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Strangford Lough Periwinkle Study

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Further information

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Executive Summary

Periwinkles are harvested intertidally for human consumption. They are gathered by hand at low tide with, on some occasions, boats being used to travel to islands to pick for winkles. In Northern Ireland the harvesting of periwinkles is unregulated with no technical measures such as closed seasons or minimum landing size (MLS) in place. The only legislation which affects periwinkle harvesting are the environmental health standards as set out in the EU Food Hygiene Regulations (EC) 853/2004 and Regulation (EC) 558/2010 which state that marine gastropods need to meet end-product requirements. Total landings of periwinkles into Northern Ireland are potential underestimates and unreliable as harvesters are not required to record or submit records.

The Agri-Food and Biosciences Institute (AFBI) have investigated the potential for a MLS and closed season to periwinkle harvesting within Strangford Lough. Monthly samples of periwinkles were collected from the intertidal region at three sites in Strangford Lough (Kircubbin, Strangford and Islandhill). A sample (60 individuals) from each site was processed to record individual weight, total shell length (TSL), total shell width (TSW), aperture length (APL) and aperture width (APW). Of these a subsample of 30 periwinkles from Kircubbin were retained for gametogenic analysis. Assignment of sex and gametogenic stage was based on pre-determined stages as outlined in Appendix 1.

The average TSL in periwinkles from Strangford Lough was 20.3mm (standard deviation ± 3.5mm). Gametogenic staging showed that spawning (stage 4) begins at low levels in December (21% of males spawning and 8% of females). For female periwinkles, the peak in spawning occurred in March 2015 (75% spawning) and February 2016 (69% spawning) with a secondary peak in April 2016 (67% spawning). For male periwinkles the peak in spawning occurred in April 2015 (when 94% were spawning) and March/April 2016 (100% spawning). Both male and female periwinkles show no spawning during the months of September to November, when the water temperature is at its highest. This is comparable with other studies carried out across the UK and Ireland (Williams, 1964; Grahame, 1975).

During this study the smallest animal found to be sexually mature was 13.86mm (the smallest animal analysed for gonad stage was 12.26mm). Maturity modelling suggested that the hypothetical size at gonad maturity was 14mm for males and 16.2mm for females. Based on previous research, which indicated that periwinkles become mature at 11-12mm, our results suggest that periwinkles from Kircubbin mature at a slightly larger size.

Recommendations

1. If a MLS is implemented it should be greater than the minimum size at which spawning occurs. It has been reported that by the end of their third year periwinkles are about 16mm (Cummins *et al*. 2002). By setting the MLS at 16mm or greater this would give periwinkles a minimum of one winter spawning.

2. A closed season during the months of January to April would best protect the spawning stock.

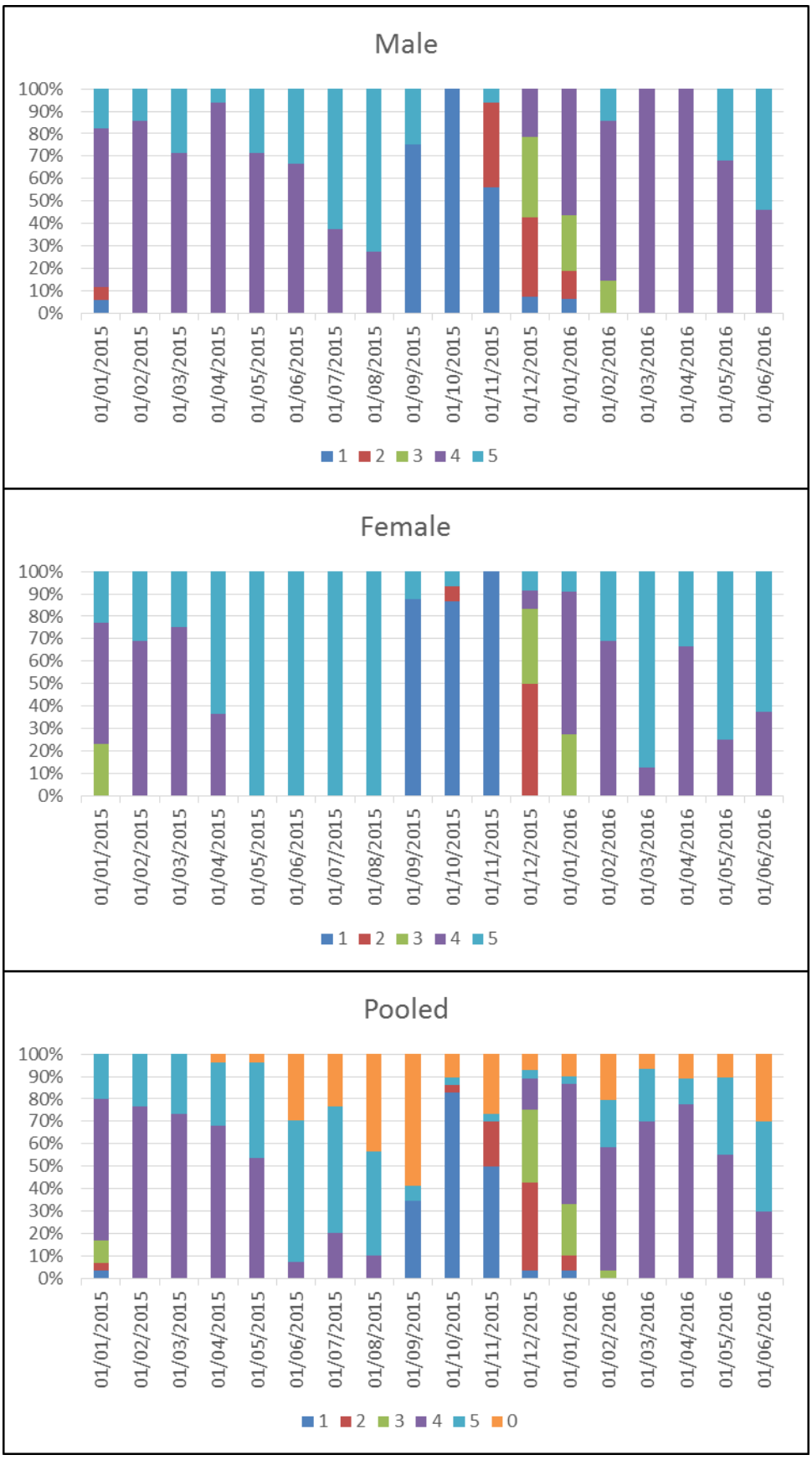

Figure A: Stage of gonad of periwinkles from Strangford Lough as determined through gametogenic studies.

Species Information

The gastropod *Littorina littorea* is the largest British periwinkle and is found on all coasts (though rare or absent on the Isles of Scilly and Channel Islands) (Jackson, 2008). Globally it extends from the White Sea (Russia) to Northern Spain, as well as being present on the north eastern shores of America. Periwinkles occur on semi-exposed to sheltered rocky shores from high water neap tides to low water spring tides (McClean and Coughlan, 1999). *L. littorea* has separate sexes with internal fertilisation. It is believed that maturity is reached around 10-12mm shell height (around 2-3 years of age), with females tending to mature at a smaller size. Grahame (1975) found that in Wales, whilst the presence of egg capsules in the plankton was reported from January to September maximum spawning occurred in March and April when temperatures were increasing. Spawning usually occurs at night on the flood tide (Evans, 1995). Fretter and Grahame (1964) described that whilst not obvious in younger specimens, there tends to be a higher female ratio, with the figure of older animals being male at 33%.

Fishery Description

Periwinkles are harvested intertidally for human consumption. They are gathered by hand at low tide with, on some occasions, boats being used to travel to islands to pick for winkles. Harvesters are not required to submit a completed log book detailing quantities collected, therefore landings records are likely to be incomplete. Using the landings reported to the Department of Agriculture, Environment and Rural Affairs (DAERA) (Figure 1) periwinkle landings reported in 2011 and 2012 had first sale values of £374,400 and £432,000 respectively. These figures are indicative of the potential value of commercial shellfish gathering but it is impossible to assess the true value of this fishery without mandatory activity reports. In general, highest volumes of harvesting occur around Christmas when market demand increases the price from approximately £1,400 to £2,200 per tonne (Cummins *et al.,* 2002).

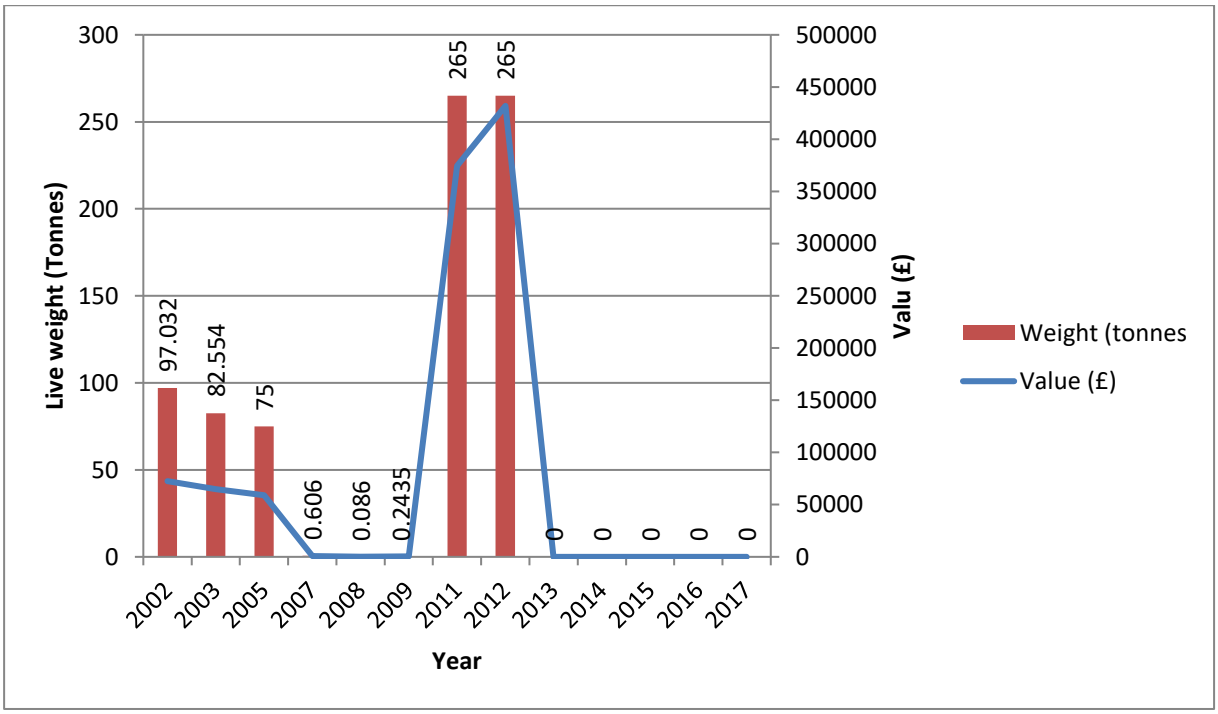

Figure 1: Reported landings of periwinkles in Northern Ireland by intertidal harvesting (Source: DAERA).

In Northern Ireland there is no minimum landing size for periwinkles, therefore, whilst large animals will be selectively harvested first, once these large animals have been removed then smaller specimens may be collected. It is reported that any animals which are not bought are returned to the shore, or, on

occasions, discarded. In Scotland, the market demand is for winkles greater than 13mm. However, due to overfishing there is a lack of animals of this size and it was reported in 1998 that 5-20% of the catch was undersized with these small animals being of no economic value (Cashmore and Burton, 1998). Additionally large animals tend to become infected with trematodes (in *L. littorea* sexual maturity seems to be a prerequisite for infections by digenean trematodes (Evans, 1995)) reducing egg production and so the smaller animals have the greatest reproductive capacity. By harvesting small animals the future reproductive potential of the population may be significantly impacted.

Winkle Management in the UK

Periwinkle harvesting is largely unregulated in Scotland and Wales. Some of the English Inshore Fisheries and Conservation Authorities (IFCA) have established periwinkle harvesting regulations in their areas. The Eastern, Cornwall, Devon and Severn, and North West IFCA's have all prohibited the harvesting of periwinkles which could easily pass through a gauge with a square opening of 16mm. In addition, the Southern IFCA operates a closed season for periwinkle fishing between the 15th May and 15th September (inclusive).

In Jersey, a paper listing potential regulatory measures was produced by the Marine Resources, Department of the Environment, in 2018. Proposed measures for managing periwinkles included;

- A bag limit of 100 for the recreational sector;
- A minimum landing size of 16mm

It is a common law right for everyone to have access to the intertidal zone and to gather shellfish. In addition, because of relatively simple equipment required to harvest periwinkles, the sector is open to a wide range of people. In Northern Ireland, under Section 42 of the 1930 Belfast Corporation Act, all shellfish gathering is prohibited along shores of Belfast Lough Whilst the Strangford Lough (Prohibition of Fishing for Shellfish) Regulations (Northern Ireland) 2001 prohibits the removal of shellfish "from or by any means of any mechanically propelled vehicle" within Strangford Lough. Whilst this prohibits the use of quad bikes or other mechanised transport for the removal of animals from the intertidal, it does not prohibit hand gathering.

Whilst periwinkle harvesting has little regulation, the products do have to meet certain environmental health standards. As laid down in The EU Food Hygiene Regulations (EC) 853/2004 and Regulation (EC) 558/2010 "marine gastropods, should be excluded from provisions on the classification of production areas". However, they still do need to meet the end-product requirements as set out by the EU Food Hygiene Regulations. Therefore all buyers of gastropods must be registered with Environmental Health so that the correct testing can be carried out prior to being sold to the public. The appropriate documentation is also required, stating the location of the area from which the animals were harvested (AFBI, 2013). In addition the EU Food Hygiene Regulations (EC) 853/2004 states that winkles should be sold through an approved establishment. A processing hall, auction house or despatch centre.

Whilst these regulations are in place, in 2013 a report investigating periwinkle harvesting in the Strangford Lough and Lecale district stated that there was no one registered for winkle harvesting within the local Councils (Clear Direction, 2013).

Strangford Lough winkle fishery

Strangford Lough is the largest Sea Lough in the British Isles with over 150 miles of coastline and more than 120 islands. The intertidal zone covers approximately 20km^2 and has ten intertidal habitats which

have been identified on the basis of substrate and wave exposure, each having a characteristic range of species.

Strangford Lough is classified as a Special Protection Area (SPA), a Special Area of Conservation (SAC), an Area of Special Scientific Interest (ASSI), an Area of Outstanding Natural Beauty (AONB), a RAMSAR site, a National Nature Reserve and was Northern Ireland's first Marine Conservation Zone (MCZ).

A search of the Marine Recorder Database for *Littorina littorea* within Strangford Lough displays almost 600 reportings (Figure 2, information provided by CEDaR). It can be shown from this that *L. littorea* is found around almost the entirety of the Strangford Lough coast.

A survey carried out between 2004 and 2005 found that winkle picking occurs at high levels around Strangford Lough, with winkle pickers accounting for 87% of all harvesters observed (Johnson *et al.,* 2008). A 2013 report which investigated winkle harvesting on the Strangford Lough and Lecale coast estimated that there are around 100 winkle collectors in the area, with most respondents to the report indicating that local collectors harvest an average of 20-25kg per trip (Clear Direction, 2013). The same report estimated that the annual harvest of periwinkles from the Strangford and Lecale area was 307-576 tonnes. Processors may grade the periwinkles into three categories; those less than 11mm are returned to the shore, those 11-15mm fall in to one category with another for 16mm+ periwinkles (Clear Direction 2013).

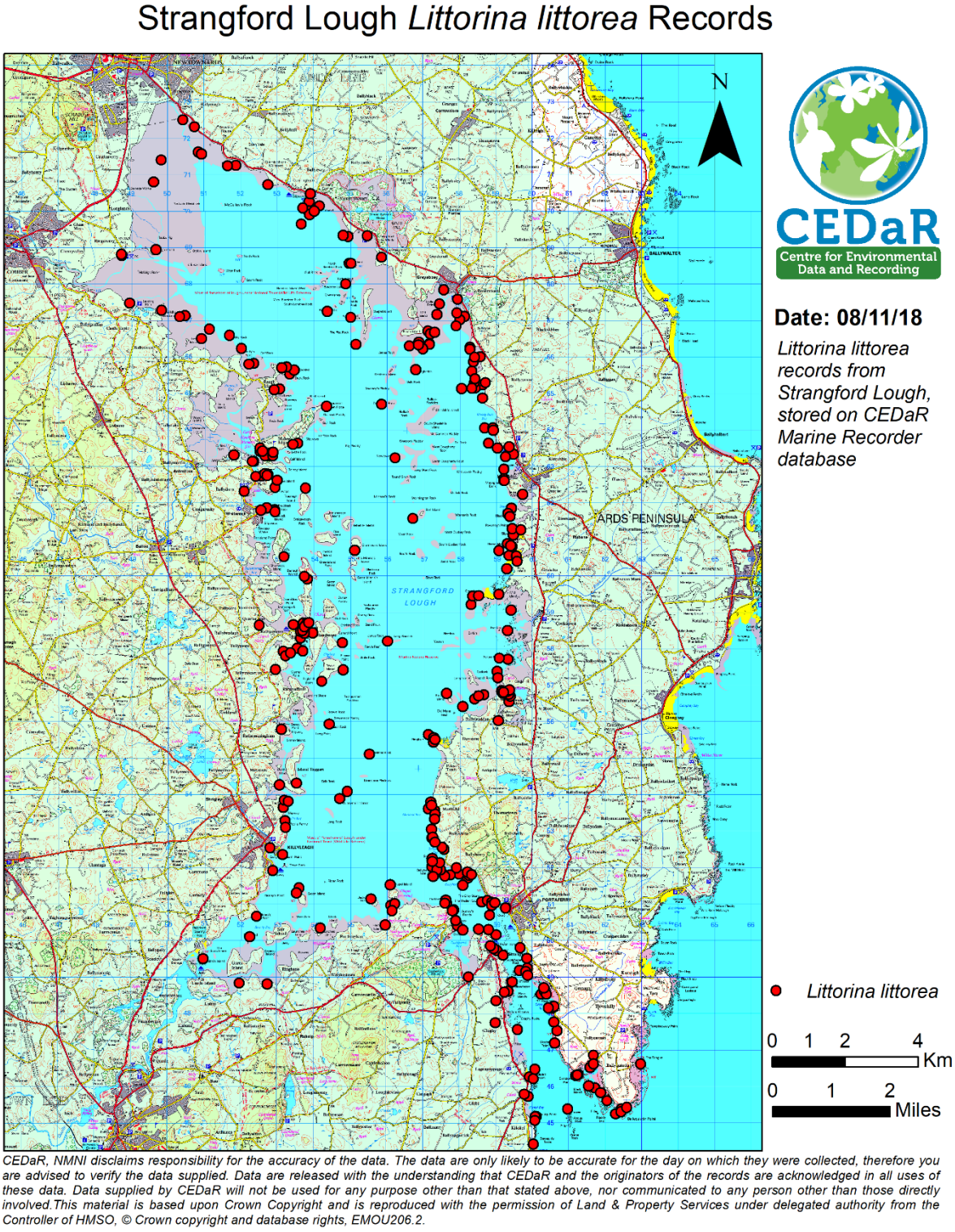

Figure 2: Results for reportings of *Littorina littorea* within Strangford Lough (Source: CEDaR, 2018).

Study Objectives

The aim of the current work was to determine potential management options for the intertidal harvesting of periwinkles from Strangford Lough. The two options investigated were;

1. Setting a minimum landing size for harvesting. This would prevent buyers from being able to hold undersized specimens, which, in return, would stop harvesters collecting undersized animals. The animals can then be left on the shore to reproduce.

2. Establishing a closed season to protect the spawning stock. This would prevent harvesters from collecting periwinkles during the months when there is a peak in spawning therefore allowing the release of larvae which will feed into the stock.

Methodology

During previous AFBI work on intertidal harvesting, periwinkle picking had been highlighted as occurring at Kircubbin and Killyleagh, both within Strangford Lough. Due to the known activity and hence presence of periwinkles at these sites, these were selected for sampling. An additional site was selected at Islandhill, Strangford Lough, to ensure coverage around the Lough (Figure 3).

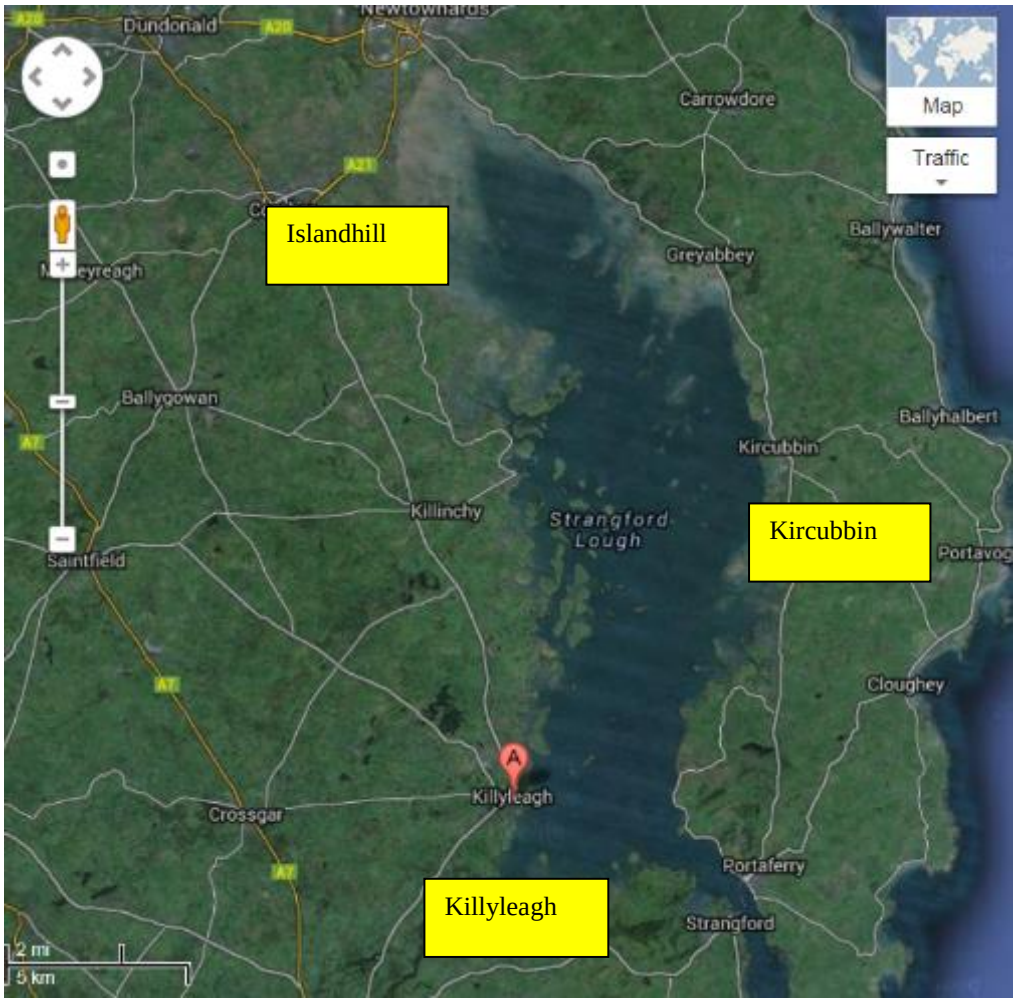

Figure 3: Location of the 3 sampling sites around Strangford Lough

Sampling commenced in January 2015. Samples were collected on a monthly basis from each sampling area. At each sampling site approximately 100 periwinkles were collected ensuring that the full range of sizes was sampled. In the lab 60 periwinkles were individually weighed and measured for total shell length (TSL), total shell width (TSW) and aperture length (APL) and aperture width (APW) (Figure 4). Individuals were examined to identify sex animal by examining for the presence of a penis (Figure 5). Thirty of these measured samples were then used for gametogenic sampling.

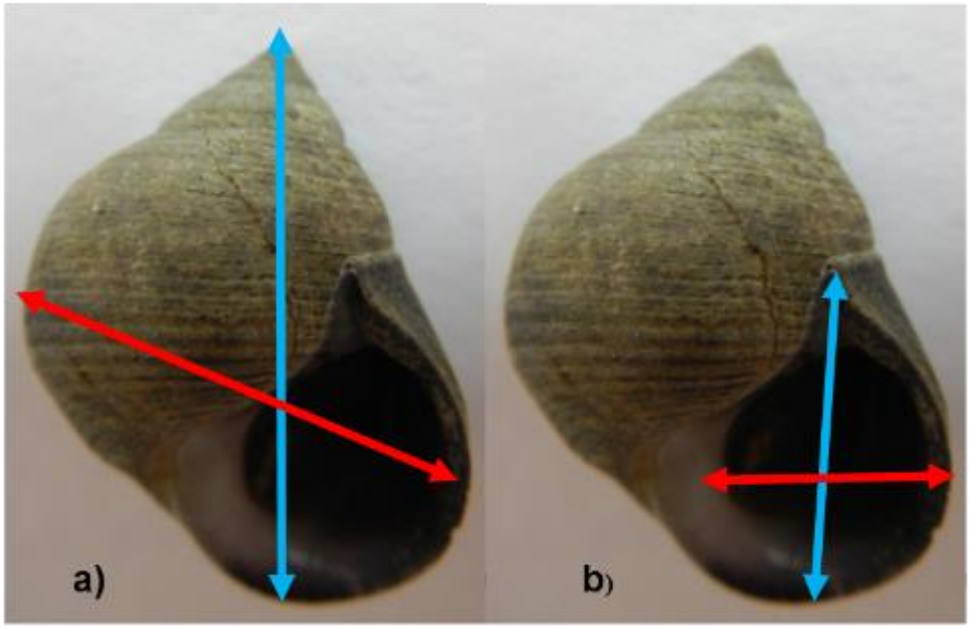

Figure 4: Measurement positions for recording a) total shell width, TSW (red line) and total shell length, TSL (blue line) and b) aperture width, APW (red line) and aperture length, APL (blue line).

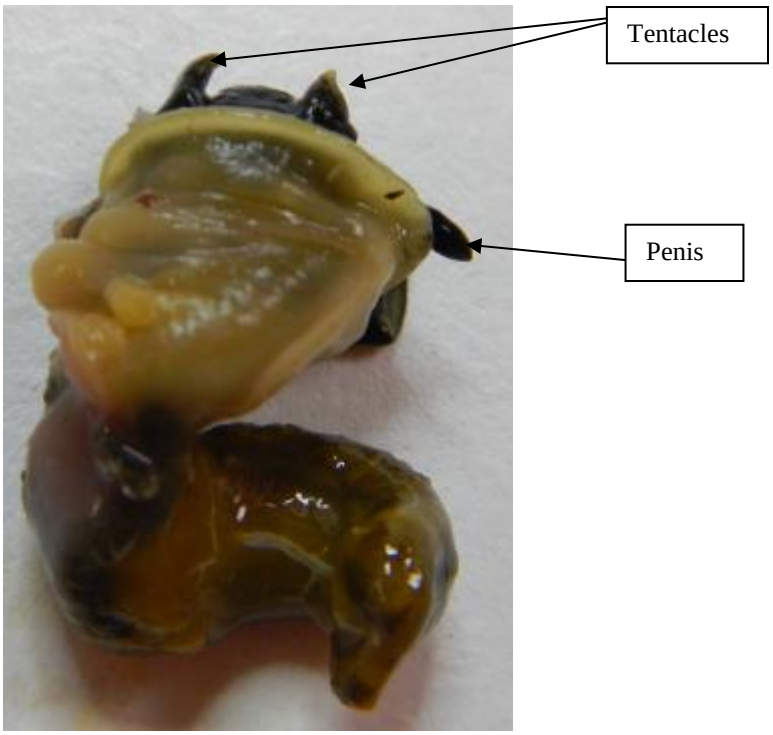

Figure 5: A male periwinkle showing the location of the penis.

Gametogenesis

Prior to the analysis of the Strangford Lough samples each reproductive stage had to be determined. A literature review was carried out examining the gametogenic stages used for other gastropods and bivalves. Based on this the periwinkle slides were examined and six reproductive stages were determined (Appendix 1).

Individual from Kircubbin were used for gametogenesis as this site was considered representative of the population. Samples were initially examined under the microscope to determine sex. If the sample was determined to be a female (eggs were present) then the assignment of the gametogenic stage was based on the photographs contained within Appendix 1a. If the sample was determined to be a male (sperm present) then the assignment of the gametogenic stage was based on the photographs contained within Appendix 1b.

Results

Table 1 provides the minimum, maximum and average total shell length (TSL) of periwinkles collected from each site from January 2015 to June 2016. There is a significant difference ($p<0.05$) between the TSL of periwinkles at the three sites, with Killyleagh having the largest average size, and Kircubbin having the smallest average size (as this study was interested in examining size at first maturity it was felt that the smaller size at Kircubbin, presumably due to the higher levels of harvesting in the area removing larger animals, would not be an issue, as we would be examining all size classes with focus on the smaller animals). However, these differences are less obvious at certain times of the year. In general the monthly average TSL follows a pattern with a decrease in TSL for all three sites between March and May 2015, September 2015 and March 2016. An increase in average TSL is noted for all three Strangford sites in February 2015 and 2016. The biggest increase in average TSL for all three sites was between September and October 2015.

As management options would be based on the entire Lough and not these specific areas, the TSL of periwinkles from Strangford Lough were pooled to provide an overall length frequency for the Lough (Figure 6).

Over the survey period the average TSL in periwinkles from Strangford Lough was 20.3mm. Very few periwinkles less than 10mm in TSL were recorded during the survey. Similarly periwinkles greater than 30mm were also low in number.

Table 1: Total shell length of periwinkles collected throughout the survey period (January 2015 to June 2016)

Month		Kircubbin			Islandhill			Killyleagh		
		Smallest	Largest	Average	Smallest	Largest	Average	Smallest	Largest	Average
2015	January	15	21	19.1	13	27	21.2	13	31	22.2
	February	16	26	21.2	20	28	22.9	19	30	24.9
	March	15	29	19.3	18	25	22.2	18	29	23.6
	April	12	21	17.4	14	26	21.3	16	27	21.5
	May	13	21	16.8	13	25	20.9	15	28	20.5
	June	13	21	17.1	13	26	20.7	14	27	22.3
	July	14	23	17.9	14	24	18	14	27	20.8
	August	14	22	18.7	17	24	21.2	17	27	22.7
	September	12	23	17	11	24	17.3	11	26	17.7
	October	10	24	18.7	13	26	21.7	12	27	21.2
	November	9	27	18	11	25	21.8	10	27	22.1
	December	9	22	17.5	12	25	21.3	12	27	22.7
2016	January	9	22	17.7	12	25	19.8	10	27	21.4
	February	12	22	18.2	12	26	22.2	13	27	22.1
	March	11	20	17.4	12	26	21.1	11	27	21.9
	April	11	21	17.8	10	25	20.3	13	29	23.4
	May	11	23	18.4	11	25	21.2	13	28	22.1
	June	10	22	17	8	24	19.4	13	27	21.9

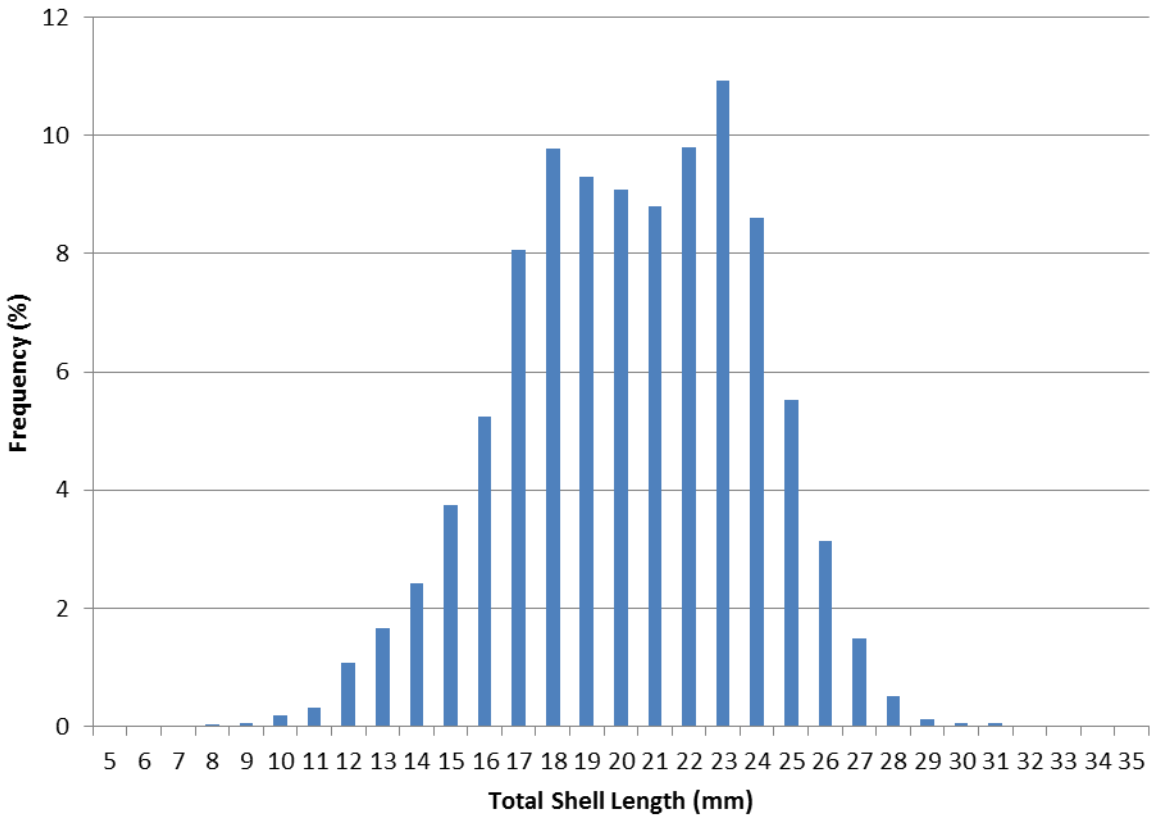

Figure 6: Total shell length frequency of periwinkles collected from Strangford Lough.

Gametogenic staging of Kircubbin periwinkles showed a pattern in gamete maturity for both males and females (Figure 7). For both sexes spawning (stage 4) begins at low levels in December (21% of males spawning and 8% of females). For female periwinkles, the peak in spawning occurred in March 2015 (75% spawning) and February 2016 (69% spawning) with a secondary peak in April 2016 (67% spawning). Whilst the first year of sampling (2015) showed that spawning of female periwinkles had completely ceased by May, in 2016 spawning of female periwinkles was still evident in May and June. For male periwinkles the peak in spawning occurred in April 2015 (when 94% were spawning) and March/April 2016 (100% spawning). For males the spawning period was also extended further than that for females, with high proportions of males (72.7%) spawning in August. Both male and female periwinkles showed zero spawning during the months of September to November when the water temperature was at its highest (Figure 8).

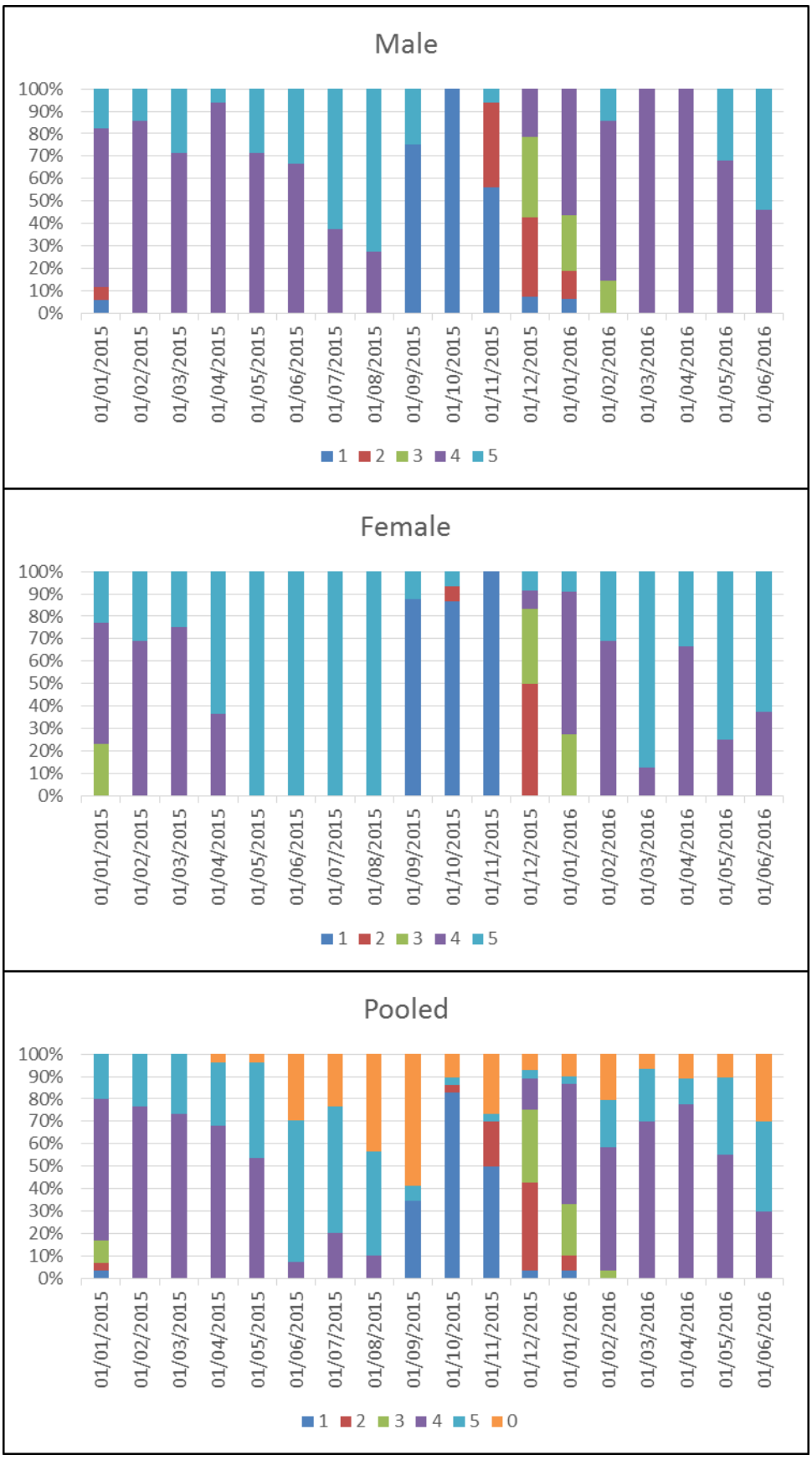

Figure 7: Stage of gonad of periwinkles from Strangford Lough as determined through gametogenic studies.

Figure 8: Proportion of male (top) and female (bottom) periwinkles at Stage 4 in relation to water temperature (recorded at an average depth of 1m from the surface) in Strangford Lough.

Virgin animals i.e. animals which have not yet become sexually mature, are classified as Stage 0. Stage 0 also includes animals which have spawned and are spent and have not yet begun to recover (it is common in such studies to have a stage which incorporates both developing (virgin) and spent recovering animals). In total 87 animals were classified as Stage 0. These animals ranged in size from 12.3mm to 23.3mm shell length (Figure 9).

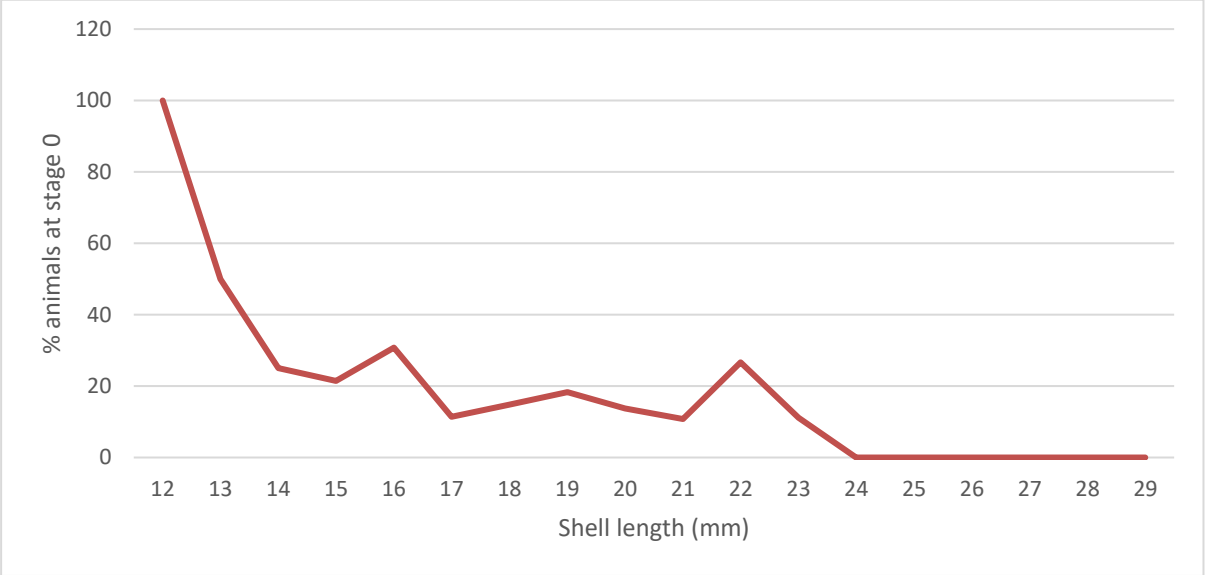

Figure 9: Proportion of periwinkles (male and females pooled) of all lengths at Stage 0.

The R package sizeMat (Torrejon-Magallanes, 2017) was used to estimate the size at sexual maturity of periwinkles collected from Kircubbin. For this approach all periwinkles collected between January and May 2015 (the time of peak spawning) were input to the analysis. The maturity ogive shows a size at gonad maturity of 14mm shell length for males and 16.2mm for females (Figure 10).

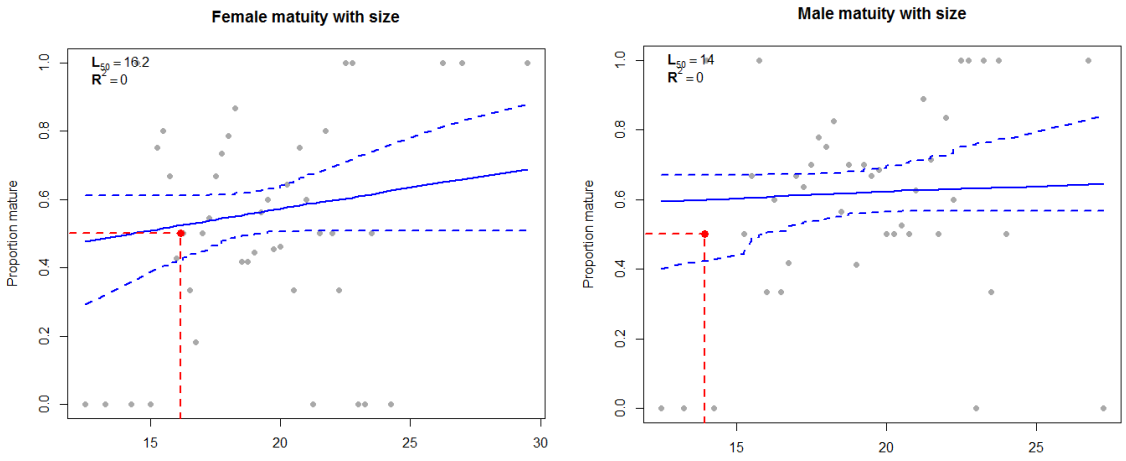

Figure 10: Size at gonad maturity based on the sizeMat R package.

Discussion

Visual inspection of periwinkles proved difficult; examination for the penis was most reliable during the spawning and spent stages (Stages IV and V). An average of 38% of males were identified correctly when confirmed by microscopic gametogenesis study.

Williams (1964) found that only rarely did periwinkles below 11-12mm in length reach sexual maturity. The smallest animal found to be sexually mature in the current study was 13.86mm in length which is in keeping with the results from the historic study. The smallest periwinkle analysed for gonad stage was 12.26mm in length.

Williams (1964) also found that periwinkles matured rapidly between December and February and by March 89% of periwinkles are fully mature or spawning. The percentage of animals at this stage remained high during April and May. The present study shows very similar results. During the months of September to November no spawning was observed. In December the periwinkles began to mature and spawn, with levels of spawning peaking in the months of February to April when an average of 71% of animals are spawning (the highest proportion was recorded in February 2015 when 77% of animals were spawning and April 2016 when 83% of animals were spawning). In May the levels of spawning dropped to around 40% and continued to decline over the summer months. Williams (1964) attributed this to the periwinkle population maturing when temperatures are at their seasonal lowest with spawning at its maximum when temperatures begin to rise. Grahame (1975) also found maximum spawning in the months of March and April on the rising temperature but with spawning occurring throughout the year, outside of the breeding season.

Again the present study is similar to Williams (1964) study as it showed that male periwinkles tended to begin spawning earlier than the females. In the current study the peak in spawning for males was reported in February 2015 and March 2016. In 2015, the peak in spawning for females was one month later than the males, occurring in March. In 2016, female periwinkles peaked in spawning in February, a month before males, but a secondary spawning peak, which was almost at the same level as the first, occurred in April, one month after the male's peak in spawning.

During this study three of the animals examined contained both eggs and sperm. Intersex has been reported within the periwinkle *Littorina littorea.* Imposex, which has been reported in many gastropod species worldwide, is caused by hormonal changes brought about by organotin compounds (e.g. tributyltin or TBT) used in antifouling paints (Wolf *et al.,* 2004). With imposex, male characteristics including a penis, become superimposed on the females own genitalia (Birchenough *et al.,* 2002). *L. littorea* however suffer from intersex. Intersex is when the female pallial organs are modified towards the structure of a male. Intersex was first documented by Bauer *et al*., (1995) who reported a gradual transformation of the female pallial tract to a prostate gland, and, in some occasions, the development of a penis with an open sperm groove. This change from female to male structures occurs over five stages. In Stage 1 (as described by Oehlmann, J. 2004) sperm, which has been transferred by the male into the bursa during copulation, may leak into the female's mantle cavity. In Stage 2, oocytes and capsular material produced by the female gland complex in the pallial oviduct section leak into the mantle cavity. This would thus show as both the presence of sperm and eggs in a single animal.

However, with such a low number of samples showing both eggs and sperm, and with the remaining sample from which the slide was prepared no longer available, conclusions cannot be drawn if this is true intersex or a case of cross-contamination when preparing the slides.

Recommendations

Minimum Landing size

It is recommended that if a MLS is implemented it should be greater than the minimum size at which spawning occurs. It has been reported that by the end of their third year periwinkles are approximately 16mm in length (Cummins *et al*. 2002). By setting the MLS at 16mm or greater this would give periwinkles a minimum of one winter spawning.

Closed Season

A closed season during the Months of January to April would best protect the spawning stock. Whilst these are profitable months for periwinkle harvesting and so would be not supported by harvesters and processors, it is the time which makes most biological sense.

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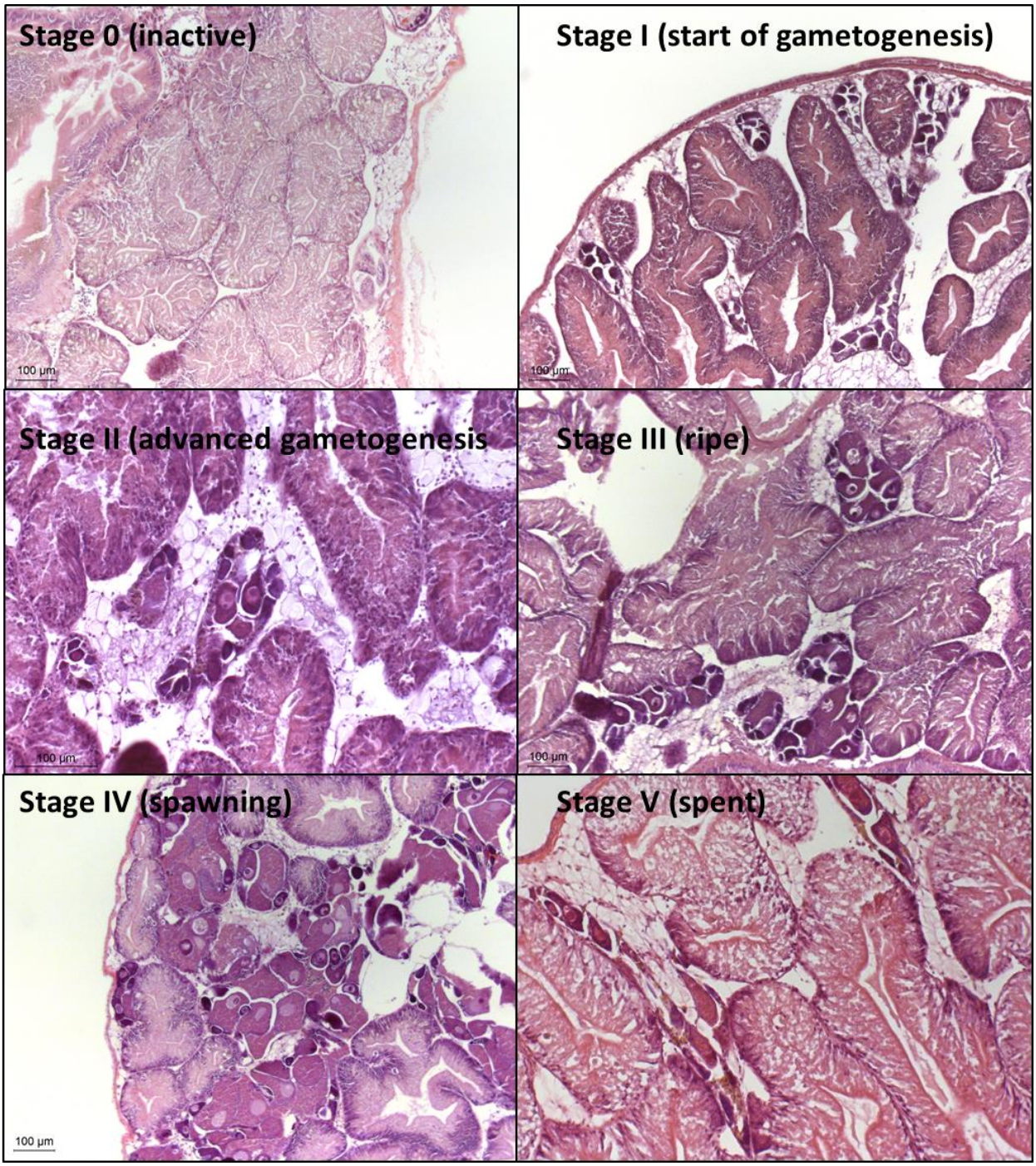
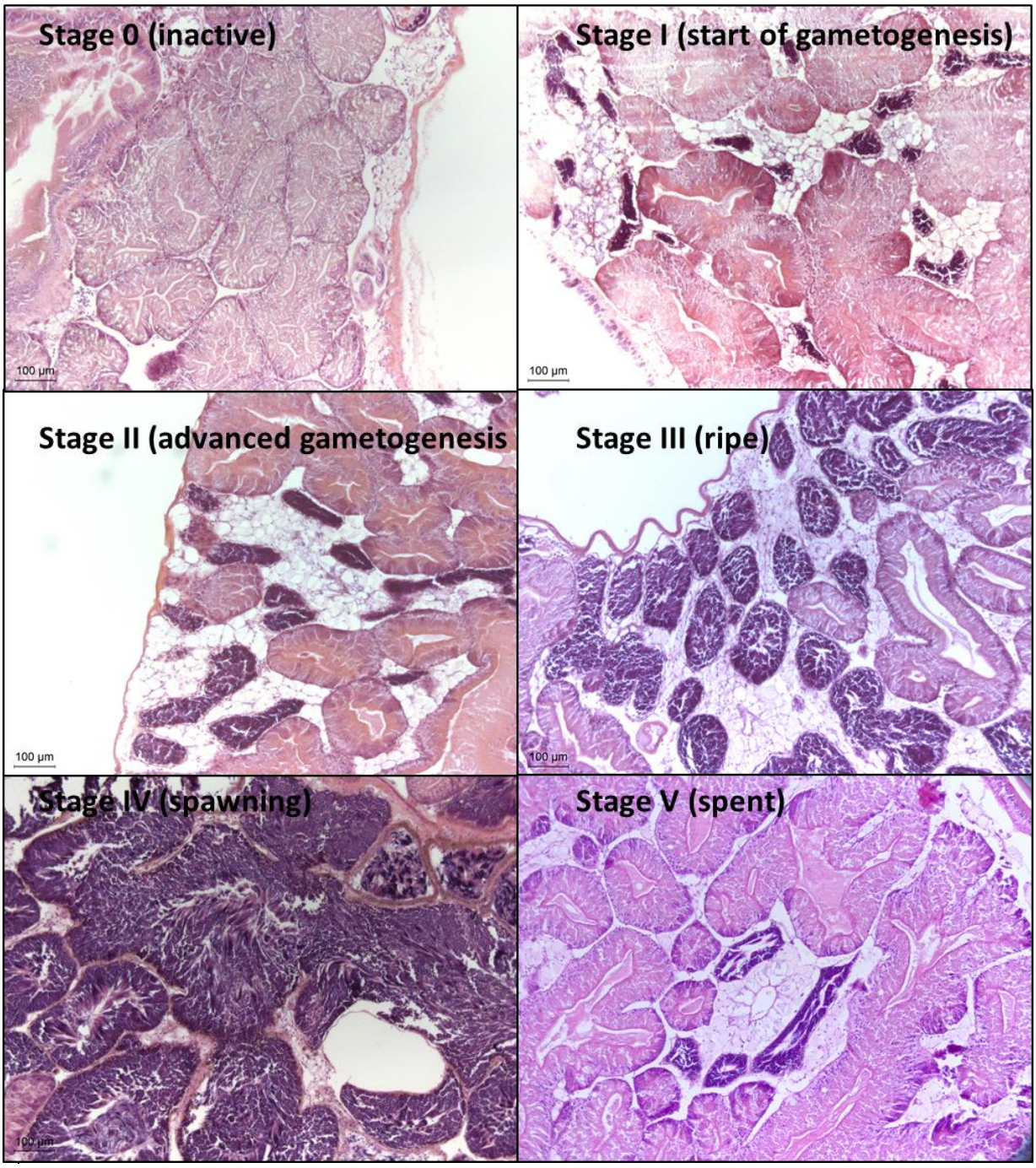
Appendix



Appendix 1a: Gametogenic stages of a female periwinkle. Stage 0 (Inactive) – sexual rest, sexes indistinguishable, absence of follicles and gametes. Stage I (start of gametogenesis) connective tissue abundant, ovocytes at periphery of alveolar walls. Stage II (advanced gametogenesis) follicle size increased and occupies entire tissue, germinal cells in all phases of gametogenesis. Stage III (ripe) oocytes take oval or polygonal shape, connective tissue replaced by follicles full of ripe gametes, free ripe oocytes observed in lumen. Stage IV (spawning) gametes are discharged, follicle walls broken and empty spaces between and within follicles, free rounded oocytes in lumen. Stage V (spent) follicles small and practically empty, occasional residual oocytes present, residual gametes degrading.



Appendix 1b: Gametogenic stages of a male periwinkle. Stage 0 (Inactive) – sexual rest, sexes indistinguishable, absence of follicles and gametes. Stage I (start of gametogenesis) connective tissue abundant, spermatocytes proliferate towards the lumina. Stage II (advanced gametogenesis) follicle size increased and occupies entire tissue, sperm in lumen forming weak columns with rails orientated towards the centre. Stage III (ripe) lumen packed with ripe spermatozoa, connective tissue replaced by follicles full of ripe gametes, spermatozoa occupy most of the follicle. Stage IV (spawning) gametes are discharged, follicle walls broken and empty spaces between and within follicles, spermatozoa lose radial disposition. Stage V (spent) follicles small and practically empty, occasional residual sperm present, residual gametes degrading.