., 2014. At each station, six reef benthos transects of 40 m x 2m were run parallel to shore, moving with the current. A gap of 5 m was left between the end of one transect and the start of the next. For each station a total area of 480 m^2 was surveyed, totalling 9,600 m^2 of area surveyed across 20 stations.

Transect depth ranged from 3 m to 17 m, with a mean depth of 7.18 m across all transects.

Each trochus found within the transect area was recorded on a survey slate and the basal diameter at its widest point was measured in mm. This survey also doubled as on-the-job training for DFMR fisheries officers. As a result, measurements of basal diameter for some stations were rounded to the nearest cm, an error that was corrected over the course of the survey.

Analysis

All analyses and charts were done using R version 4.3.2 installed on R-Studio (R Core Team 2023). Data was cleaned and manipulated using the dplyr package (Wickham et al. 2023), graphics were produced using the ggplot2 package (Wickham 2016).

Length frequency distribution was plotted using 10 mm bins as surveyors for some of the stations rounded their measurements to the nearest cm.

Densities for each station were calculated by summing the total count of trochus across all transects for that station and dividing that number by the total area surveyed (480m^2 per station). These figures are presented as number of trochus per hectare for ease of comparison with established reference points and previous reports on trochus status. All errors displayed in the text and figures are 95% confidence intervals.

To calculate dry and wet weight of each trochus, we applied the length–weight relationships used in Tardy et al.'s (2009) assessment of trochus resources in Kosrae to facilitate comparison. This report used length–weight relationships established from Wallis and Futuna as follows:

$$\textit{Wet weight } W = 0.29 \times L^{3.07} \quad (R^2 = 0.99)$$

$$\textit{Dry weight } W = 0.31 \times L^{2.92} \quad (R^2 = 0.99)$$

Whereby W = weight in grams and L = basal diameter in cm. Wet weight is the whole animal, including the soft body inside the shell. Dry weight only includes the shell.

Stock estimates were calculated by multiplying mean station-level density and biomass (wet and dry) by the total area of available trochus habitat. For this area, we used estimates sourced from Allen Coral Atlas (Allen Coral Atlas, 2024). Reef crest, reef slope and sheltered reef slope habitat types were selected from Allen Coral Atlas based on known distribution of trochus. We took 80% of this resulting area to create a conservative estimate of total trochus habitat available in Kosrae. This resulted in a conservative area of 558.62 ha, compared with 539.12 ha of habitat used to estimate total stock in the 2008 survey (Tardy et al., 2009). We applied this new habitat area estimate to the densities and biomass values from the 2008 study to enable easy comparison between the two surveys.

Stock estimates were calculated for the whole island, in addition to estimates of stock inside and outside the Trochus Sanctuary reserve. We also calculated the mean harvestable stock; defined as trochus between 76 mm and 102 mm (3 and 4 inches), found outside the Trochus Sanctuary.

Results

Distribution of stock around Kosrae

Trochus is found at 19 out of 20 of the survey stations. Mean density for all stations is 411 trochus/ha ±170, ranging from 0 at Hiroshi Point in the southeast, to 1979 trochus/ha at Trochus Sanctuary in the west (figures 1 and 2). The highest densities are in the northeast, and along the west coast. Four survey stations have densities exceeding 500 trochus/ha – Mutunlik, Mwot, Naco and Trochus Sanctuary. The latter (Trochus Sanctuary) is a reserve where trochus harvest is forbidden, even when the fishery is open.

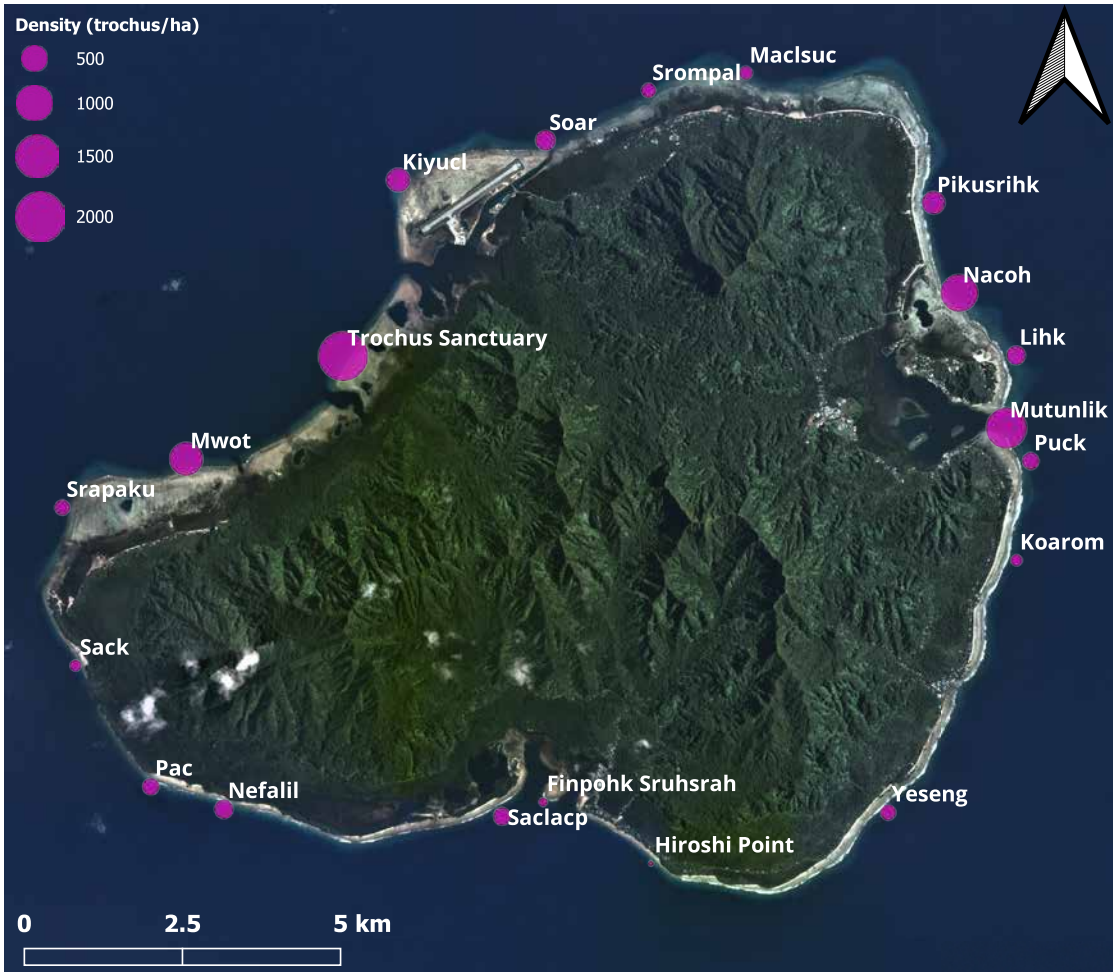

Figure 1. Survey sites around Kosrae. Size of marker corresponds with density (trochus/ha) found at each location.

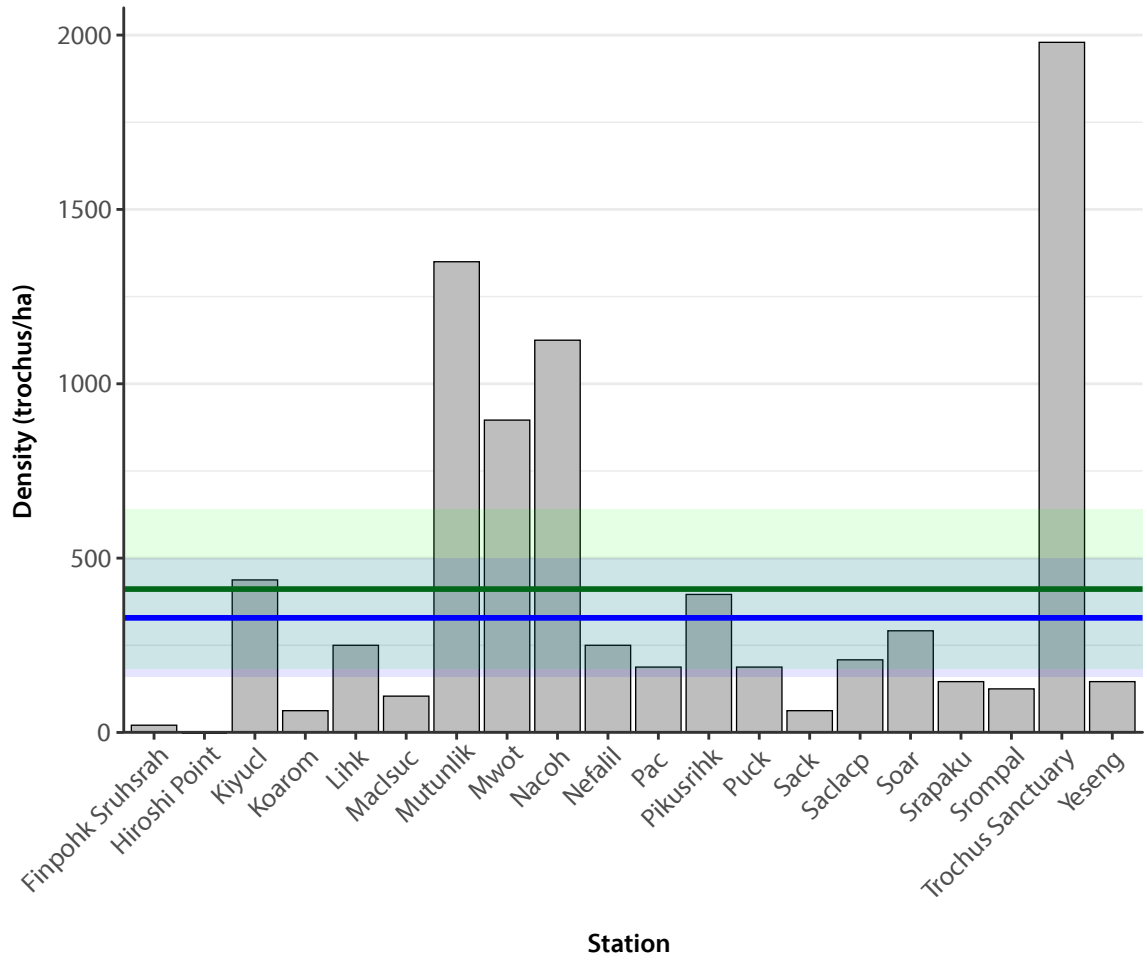

Figure 2. Density of trochus per hectare at all survey stations. Green line and associated shaded area indicate mean and 95% confidence interval of all survey stations. Blue line and shaded are indicate mean and 95% confidence interval of stations outside the Trochus Sanctuary reserve.

When we remove Trochus Sanctuary from the calculations, mean density of trochus in areas normally open to fishing is 328 trochus/ha ±170 (see Table 1 on p. 7).


Kalo Pakoa, ©SPC

Distribution of mean wet biomass follow similar patterns to density distribution. Mean wet biomass for all stations is 116.80 kg/ha ±47.73. Ranging from 0 kg/ha at Hiroshi Point to 412.57 kg/ha in Trochus Sanctuary (figure 3). Mutunlik, Mwot, Naco and Trochus Sanctuary all have the highest biomass of trochus.

Mean biomass in normally fishable areas (excluding Trochus Sanctuary) is 101.23 kg/ha ±38.70.

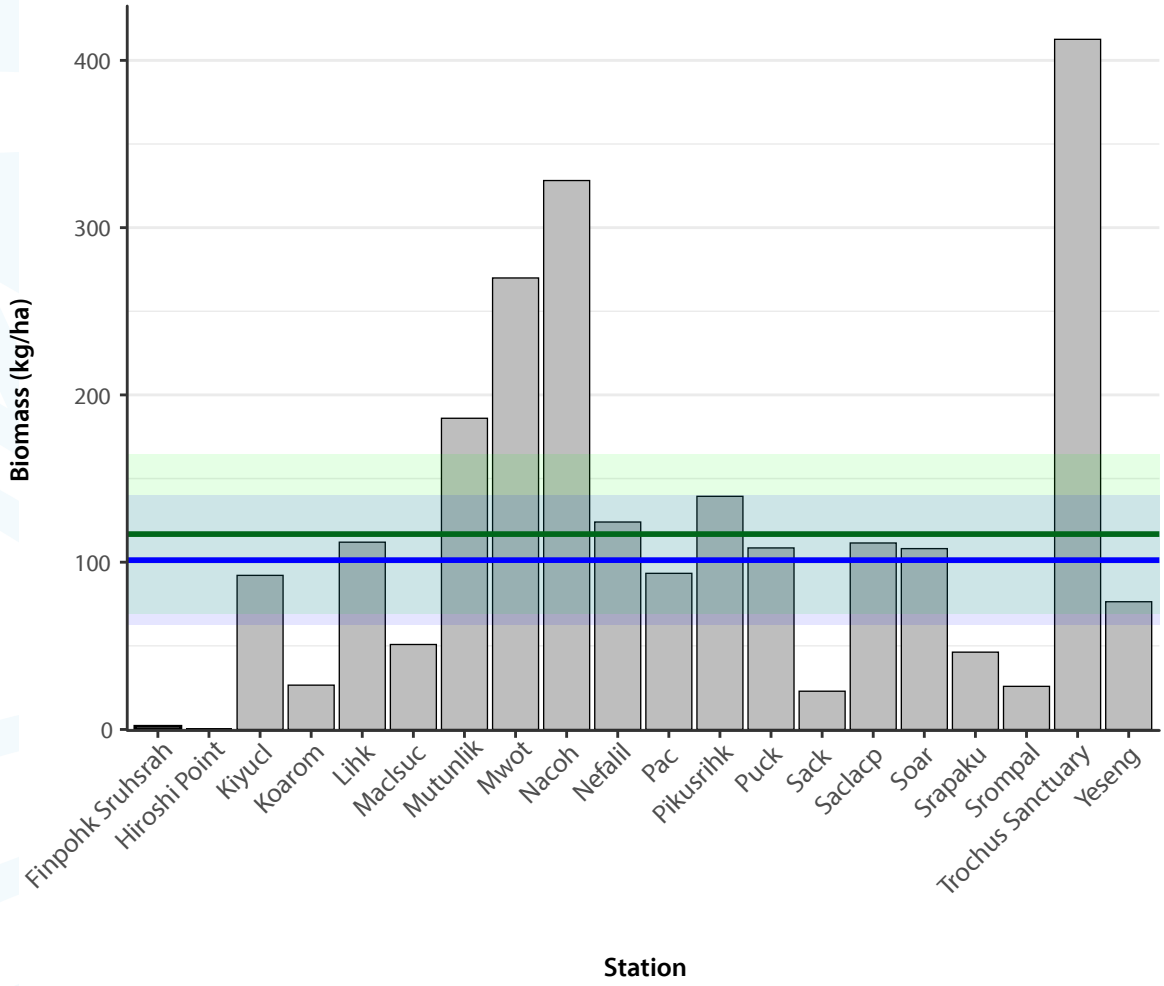

Figure 3. Wet biomass of trochus in kg/hectare at all survey stations. Green line and associated shaded area indicate mean and 95% confidence interval of all survey stations. Blue line and shaded are indicate mean and 95% confidence interval of stations outside the Trochus Sanctuary reserve.

Length distribution

The mean basal diameter of trochus is 98.2 mm ±1.7, ranging from 45 mm to 143 mm. When excluding Trochus Sanctuary, the mean size across fishable areas is smaller at 93.1 mm ±2.3.

Out of a sample of 377 trochus, 100 (26.5%) are oversized, 192 (50.9%) are within harvestable range and 85 (22.5%) are undersized (figure 4).

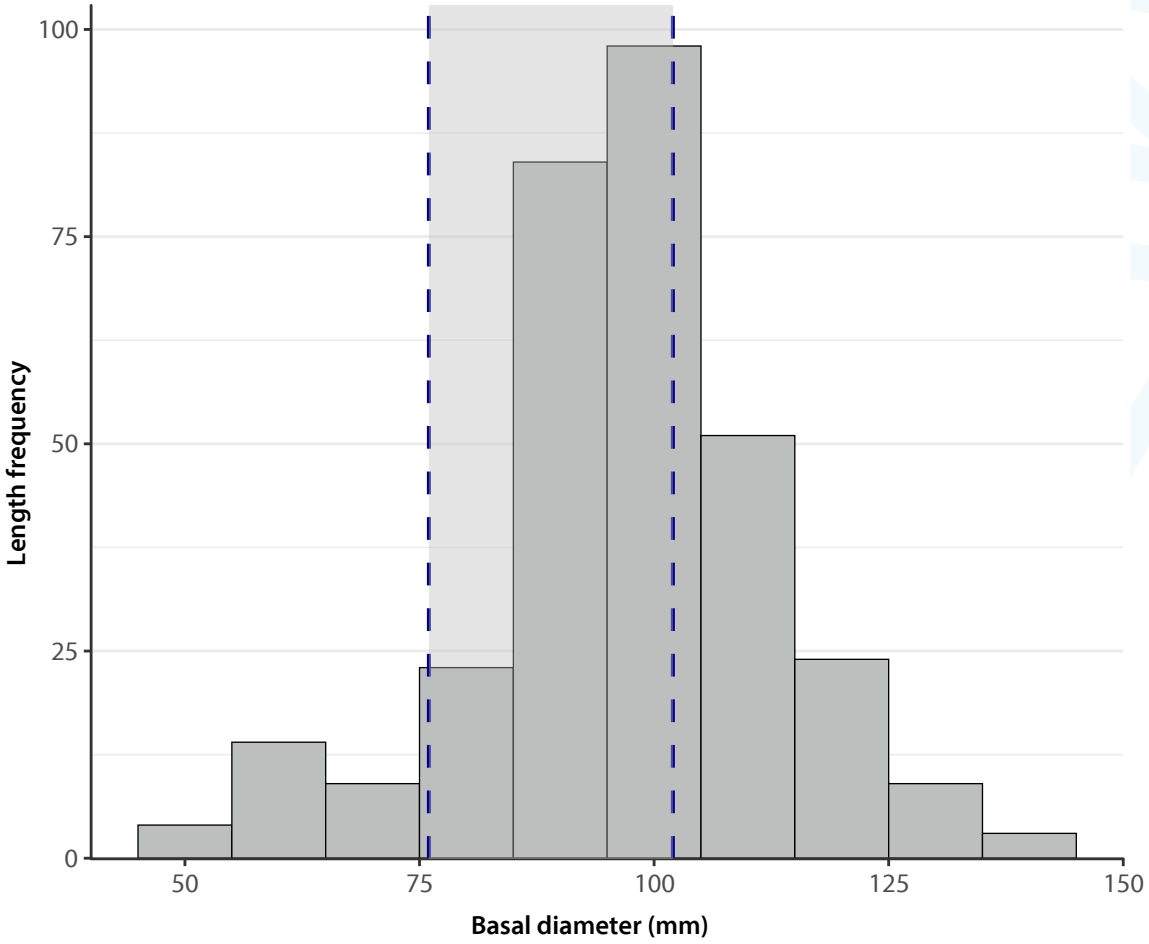

Figure 4. Length frequency distribution of trochus with 10 mm size bins. Blue dotted lines indicate the range of sizes that are legal to harvest when the fishery is open. This is between 3 and 4 inches, or 76 to 102 mm.

Stock estimate

Using habitat area estimates from Allen Coral Atlas, total stock of trochus in Kosrae in 2024 is 229,732 trochus ±95,217 (figure 5, table 1). This is comparable with the 2008 area-adjusted stock estimate of 206,801 trochus ±40,511.

In 2024, reefs that would be open to harvest have 169,677 trochus ± 87,979. Trochus Sanctuary in 2024 is estimated to contain 84,233 trochus.

By examining 95% confidence intervals, we can see that total stock estimates do not differ significantly between 2024 and 2008 (figure 5). Trochus Sanctuary has seen a substantial increase in stock since 2008 – from 20,518 trochus ±3,268 to 84,233 trochus across 42.56 ha.

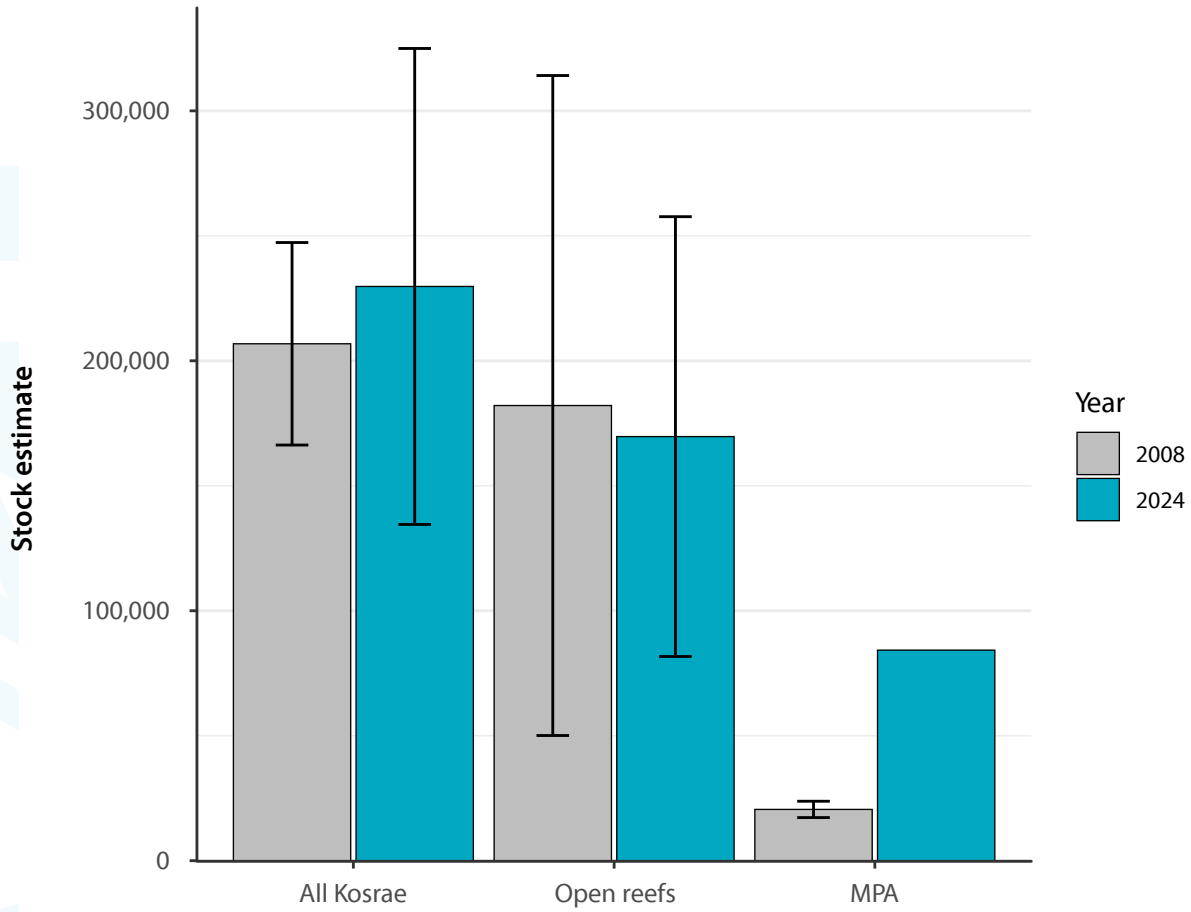

Figure 5. Stock estimates in count of trochus across all suitable habitat in Kosrae, habitat open to fishing, and habitat within the MPA "Trochus Sanctuary". Data compared between 2008 and 2024. 2008 data have been adjusted for area differences and sourced from Tardy et al. 2009.

Table 1. Mean station-level density between 2024 and 2008 (trochus/ha) and resulting stock estimates. Error is 95% confidence interval about the mean (CI95). There is no CI95 for the MPA in 2024 as only one survey station was done within this area that year. 2008 data from (Tardy et al., 2009). Note that the MPA covers 7.6% of estimated trochus habitat area.

		Density (trochus/ha) ± CI95		Stock estimate± CI95	
	Estimated area (ha)	2024	2008	2024	2008
All Kosrae	558.62	411 ±170	370 ± 73	229,732 ±95,217	206,801 ±40,511
Open reefs	516.16	328 ±170	353 ± 256	169,677 ±87,979	182,101 ±132,023
MPA	42.56	1979	482 ± 72	84,233	20,518 ±3,268

The estimated number of trochus within the legal harvestable size range of 76–102 mm (3–4 inches), is 116,496 trochus ± 82,689 in 2024, giving a conservative harvestable stock estimate of 33,807 trochus (table 2; the lower limit of the 95% confidence interval).

Wet and dry weights of harvestable stock based on length measurements can be found in table 2. We estimate harvestable stock of 10,523 kg wet weight and 7,995 kg dry weight of trochus based on the lower limit of the 95% confidence interval. These are lower than those estimated in 2008 (16,887 kg wet and 12,905 kg dry).

Table 2: Estimated abundance, wet weight and dry weight of trochus within harvestable size range (76 mm–102 mm) outside the reserve area (Trochus Sanctuary) in 2024 and 2008 using an estimated habitat area of 516.16 ha. Means are aggregated from the station level. Harvestable stock is calculated as the lower limit of the 95% confidence interval around the mean.

	Stock estimate (count)		Wet weight (kg)		Dry weight (kg)	
	2024	2008	2024	2008	2024	2008
Mean stock ±CI95	116,496 ±82,689	145,428 ±105,435	33,634 ± 23,111	27,485 ±10,598	25,634 ±17,639	21,003 ±8,098
Harvestable stock	33,807	39,993	10,523	16,887	7,995	12,905

Discussion

Both the overall mean density of trochus (411 trochus/ha ±170), and the density of those outside Trochus Sanctuary (329 trochus/ha ±170) are below the recommended reference point of 500 trochus/ha to open the harvest (Pakoa et al., 2014; Tardy et al., 2009). Furthermore, only four stations out of the 20 surveyed have densities above this threshold, one of them being Trochus Sanctuary where fishing for trochus is prohibited even during open harvest periods.

Despite the fishery being at rest for the past 11 years, the stock status of trochus in 2024 (229,732 trochus ±95,217) is similar to that in 2008 (206,801 trochus ±40,511), only one year after a 26 tonne (dry weight) harvest. After an 11-year period without a harvest we would expect the condition of stock to have improved beyond that seen after one year of protection. Especially as trochus are estimated to live between 10 to 15 years (Nash, 1993). This suggests either some poaching activity, damage to appropriate habitat, or it may be due to depletion of stock past a critical point during the last harvest; 43.58 tonnes in dry weight was harvested in total between December 2012 (21.82 tonnes) and July 2013 (21.76 tonnes), almost twice the stock estimated to have been available four years earlier in 2008 (Tardy et al. 2009).

The distribution of trochus in 2024 around Kosrae remains consistent with the 2008 study, where most are found along the west coast in the reserve, and in the north-east, with very low densities along the south coast. Besides the obvious lack of fishing pressure along the west coast within Trochus Sanctuary, the high densities and biomass found in the north-east may be due to larger areas of reef flat and back reef available in this area upon which smaller, juvenile trochus can settle and then populate the outer slopes as they mature.

In 2008, 5.8% of trochus were undersized, 50.1% of trochus were within the legal-size limits on Kosrae (between 3 and 4 inches or 7.6 and 10.2 cm), and 44.1% of the stock was oversized (> 10.2 cm basal diameter). In 2024, 22.5% are undersized, 50.9% within harvestable range and 26.5% oversized. It should be noted that for both surveys, no stations were placed on the reef flat where smaller trochus would be expected to be found. The relative decrease in larger individuals may be because of fishing effort during the 2012–2013 harvests leading to lower recruitment in the subsequent years for this cohort. However, as data tracking the length distribution of this stock over time are lacking, it's difficult to draw firm conclusions.

Recommendations

- Given that mean density of trochus across Kosrae is below the reference value of 500 trochus/ha, we recommend that fishery stays at rest to allow the stock to recover further.
- The Trochus Sanctuary reserve seems to be working effectively to protect a significant proportion of the stock. We recommend that this area stays in place.
- Monitoring should be repeated in 3–5 years using the same methods presented here to assess whether the stock has recovered further. Furthermore, we recommend further analyses using habitat data collected alongside the trochus counts to better understand habitat drivers behind trochus distribution in Kosrae.

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Appendix I: Summary data

Table 1. Summary information for each station surveyed around Kosrae for Rochia nilotica. Count is number of trochus counted at that station during the survey, area is area surveyed in m^2. Mean diameter and mean wet weight are per trochus. Density and wet biomass are summarised to the station level. All errors are 95% confidence intervals.

Station	Count	Latitude	Longitude	Area (m^2)	Mean diameter (mm)	Mean wet weight (g)	Density (trochus/ ha)	Wet biomass (kg/ha)
Finpohk Sruhsrah	1	5.271253	162.9685	480	65	91	20.83	1.89
Hiroshi Point	0	5.262543	162.9839	480	NA	NA	0.00	0.00
Kiyucl	21	5.359523	162.9479	480	86 ±11	260 ± 83	437.50	92.12
Koarom	3	5.30557	163.036	480	107 ± 3	424 ±35	62.50	26.49
Lihk	12	5.334649	163.036	480	119 ±8	597 ±122	250.00	111.96
Maclsuc	5	5.374716	162.9974	480	112 ±4	488 ±57	104.17	50.80
Mutunlik	54	5.324323	163.0346	400	91 ±4	266 ±31	1350.00	186.04
Mwot	43	5.319947	162.9177	480	101 ±3	360 ±35	895.83	269.91
Nacoh	54	5.343483	163.0278	480	94 ±3	292 ±26	1125.00	328.15
Nefalil	12	5.270266	162.923	480	112 ±6	496 ±70	250.00	124.02
Pac	9	5.273456	162.9127	480	110 ±14	498 ±143	187.50	93.34
Pikusrihk	19	5.356301	163.0242	480	100 ±8	352 ±43	395.83	139.37
Puck	9	5.319648	163.038	480	118 ±8	579 ±102	187.50	108.53
Sack	3	5.290631	162.9019	480	102 ±1	366 ±14	62.50	22.86
Saclacp	10	5.269233	162.9627	480	113 ±12	535 ±123	208.33	111.47
Soar	14	5.365145	162.9689	480	97 ±13	371 ±155	291.67	108.12
Srapaku	7	5.313049	162.9000	480	97 ±6	317 ±57	145.83	46.22
Srompal	6	5.372221	162.9836	480	82 ±14	206 ±97	125.00	25.78
Trochus Sanctuary	95	5.334534	162.9401	480	93 ±2	283 ±18	1979.17	412.57
Yeseng	7	5.269784	163.0177	480	114 ±7	524 ±102	145.83	76.36

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