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Assessment of Growth and Reproductive Biology of *Porphyra* species

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Abstract

Objectives: The study aimed to identify, estimate, compare and monitor the growth rates, reproductive patterns and ecological parameters in the natural grounds of *Porphyra* spp. in Claveria, Cagayan. **Methods/Findings:** Techniques to sample different species was done three times a week per station for gathering the results. Random sampling of *Porphyra* thallus was done on a regular basis for binomial on weekly basis for laboratory experiment to obtain the actual results of the study. Growth of Porphyra was calculated using the formula. Ecological factors were monitored using available equipment and gadgets. *Porphyra marcosii* appeared in November and December until January and disappearing in February. *P. suborbiculata* were last to disappear compared to other species. The growth rate increment was noted for *P. marcosii* in December. *P. crispata* showed variable growth with *P. suborbiculata*. Spore formation was noted in November in artificial substrates which appeared as dark encrustations; thallus was confirmed upon reaching 2-3 mm via microscope observation. Spore observation such as conchospore released in October that eventually observed in November. *P.monospore* released by young massive growth of new thallus in December and January. The development of carposporangium in *P. marcosii* was observed in December while *P. crispata* and P. *suborbiculata* were observed in January and February until the thallus turns green. **Application:** Ecological parameters such as strong winds and low temperature triggered the release of conchospore while strong wave action and long day length contributed to the occurrence and distribution of *Porphyra*. Dissolved oxygen and temperature showed a negative relation to all the growth parameters of *P. marcosii* and *P. crispate*. Ecological parameters showed positive relation to *P. suborbiculata* such as, salinity, relative frequency, diffusion rate and to its cover. Government must put up laboratory of *Porphyra* species ready for spores for Mari culture. And culture technology for the propagation of *Porphyra* species ready to use as ingredients of food processed to increase income.

Keywords: Biology, Growth, Marine Algal Assessment, *Porphyra*

1. Introduction

1.1 Background of the Study

In the long struggle to achieve mastery over the powerful forces of nature, man has always turned to plants for help such as food, shelter, clothing, weapons, and healing, and even for relief from the hardship of life. No wonder that from the most primitive to the most advanced societies plants have been attributed with magical powers and that is probably the reason why many researchers study plants because of their significant contributions as food and their by-products[1–5].

One of the plants in the Philippines is well-known for its richness in marine algae, yet our country remains lagging behind other countries in the utilization of seaweeds resources for food and for commercial purposes[6]. Considering the country's limited terrestrial resources and exponential increase in population, seaweed resources should be tapped as food and other products in order to place the future demand projection clearer in perspective[7,8].

The most commercially important algae are the members of class Rhodophyceae which is popularly called red algae. One of the most popular among the red algae is genus *Porphyra*, which is commonly known as *"gamet"*

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by the Ilocanos. *Porphyra* is known as "*laver*" in the European and American countries and as "*nori*" in Japan, "*kim*" in Korea and "*zicai*' in China where it is the single most commercially valuable marine products[9]. In Hawaii, *Porphyra* is also known as "*limu*" or "*luau*". In Scotland, it is known as "*slacke*". "*slouk*", "*sloukaon*", "*sloukaum*".

Porphyra species appears on rocky shorelines throughout the world, including a few species in the tropics or at the poles. The greatest diversity is found in cold-temperate and boreal regions. Most species appear in winter or summer annuals and can bear desiccation, so they live in the highest and driest reaches of the intertidal zone. *Porphyra* thalli appear in nature as free-living organisms and their microscopic filaments known as *conchocelis* that bore into calcium carbonate substrates such as oyster shells. *Porphyra* blades may appear from circular to linear in outline, with size ranging from few centimeters to over a meter length. Their color also varies from rose to pink while for submerged species to variously mottled red, yellow, brown and green in intertidal species[10].

The study assessed the existing growth and reproductive biology of *Porphyra* species particularly in Barangay Taggat, Claveria, and Cagayan. Specifically, preliminary information on the growth, reproductive biology and ecological parameters affecting their occurrence and distribution are necessary prior to massive propagation of these resources.

Porphyra as organism found in the bodies of water particularly in the sea is very significant source of food of the populace and a source of income of the people particularly residing in the sea shore where *Porphyra* is available. With the *Porphyra* available in the sea shore its very good source of vitamins, minerals and other benefits which we get from the said organisms living in the sea particularly in a rocky shore and in a temperature region[11].

With the above information, concepts, principles and practices, the researcher was able to formulate the conceptual framework of the study found in Figure 1 which is deem significant to the populace which these species are not available in their locality which is very important source of food which could prevent the occurrence of goiter.

1.2 Materials and Methods

The material used are the artificial substrate, rocks, oyster shells, polyethylene twine and abaca ropes were laid to the target area, microscope, camera, thermometer, portable diffuse oxygen meter, refractometer, digital pH meter, and clod cards.

The procedure used in gathering the result of the study was as follows: permission from the Municipal mayor was sought to undertake study in their vicinity; preliminary ocular surveys and interviews with the people were conducted in September and October to determine the scope and to obtain initial information; necessary prior arrangements to the conduct of the study such as, laying down the artificial substrate, rocks, oyster shells, polyethylene twine and abaca ropes for the spore to lay down for examination in the laboratory was done in the designated station of the study area.

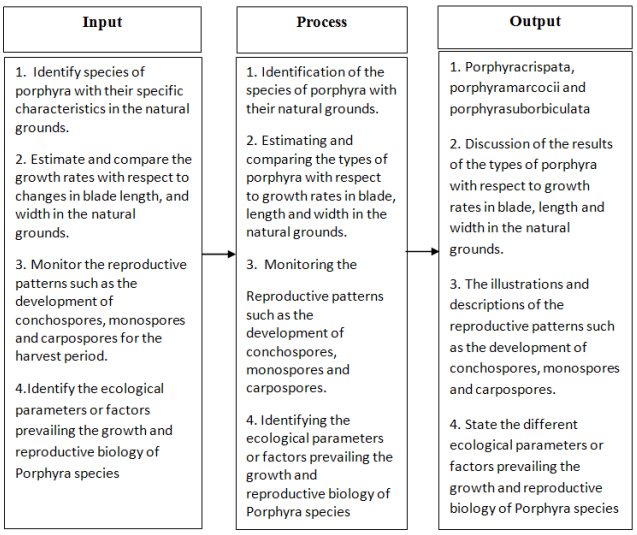

Figure 1. Conceptual paradigm of the study.

The methods used was sampling techniques for the different species for three times per week per station for the duration of the study, growth monitoring random sampling were done on a basis for example binomial or weekly basis with the use of a formula used by [12].

$$GR = P/T$$

where, GR = growth ratio

P = mean change in parameters, length, width

T = mean change in time

For spores monitoring, the laid artificial substrate, rocks, oyster shells, polyethylene twine and abaca ropes were taken weekly for laboratory examination with the use of digital microscope and camera for documentation.

For the ecological parameters monitoring was monitored using available equipment and gadgets; for temperature and dissolved oxygen are measured with an ordinary thermometer and portable diffuse oxygen meter respectively; for salinity of the water was measured using refractometer and its pH through the use of digital pH

meter, for water movement was measured using clod cards introduced by [13].

Data measurements are done once a month from November to February, the formula used to estimate the water movement.

1.3 Results and Discussion

The different identified types or classifications of *Porphyra* species:

1.3.1 Species of Porphyra

Three (3) species of *Porhyra* namely *Porphyra crispata*, *P.marcosii* and *Porphyra suborbiculata* were collected and identified in the lagoon of Taggat Norte, Claveria, Cagayan from November 18, 2017 to February 28, 2018. These species were found in the sharp rocky supra littoral zone of the islands affected by strong wave actions (Figures 2–4)[12-13].

Figure 2. Plate 1. Habits of Porphyra crispata growing in the splash zone of Taggat Norte, Claveria, Cagayan.

Figure 3. Plate 2. Habits of Porphyra marcosii growing in the splash zone of Taggat Norte, Claveria, Cagayan.

Thallus is of membranous and foliaceous and about 2 cm tall and 4 cm wide (matured) appearing brownish to dark purple in color. Blade margin at times dentate often ruffled, forming soft and rubbery with chordate base. Cross-section shows monostromatic layer of rectangular cells with carpogonial and spermatangial portions observed at the margins.

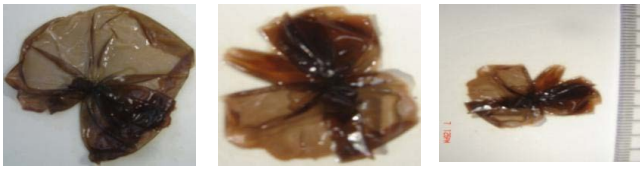

Figure 4. Plate 3. Habits of Porphyra suborbiculata growing in the splash zone of Lagoon, Taggat Norte, Claveria, Cagayan.

Materials examined:

ICA 005; 013; 018. Station 1, Taggat Claveria, Cagayan December 2017; ICA 023; 035 Station 2,Taggat, Claveria December and January 2018; ICA 030; 048 Station 3, Taggat, Claveria, January and February 2018

Plate 2 *Porphyra marcosii* Cordero[14]. Thallus generally appearing lanceolate reaching 110-112 cm tall; 8-12 mm wide; appearing brownish to purple, entire margin often ruffled; apex often attenuated; base chordate to the substrate by minute disc-like holdfast. The species often appear in November to January, disappearing in last week of February often intermingled with *Bangia* species in the supra littoral fringe.

Materials examined:

ICA 001-05; Station 1, Taggat Claveria, Cagayan November 2017; ICA 030-38; Station 2, Taggat, Claveria, Cagayan, December-January 2018; ICA 25-29, Station 3, February 2018.

Plate 3 is *Porphyra suborbiculata* Kellman Cordero as cited[3]. *Thallus* appears in clusters; purple to brown in color; membranaceous, 3-5 cm board 1.5 to 2.5 cm long. Blade often 3-5 margin slightly undulate; attached in rocks by rhizoids; base chordate to umbiculate, sometimes lobulate.

Materials Examined:

ICA 12-15, Station 3, Taggat Claveria, Cagayan, December, 2017; ICA 20-22, Station 2, Taggat Claveria, Cagayan December, 2017; ICA 23-25, Station 3 Taggat, Claveria, Cagayan, December 2017.

2. Growth Rate Observation

The mean growth rates of *Porphyra* as noted in Figure 5 that among species, *Porphyra suborbiculata* had the high-

est growth followed by *Porphyra marcosii* while the lowest was observed in *Porphyra suborbiculata*.

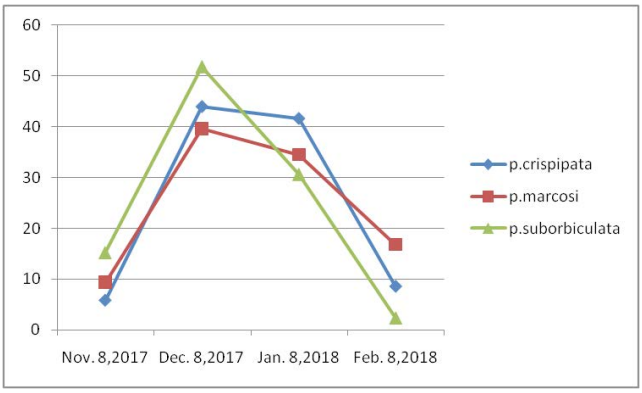

Figure 5. Monthly growth increment (mm^2) of Porphyra spp. in Taggat Claveria, Cagayan from November 20017 to February 2018.

During the month of November 2017, result shows that the highest increment was observed in *Porphyra marcosii* with a mean growth of 11.85 mm followed by*Porphyra suborbiculata* (11.80 mm) and the lowest was noted in *Porphyra crispata* with a mean growth of 3.9 mm.

For the month of December, however, the highest growth was observed in *Porphyra suborbiculata* with a mean 42.7 followed by *Porphyra marcosii* (13.75 mm) and the lowest was *Porphyra crispata* (6.8 mm). In January 2018, *Porphyra suborbiculata* continues to have the highest (22.4 mm) followed by *Porphyra crispata* with a mean growth of 13.2 mm and the lowest was noted in *Porphyra marcosii* (9.75 mm). In the month of February, there was a negative growth except for some species of *Porphyra marcosii* which had 17.5 mm growth and *P. crispata* which had 1.1 mm growth.

The monthly mean growth increment of the 3 species results shows that although *Porphyra marcosii* had the highest individual growth in terms of length, the overall growth parameters shows that *P.orphyra suborbiculata* had generally higher growth in the early part of the harvest season i.e. November and December of 15.21 and 51.82 mm respective while for the succeeding months shows that *Porphyra crispata* is higher of 41.67 mm while in December had *Porphyra marcosii* of 16.75 mm.

The observed growth parameters clearly indicate that P*orphyra marcosii* were first to appear, hence, they are the most sensitive to environmental factors that favour the growth for the period of occurrence. However, for the month of December, the 2 other species (*P. crispata* and *P. suborbiculata)* were observed to be dominant. The limited area of occurrence of the 3 species during the second month could be attributed to limited suitable substrate and competition among the 3 species. According to [1] the strong waves brought by north easterly winds could have brought negative effect to the species which were most likely subjected to tear because of their long lance late morphology. Moreover, the intermittent calm condition exposed these species for possible desiccation. The effect was observed positive in the 2 other species (*Porphyra suborbiculata* and *Porphyra crispata*) which were low lying in growth. The *monospore* released during the month of January had greatly contributed to their massive growth and occurrences. As observed from the frequency data, *Porphyra marcosii* dominated the species present in December but starting from February until the seasons is over, *Porphyra suborbiculata* was observed to be more abundant.

Through an interview with people living in the area and gatherers, they mentioned that the early rain, strong north easterly winds and rough seas in November greatly induce the release of *conchospore* that triggered the growth of *Porphyra.*

In the month of December, it was also observed that longer intermittent calm weather allowed seaweed gatherers to flock to the area. However, as soon as the weather example. strong rain and rough seas prevails, a renewed growth of *Porphyra* was observed. The prevailing condition continued until January to February but species eventually turned green when long spell of calm seas and warm weather prevailed which signals the end of *Porphyra* season.

3. Growth Ratio

The result of the growth ratio which is a measure of increase through change in parameters, example length, and width within certain period of time is presented in Figure 5. *Porphyra* has reached a maximum blade size of 62.5 mm which was observed in December 2017 while *Porphyra marcosii* has the longest blade length of 37.65mm. *Porphyra suborbiculata* moreover has blade parameter of 35.5 mm which happened in January 06, 2018.

It was noted that parameter readings varied for each week for the duration of the study. This data therefore shows the effect of indiscriminate harvesting among gatherers. Moreover, the long spell of calm weather rendered

the species exposed to desiccation resulting in wear and tear in addition to grazing of invertebrates.

Taking into consideration the mean differences of the weekly measurement, results shows that *Porphyra suborbiculata* and *P. marcosii* had a maximum growth of 24.5 mm which was observed in mid and later part of January 2018 while *Porphyra crispata* had its maximum growth of 13.2 mm which was observed in early January.

The observations below could be attributed to the strong waves and rain action, high diffusion rate or current movement and low temperature that prevailed over that period.

Statistical Analysis of growth increment of *Porphyra* species from November 2017 to February 2018 across months shown in Figure 6. As the results show that there is no significant difference on the monthly growth increments of all the species although *Porphyra marcosii* has generally higher in the early part of the season because of its lanceolate morphology. The results further attest that the genetic makeup of the species is one consideration for their growth performance in addition to the environmental condition.

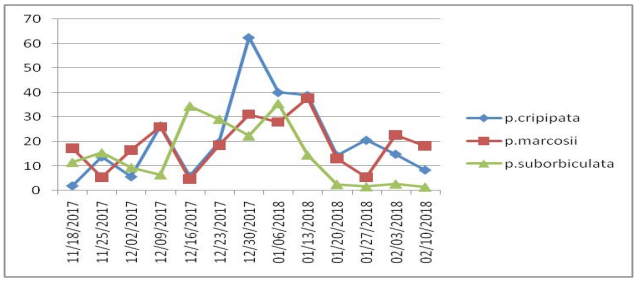

Figure 6. Initial growth increment of Porphyra spp. in Taggat Claveria, Cagayan from November 2017 to February 2018.

4. Spore Monitoring and Observations

Conchospore: Released spores through *conchocelis* stage were collected via artificial substrates namely abaca ropes, polyethylene twine, oyster shells, and rocks. It was noted that *conchospores* were released in November as dark pigments mitotically growing and visible as dark encrustations in the supra littoral fringe. However, their growth was not regularly monitored due to difficulty of retrieving substrates caused by continuous rough weather as shown in Figures 7–13.

Monospore: Young thallus of *Porphyra* was observed visible in a sampling conducted in November 17, 2017. Immediately upon notice, artificial substrates were brought to the laboratory for microscopic observation. Results revealed that thallus, approximately 2 weeks old, developed *monosporangium*. The result, however, had to be confirmed due to difficulty of retrieving other substrates considering the very rough condition in the area. Theoretically, the massive growth of *Porphyra* may be attributed to the release of *monospores* by young thallus in the succeeding months which resulted to abrupt increase in the area occupied.

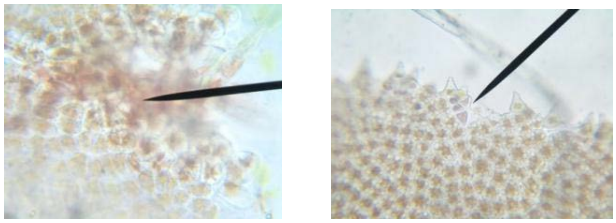

Figure 7. Plate 4. Monospore in the margin of young Porphyra marcosii in Station 1, Station 2, December 2017.

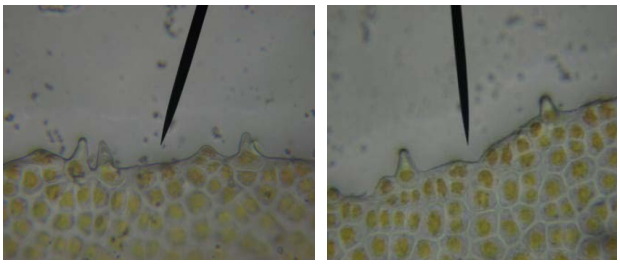

Figure 8. Plate 5. Porphyra marcosii in Station 1, Station 2, and Station 3 respectively, December 2017.

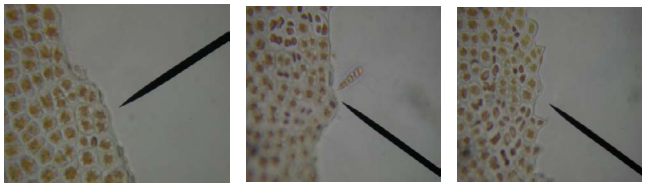

Figure 9. Plate 6. Carpospores in margin of Porphyra crispata in Station 1, Station 2, and Station 3 respectively, December 2017.

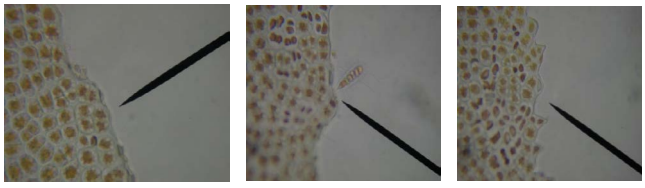

Figure 10. Plate 7. Monosporangium in P. crispata in station 1, station 2, and station 3 respectively, December 2017.

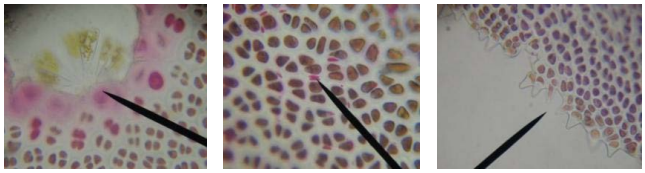

Figure 11. Plate 8. Margin of Porphyra crispata showing monosporangium, December 19, 2017 (Station 1).

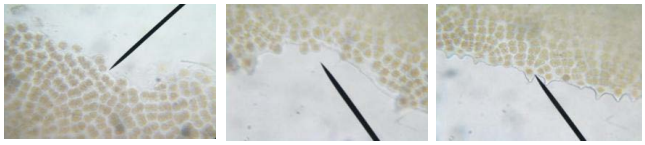

Figure 12. Plate 9. Margin of Porphyra crispata showing carposporangium, January 14, 2018 (Station 2).

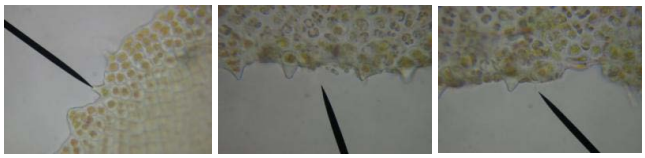

Figure 13. Plate 10. Margin of Porphyra crispata showing monosporangium February 05, 2018 (station 3).

Carpospores. Then deterioration of *Porphyra* thallus with outset of the harvest season with an increase of temperature, salinity and decrease in diffusion rate and dissolved oxygen are some of the parameters being considered for the development of *carposporangium* necessary for the production of carpospores. Laboratory observations show that trichogyne in *Porphyra marcosii* was developed as early as December but most was observed in January. Moreover, the *carposporangium* of *Porphyra crispata* was first noted in January and is continuing and increasing in frequency per thallus in the middle of February. The *carposporangium* in *Porphyra suborbiculata* likewise were observed in the thallus in January but the highest production was noted towards the end of the season. The release of carpospores was not done intensively because of technical concerns like availability of special microscope of high magnification among others as shown in Figures 14–17.

5. Environmental Factors

Environmental factors such us temperature, salinity, pH, dissolved oxygen and water movement greatly influence the growth, occurrence and distribution of marine organisms.

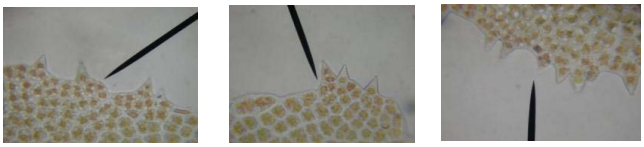

Figure 14. Plate11. Margin of Porphyra marcosii showing carposporangium, December 18, 2017 (Station 1).

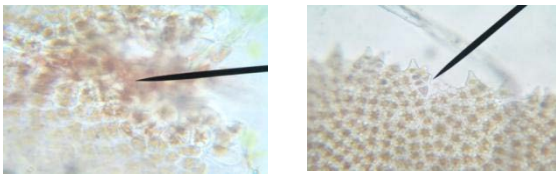

Figure 15. Plate 12. Margin of Porphyra marcosii showing carposporangium, January 14, 2018 (Station 2).

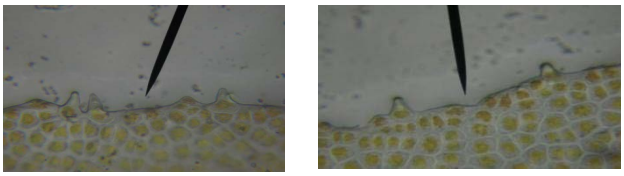

Figure 16. Plate 13. Margin of Porphyra marcosii showing carposporangium February 05, 2018 (Station 3).

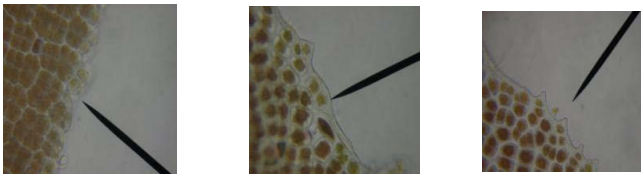

Figure 17. Plate 14. Margin of Porphyra suborbiculata showing carposporangium February 05, 2018(Station 3).

Salinity reading which is a measure of dissolved ions showed a mean reading of 38 ppt for the entire duration of the study. Moreover, pH which measures acidity and alkalinity showed a slight alkaline condition with a rage of 7.8-8.0 mg/l as observed in November, December, January, and February. Dissolved Oxygen measurement showed that there was a consistent high value which is above 6 mg/l. The high value may be attributed to the windy condition prevailing in the area and high current flow that was observed throughout the duration of the study.

The temperature reading was 25.6 ^{0}C in November increasing slightly in December and January with a reading of 25.9 ^{0}C and in the month of February in will decrease to 26 ^{0}C due to hot weather that comes in.

The above mentioned factors favour the growth of *Porphyra* in those islands. Moreover, the occurrences of

Porphyra in the splash zones can be attributed to the effect of competition among other classes of seaweeds which occur submerged in water occupying mostly the mean littoral zone.

The water movement measured by clod cards indicated a high value of 38.09 gh^{-1} which is favourable for the growth of *Porphyra*. The water movement is important as a means of distributing nutrients, gases and reproductive spores of seaweeds in general. The above observation can be considered as one factor the rapid growth and occurrences.

Further information gathered through interview suggests that the strong north easterly winds and rain triggered the growth, occurrence and distribution of *Porphyra* in the area. "Ti panag dakkel ken pinagado ti gamet ket nu napigsa ti tudo ken nalamiis t tiyempo, aglalo nu mataltalpiyakan ti danum iti baybay jay pagtubtubwan ti gamet nga ig-igid ti bat-bato ken napin-pintas ti agruwar nga gamet".

Correlation analysis of the different growth parameters with ecological parameters showed that for *Porphyra marcosii*, temperature and dissolved oxygen were highly negatively correlated with all the growth parameters. This indicates that the lower temperature and higher dissolved oxygen favour the growth of the species in the area. As to *Porphyra crispata*, temperature and dissolved oxygen were significantly correlated with relative frequency. This means that this species favour a relatively lower temperature but higher dissolved oxygen. In *orphyra suborbiculata*. Salinity was significantly negatively correlated with relative frequency while diffusion rate was significantly positively correlated with cover. This species, therefore favour a relatively lower salinity and higher movement.

Moreover, based on the results, dissolved oxygen was highly positively correlated with temperature.

Based on this correlation analysis, the growth parameters on the different species of *Porphyra* are said to be affected by some ecological parameters in the area, specifically temperature and dissolved oxygen for *Porphyra crispata* and *Porphyra marcosii* and salinity and diffusion rate *Porphura suborbiculata*.

6. Summary

The identified types or classification of *Porphyra* species are as follows:

The (3) *Porphyra* species occur in Taggat Norte, Claveria, Cagayan namely *Porphyra crispata*, *Porphyra marcosii* and *Porphyra suborbiculata* from the month of November 2017 to February 2018.

Results show that *Porphyra marcosii* were first to appear (November), slowly declining in December until early January and disappearing in the later part of February. However, two other species namely *Porphyracrispata* and *Porphyra suborbiculata* for the month of December continuously occurring throughout the duration of the harvest season.

The growth rate increment likewise shows significantly higher growth parameters for *Porphyra marcosii* in the early season until December but decline steadily for the entire duration. *Porphyra crispata* on the other hand shows variable growth parameters together with *Porphyra suborbiculata*. This information, however have yet to be verified considering some factors such as indiscriminate harvesting which was so rampant in the study area.

Spore formation was noted in November was artificial substrates that appear as dark encrustations, however thallus of *Porphyra* were confirmed upon reaching 2-3 mm via microscope observation. These support the theory that these accessory spores are responsible for the abrupt increase of *Pophyra* at the outset of the harvest season.

Spore observation also shows that *conchospore* release could have been done in October that allowed species to be eventually observed in November. However, the *monospore* released by young thallus contributed to the massive growth of new thallus observation in December and in January. The development of *carposporangium* varied among species with Porphyra*marcosii* observed as early as December while the other species namely *Porphyra crispata* and *Porphyra suborbiculata* were observed in abundance in the January and February until the thallus turns green in the later part of the month.

Ecological parameters like the presence of strong north easterly winds and low temperature triggered the release of *conschospore* while strong wave action and long day length contributed to the occurrence and distribution of *Pophyra* in the area. Statistically, the dissolved oxygen and temperature observed for the months showed a negative relation to all the growth parameters of *Porphyra marcosii* while in *Porphyra crispata*, these ecological parameters showed positive relation to relative frequency

of the species. In *Porphyra suborbiculata*, on the other hand, salinity was negatively related to relative frequently, while diffusion rate was positively related to its cover.

7. Conclusion

Based on the result of the study, the *Porphyra* thallus generally appear in November to February with the peak of occurrence in December to early part of January. *Porphyra marcosi* are generally more sensitive to prevailing weather conditions which contribute to their occurrence in November. Competition among species is prevalent considering the limited space of occurrences with the low lying species namely *Porphyra crispata* and *Porphyra suborbiculata* generally dominate the area. The premature harvest of thallus likewise favours the *monospore* release that contributed to the massive occurrence and distribution of *Porphyra*. *Porphyra* growing in the splash zone are generally affected by desiccation during calm weather affected the growth, occurrence and distribution of the seaweeds. Moreover, ecological parameters like temperature, dissolved oxygen, water movement and salinity generally affected the occurrence and distribution of *Porphyra* in the area.

8. References

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