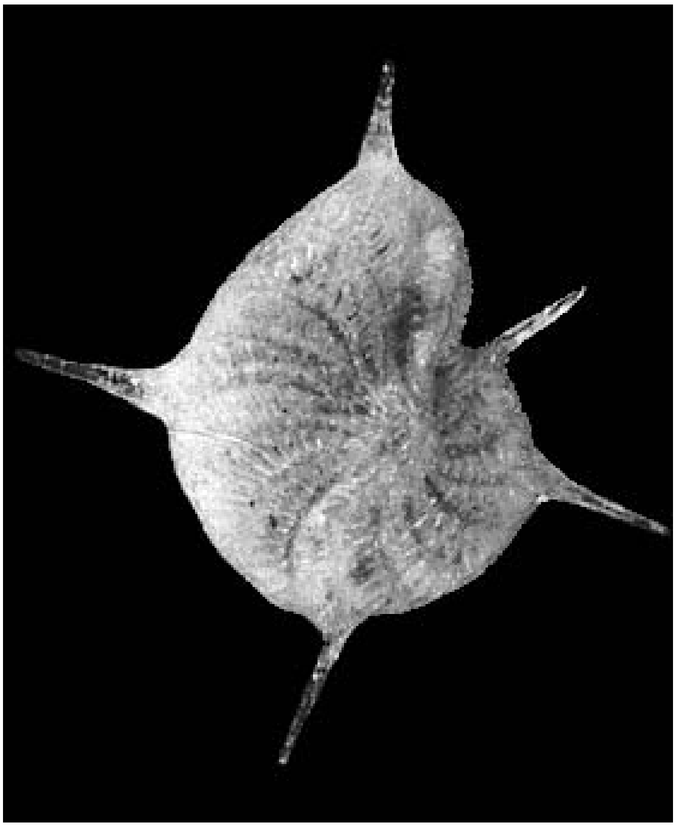

# Distribution and Occurrence of Benthic Foraminifera (Protozoa) in the Georges River:

*An Environmental Assessment*

**November 2011**

With support from

Lower Georges River Sustainability Initiative

NSW GOVERNMENT | CMA Sydney Metropolitan CATCHMENT MANAGEMENT AUTHORITY

Sutherland Shire COUNCIL

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## Contents

# 1 - Introduction

During the last several decades the human impact on the marine environment has increased enormously, in particular on the coastal zone with much of the recent urban developments adjacent to or overlooking waterways. One of the difficulties in establishing the level of environmental stress is the lack of reference base levels and a suitable methodology for the treatment of long-term data. Any attempt to evaluate physical-chemical parameters of the water masses is, by the very nature of the measurement methodology, time related; it gives only a snapshot of the environment. While this approach is valid for an immediate response to environmental disasters, either for a punitive action or/and for a remedial action, it fails to detect and monitor subtle long-term changes in the water qualities.

A permanent record of these events is, however, available in the beds of our waterways; the distribution of benthic organisms and the sediment geochemistry reflect very closely the behaviour and quality of the water masses they interact with.

The effects of quality changes, even slight but persistent in time, have cumulative effects on the seabed. Some benthic life is affected by the concentrations of the heavy metals in the sediments and, in turn, humans can also be affected via the food chain. Other organisms are mainly affected by the water quality and thus reflect the prevailing conditions at the sampling site.

The methodology here described has been applied with success to Australian waters such as Broken Bay, Cowan Creek, Brisbane Waters, Port Hacking and Botany Bay. Within the Botany Bay Catchment the following areas have been investigated: Botany Bay (Albani, 2008), Cooks River, Scarborough Ponds (Albani, 2005; Albani et al., 2011), Kyle Bay (Albani, 2007). In coastal environments characterised by industrial pressures it has been possible to identify areas with significant ecological abnormality (Albani, 1993; Albani, et al., 1984; Albani et al., 1991; Albani et al., 1998; Serandrei Barbero et al., 1997; Serandrei Barbero et al., 2004). In addition, the methodology adopted here has made it possible to monitor time-related environmental changes internationally (Albani et al., 2007, 2010; Serandrei Barbero et al., 2006) in estuarine environments.

The sediment distribution and the geochemical characteristics of Georges River have been presented in a separate report (Albani and Rickwood, 2010).

## 2 - Benthic foraminifera.

Foraminifera are marine unicellular protozoa that secrete a shell (test) of calcium carbonate; their size generally ranges from 0.1 to 2 mm. They are very sensitive to variations in the physical-chemical characteristics of their environment such as salinity, temperature, food availability and water qualities. The high abundance of individuals (population) and the considerable variety of species (assemblage) present in a small sample of the bottom sediment, even in a restricted environment, make it possible to recognise any slight changes in the total assemblage, as well as in the various populations. Often these differences are not in the presence or absence of various species, i.e. at the assemblage level, but in the relative abundance of the various species.

Because of their short life span, approximately 9-12 months, and the fact that they secrete a shell, the occurrence of foraminifera is not restricted to the time of the sampling and it offers a time-integrated view of the water qualities.

If the main aim is to recognise ecologically similar environments, it is desirable to adopt a technique that would tend to minimise seasonal variations. Both living and dead individuals are considered, thus eliminating the problem of repetitive sampling due to seasonal variations; an integrated view that includes seasonal variations is obtained.  Temporary changes in conditions, which although may produce drastic but short lived effects on the benthic population, have little impact on the overall data base as the span of time of the sampled population may be of a few years. Only those persistent conditions that affect permanently the overall assemblage can be recognised. Because of these capabilities, the benthic foraminifera are an ideal group of organisms for long term monitoring purposes.

In recent years numerous studies conducted along the eastern coast of Australia and overseas have shown that benthic foraminifera can be very effectively used to delineate ecological provinces (biotopes). The level at which the various sediment samples link together to form the biotope, is an expression of faunal similarity.
To be able to recognise such conditions of environmental stress in the Australian estuaries is of great importance for the remediation, planning and monitoring programs. In particular for those waterways that are subject to urban and industrial pressure such as the Cooks River, Georges River and Botany Bay.

## 3 - Methodology

Sampling is carried out using a modified “grab sampler” that obtains a sample of the top 10 cm of the seabed over a surface area of 40 $cm^2$ (Fig. 1). The grab is easily used from a relatively small vessel (Fig. 2) and the sample obtained is placed in a plastic bag (Fig. 3). The sampling was conducted over 3 weeks to minimise any variation due to weather conditions.
A portion of 60 $cm^3$ is taken from the original sample (Fig. 4), wet sieved through a 63µm nylon mesh to eliminate silt and clay. The residue is dried and the foraminifera concentrated using a floatation method (Fig. 5). The concentrate generally contains up to 10,000-20,000 individuals; this assemblage is subdivided using a micro splitter to obtain a representative assemblage of about 500 - 800 individuals. All the individuals are identified through microscopic examination (Fig. 6), their number recorded and, finally, expressed as percentage species population of the total assemblage present in the sample. In past experience (Serandrei Barbero, 1997) an assemblage greater than 600 individuals does not change the final percentage value of each population. The percentage population of each species, with respect to the total assemblage form the numerical basis for the statistical analysis.

Figure 1 – The sampling “grab” in the open position.


Figure 2 – One of the sampling vessels

Figure 3 – Seabed samples being transferred into plastic bags

Figure 4 – The samples in plastic bags ready for analysis


Figure 5 – The sieving process

Figure 6 – The samples ready for microscopic examination

The data set is processed using a number of statistical approaches, among which are factor and cluster analyses. The results are shown as a dendrogram that graphically groups together the samples according to their level of similarity, based on the composition of the foraminiferal fauna, and therefore they identify areas of similar environmental conditions (biotopes).

The results are plotted on thematic maps to indicate the distributions of the various species (Appendix 1) and they reflect the conditions of the estuary/river bed at the time of sampling and when compared with the results from similar future studies will reveal time-related changes (environmental improvements or/and deteriorations), which can form the basis for long-term monitoring programs.

## 4 – Results

### 4.1 – Foraminiferal assemblages.

Sixty samples have been used to evaluate the distribution of the foraminiferal benthic assemblage in Georges River Estuary (Fig.7).
The Georges River has been traditionally subdivided into an upper section from the source around Appin to the Liverpool Weir and it consists of fresh water. The middle section is from Liverpool Weir to Salt Pan Creek and the lower section from Salt Pan Creek to the river’s mouth in Botany Bay. The middle and lower sections from Liverpool Weir to Botany Bay are subject to tidal response.

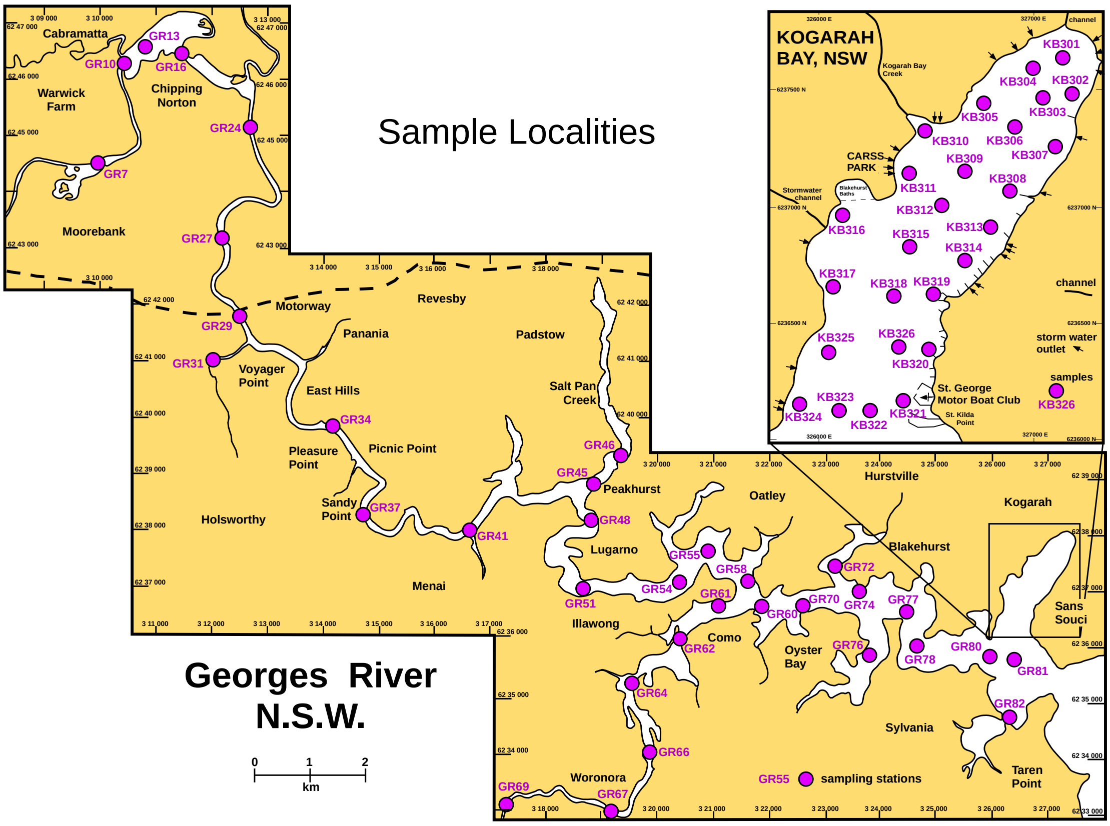


Figure 7 - Locations of the sampling sites used for this study

The large catchment area (960 km$^2$) and the relative small surface area of the watercourse, 96 km long, but generally narrow, and the high level of urbanisation are reflected in the variable conditions of the water qualities.

The foraminiferal assemblages reflect this hydrodynamic regime with a large number of species occurring often in 1 sample only. In order to assess the difference between a narrow river course and a wider embayment, that generally offers more stable conditions, Kogarah Bay has been included in the samples used for this study.

Out of the 60 sampling sites on the Georges River estuary, 6 of them, equivalent to 10% of the total samples, did not record any benthic foraminifera.

The numeric distributions of the 41 species found are based on the remaining 54 samples. The numeric treatment of the total assemblages is based on a data set of 380 data points and the number of individuals in each sample varies from 6 to 2008.

In Table 1 a summary of the quantitative character of each species is shown together with the level of occurrence.

| | Foraminiferal species | average | median | range | occurrence |
|---|---|---|---|---|---|
| 1 | *Ammodiscus incertus* | 14.86 | 0.92 | 0.78 - 65.91 | 5 |
| 2 | *Protoschista findens* | 4.05 | | | 1 |
| 3 | *Reophax scorpiurus* | 2.85 | 2.85 | 2.05 - 3.64 | 2 |
| 4 | *Miliamina fusca* | 10.46 | 5.41 | 0.12 - 41.18 | 9 |
| 5 | *Haplofragmoides australensis* | 37.46 | 37.77 | 2.70 - 85.00 | 18 |
| 6 | *Ammobaculites subcatenulatus* | 6.16 | 4.13 | 0.68 - 19.35 | 10 |
| 7 | *Ammotium cassis* | 0.83 | 0.91 | 0.68 - 0.92 | 3 |
| 8 | *Textularia conica* | 7.66 | 7.66 | 7.06 - 8.26 | 2 |
| 9 | *Textularia pseudogramen* | 1.70 | 1.70 | 1.55 - 1.85 | 2 |
| 10 | *Eggerella australis* | 11.86 | 7.14 | 0.40 - 100.0 | 35 |
| 11 | *Trochammina inflata* | 4.21 | 1.70 | 0.13 - 34.48 | 20 |
| 12 | *Paratrochammina bartrami* | 19.03 | 8.53 | 0.91 - 52.63 | 5 |
| 13 | *Tritaxis conica* | 5.41 | 5.27 | 1.85 - 10.34 | 10 |
| 14 | *Spiroloculina communis* | 0.56 | | | 1 |
| 15 | *Spiroloculina lucida* | 3.01 | 2.32 | 0.12 - 6.49 | 11 |
| 16 | *Quinqueloculina lamarckiana* | 0.29 | 0.29 | 0.28 - 0.30 | 2 |
| 17 | *Quinqueloculina oblonga* | 5.77 | 2.99 | 0.81 - 14.55 | 7 |
| 18 | *Quinqueloculina seminula* | 2.27 | 1.57 | 0.35 - 5.56 | 4 |
| 19 | *Quinqueloculina subpolygona* | 0.40 | | | 1 |
| 20 | *Quinqueloculina tasmanica* | 2.99 | 1.44 | 0.35 - 9.09 | 10 |
| 21 | *Quinqueloculina tenagos* | 0.20 | | | 1 |
| 22 | *Quinqueloculina tropicalis* | 4.96 | 1.39 | 0.92 - 16.67 | 5 |
| 23 | *Triloculina tricarinata* | 0.54 | | | 1 |
| 24 | *Miliolinella labiosa* | 0.10 | | | 1 |
| 25 | *Guttulina problema* | 2.62 | 0.78 | 0.28 - 16.67 | 14 |
| 26 | *Lagena striata strumosa* | 0.21 | 0.26 | 0.10 - 0.28 | 3 |
| 27 | *Fissurina fasciata carinata* | 0.19 | 0.19 | 0.10 - 0.28 | 2 |
| 28 | *Brizalina striatula* | 2.29 | 0.79 | 0.12 - 16.67 | 14 |
| 29 | *Bolivina robusta* | 2.49 | 2.23 | 0.10 - 5.13 | 3 |
| 30 | *Siphogenerina raphana* | 0.53 | 0.53 | 0.26 - 0.80 | 2 |
| 31 | *Bulimina gibba* | 0.60 | 0.56 | 0.26 - 1.00 | 3 |
| 32 | *Cancris auriculus* | 0.50 | | | 1 |
| 33 | *Ammonia aoteana* | 53.29 | 49.31 | 1.36 - 100.0 | 48 |
| 34 | *Elphidium advenum advenum* | 11.36 | 8.87 | 0.59 - 42.86 | 20 |
| 35 | *Elphidium advenum limbatum* | 11.28 | 9.47 | 1.11 - 29.03 | 23 |
| 36 | *Elphidium albanii* | 8.28 | 6.67 | 2.55 - 46.15 | 28 |
| 37 | *Elphidium craticulatum* | 7.46 | 2.94 | 0.55 - 21.71 | 13 |
| 38 | *Elphidium hispidulum* | 0.20 | | | 1 |
| 39 | *Elphidium hawkesburiensis* | 1.35 | 0.85 | 0.82 - 2.39 | 5 |
| 40 | *Elphidium lene* | 8.27 | 3.99 | 0.09 - 45.95 | 26 |
| 41 | *Elphidium macellum* | 1.81 | 0.71 | 0.28 - 9.09 | 8 |

Table 1 – average, median and range of abundance of each species; occurrence is in number of sampling sites in which each species is present.

Of the 6 sampling sites without benthic foraminifera 4 are likely to be linked to water quality conditions and land use:

GR7 – close to the Sewage Works at Warwick Farm and receiving water inputs from Lake Monroe.

GR31 – just downstream from the Holsworthy Sewage Treatment Plant that was decommissioned in 2008.

GR34 – off Pleasure Point, sewered in 2001 with a reduction of the septic tanks leakages

GR46 – Salt Pan Creek downstream from the industrial estates.

GR58 – off Gungah Bay. The SewerFix programme (2006-2008) reduced wet weather overflows.

GR51 may require a closer investigation of the River, the land use and the location of effluent from drains.

Upstream from Sandy Point the benthic fauna (Fig. 8) becomes restricted to 1 or 2 species only, while the greatest diversity is in the most downstream portion of the study area with a maximum of 24 species.

A greater influence of the tidal flow appears to be reflected in such great diversity.

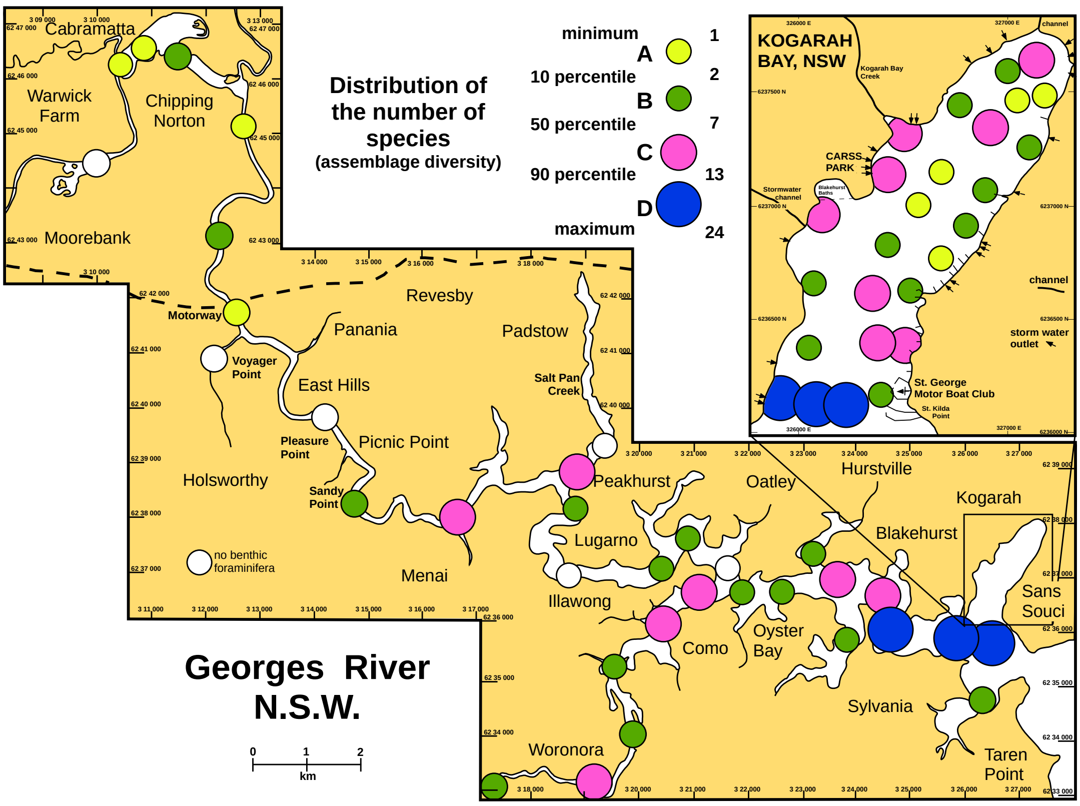


Figure 8 – Distribution of the number of species throughout the study area.

A similar pattern is exhibited by the number of individuals present at each station (Fig.9) but with a more regular increase from Chipping Norton to Taren Point.

The only exceptions, with low diversity, are at GR60, just off the railway bridge at Como and GR72 in the downstream section of Oatley Bay. At these locations a more intensive monitoring program should be considered.

The relatively small catchment area of the Woronora River and the stability of its soil cover (i.e. bushland) determine a lower level of sediment input reflected in a higher number of benthic individuals. Kogarah Bay shows a similar pattern.

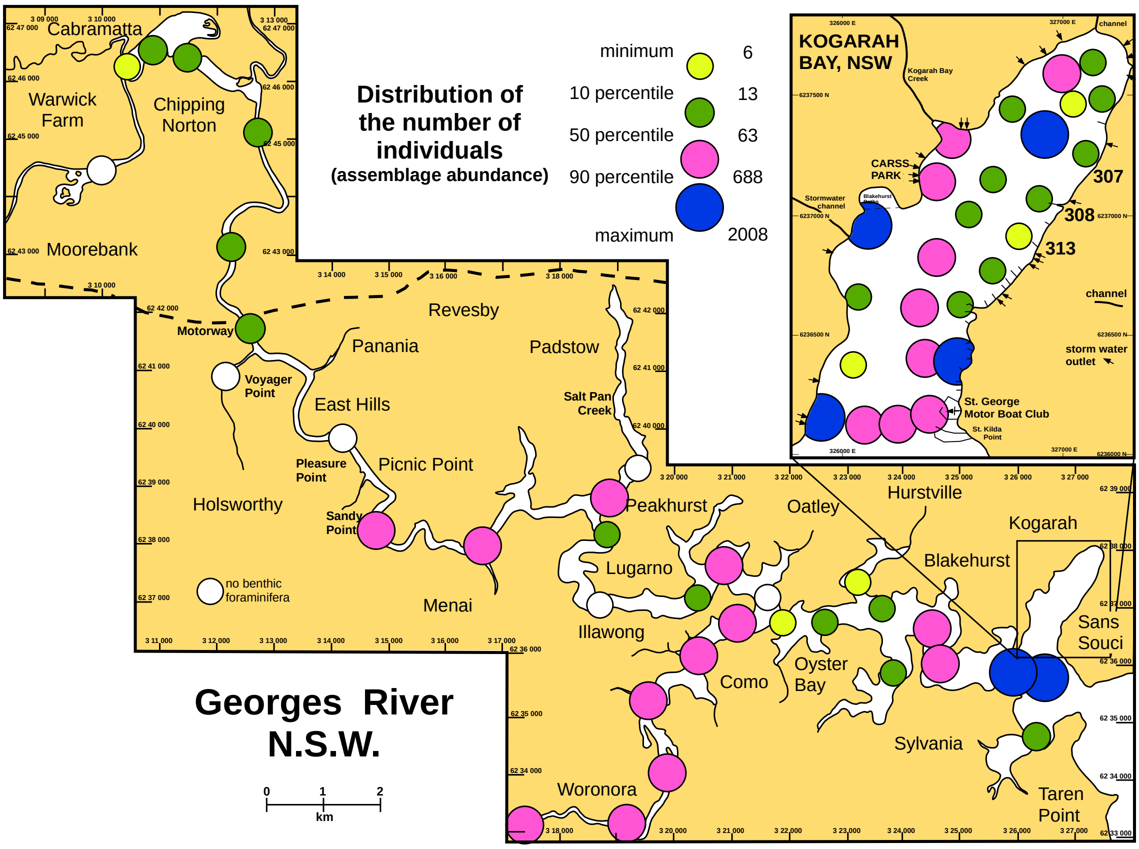


Figure 9 – Distribution of the number of individuals throughout the study area.

## 4.2 – Foraminiferal Biotopes

Q-mode cluster analysis has been applied to the total data set. The similarity matrix has been generated using the Euclidean distance coefficient and the

output has been plotted as a dendrogram, which graphically represents the links between stations on the basis of the levels of faunal similarity.
Seven groups have been recognised and interpreted (Fig. 10).

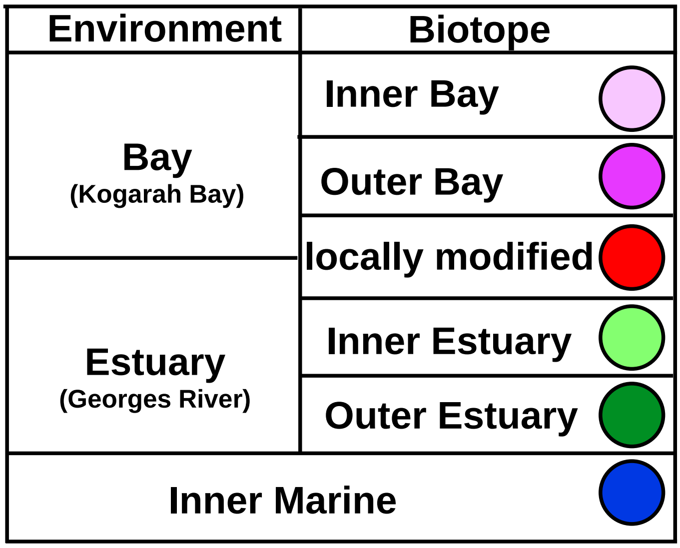


Figure 10 – Foraminiferal Biotopes and environmental considerations.

The Biotopes are labelled following their predominant occurrence in the study area (Fig. 11).

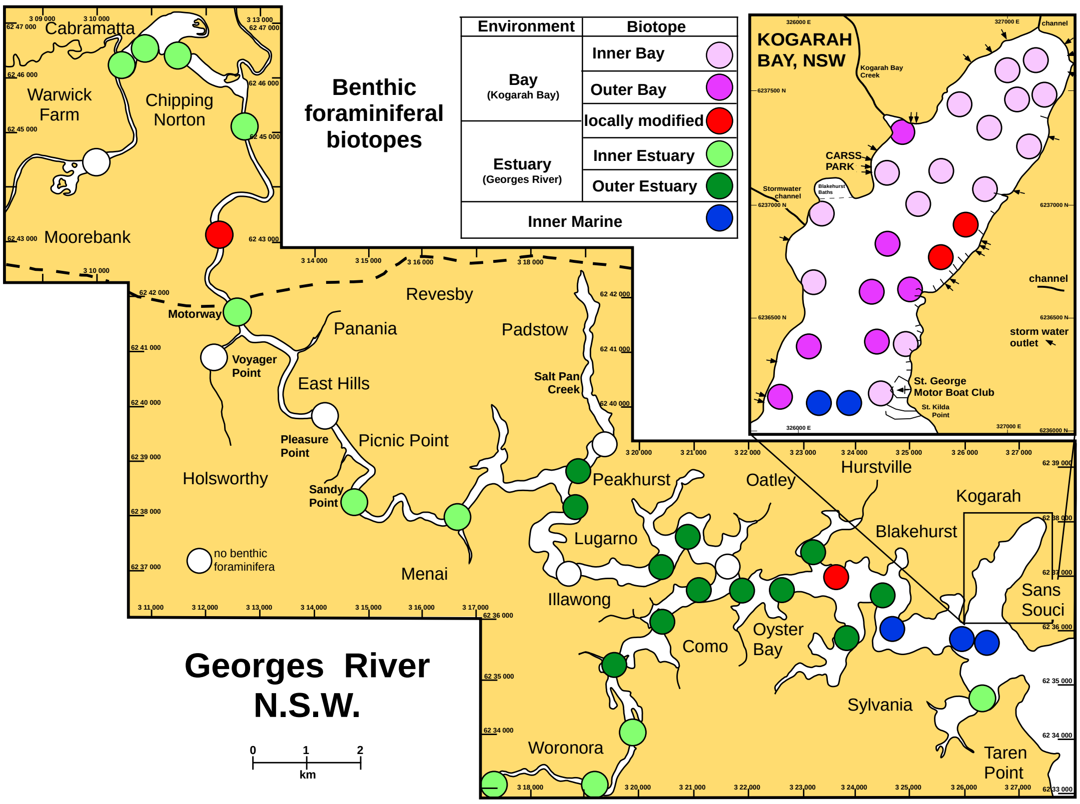


Figure 11 – Distribution of the Biotopes in the study area.

| | Foraminiferal species | E1 | E2 | B1 | B2 | T |
|---|---|---|---|---|---|---|
| 1 | *Ammodiscus incertus* | ■ | ■ | | | |
| 2 | *Protoschista findens* | ■ | | | | |
| 3 | *Reophax scorpiurus* | | ■ | | | |
| 4 | *Miliamina fusca* | ■ | ■ | ■ | | |
| 5 | *Haplofragmoides australensis* | ■ | ■ | | | ■ |
| 6 | *Ammobaculites subcatenulatus* | ■ | ■ | | | |
| 7 | *Ammotium cassis* | ■ | ■ | | | |
| 8 | *Textularia conica* | | ■ | | | |
| 9 | *Textularia pseudogramen* | | | | ■ | |
| 10 | *Eggerella australis* | ■ | ■ | ■ | ■ | ■ |
| 11 | *Trochammina inflata* | ■ | ■ | ■ | ■ | ■ |
| 12 | *Paratrochammina bartrami* | ■ | ■ | | | |
| 13 | *Tritaxis conica* | | ■ | ■ | | |
| 14 | *Spiroloculina communis* | | | | | ■ |
| 15 | *Spiroloculina lucida* | ■ | ■ | | | ■ |
| 16 | *Quinqueloculina lamarckiana* | | | | | ■ |
| 17 | *Quinqueloculina oblonga* | | | ■ | | ■ |
| 18 | *Quinqueloculina seminula* | | | | | ■ |
| 19 | *Quinqueloculina subpolygona* | | | | | ■ |
| 20 | *Quinqueloculina tasmanica* | | | ■ | ■ | ■ |
| 21 | *Quinqueloculina tenagos* | | | | | ■ |
| 22 | *Quinqueloculina tropicalis* | ■ | ■ | | | |
| 23 | *Triloculina tricarinata* | | | | ■ | |
| 24 | *Miliolinella labiosa* | | | | | ■ |
| 25 | *Guttulina problema* | | | ■ | ■ | ■ |
| 26 | *Lagena striata strumosa* | | | | | ■ |
| 27 | *Fissurina fasciata carinata* | | | | | ■ |
| 28 | *Brizalina striatula* | | ■ | ■ | ■ | ■ |
| 29 | *Bolivina robusta* | | | | | ■ |
| 30 | *Siphogenerina raphana* | | | | | ■ |
| 31 | *Bulimina gibba* | | | | | ■ |
| 32 | *Cancris auriculus* | | | | | ■ |
| 33 | *Ammonia aoteana* | ■ | ■ | ■ | ■ | ■ |
| 34 | *Elphidium advenum advenum* | | | ■ | ■ | ■ |
| 35 | *Elphidium advenum limbatum* | | ■ | ■ | ■ | ■ |
| 36 | *Elphidium albanii* | | ■ | ■ | ■ | ■ |
| 37 | *Elphidium craticulatum* | | | ■ | ■ | ■ |
| 38 | *Elphidium hispidulum* | | | | | ■ |
| 39 | *Elphidium hawkesburiensis* | | | | | ■ |
| 40 | *Elphidium lene* | ■ | ■ | ■ | ■ | ■ |
| 41 | *Elphidium macellum* | | | ■ | ■ | ■ |

E1- Inner Estuary; E2 Outer Estuary; B1- Inner Bay; B2- Outer Bay;
T- Inner Marine

Table 2 – Distribution of each species within the Biotopes.

Three environments are clearly identified; open Bay, Estuary and Inner Marine that extends in the outer portion of Kogarah Bay. In addition 4 sampling sites, 2 each in the Estuary and the Bay appear to be related to local inputs possibly from urbanisation and they are labelled as “locally modified”. Some further environmental assessment is suggested. In Kogarah Bay the inputs seem to be associated with the stormwater outlets as both stations are in proximity of the same input source.

It must be noted that the distributions of the Foraminiferal Biotopes along the Georges River, downstream from the weir, closely coincide with the traditionally established subdivisions of the River itself.

The composition of each Biotope is tabulated in Table 2.

## 4.3 – Foraminiferal species

The distribution of the 41 foraminiferal species is closely linked to the environmental conditions prevailing in the different sections of the Georges River.

A great number of species (14 = 34% of the foraminiferal fauna) occur in 10% or less of the sampling sites and only 7 (= 17% of the fauna) occur more than 90% of the stations (Fig. 12).

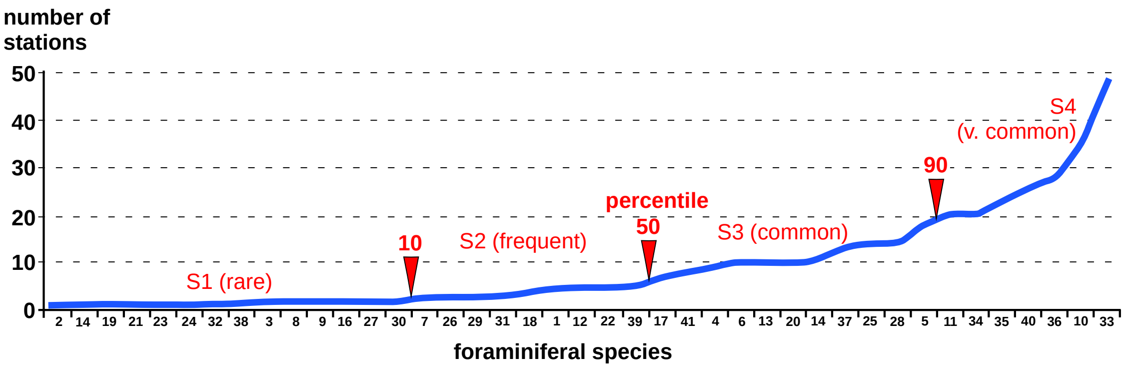


Figure 12 – Distribution of the foraminiferal species (see identifiers, Tables 1, 2) according to the number of stations in which they occur.

They can be subdivided into four groups according to their occurrence.

**Group S1** – It is composed by rare species occurring generally in 1 or 2 sampling sites. Nine of them (species 14, 16, 19, 21, 24, 27, 30, 32, 38) are restricted to the Inner Marine Biotope that benefits from the influx of marine waters; two species are present in the Kogarah Outer Bay (9, 23) and 2 in the Outer Estuary (3, 8). Only one species (2) is present in the Inner Estuary. The Inner Marine Biotope has the greatest diversity of all the biotopes and reflects the marine input.

**Group S2** – This group consists of the 50 percentile of the fauna (9 species = 22% of the total fauna) and again the Inner Marine Biotope shows a slightly richer fauna with 5 species (18, 26, 29, 31, 39) while the remaining 4 species are present in the estuary (1, 7, 12, 22).

**Group S3** – Common species form this group (11 species = 27% of the total fauna). They show a much wider occurrence although with some selective presence. Three species (17, 25, 41) are present in the Inner Marine and in the Inner and Outer (Kogarah) Bay Biotopes; 2 (6, 15) are present in the Inner Marine and Estuary Biotopes, 4 species (4, 5, 13, 28) occur in the Estuary and Bay while 2 (20, 37) in Kogarah Bay only.

**Group S4** – Only 7 species (equivalent to 17% of the fauna) are very common and occur in most sampling sites. Three (10, 11, 33) are the most cosmopolitan species in the study area, while 2 (34, 36) are present only in the Outer Estuary and Kogarah Bay Biotopes. Two more (35, 40) occur in the outer portion of the Estuary and in Kogarah Bay environments.

While these distributions are the results of the present sampling program, the variability of the environmental parameters may generate a slightly different pattern if sampling is repeated after a long period of relative uniform conditions, both climatic and land use.

In the Appendix the distributions of each individual species are shown as thematic maps. The identifications are based on the Interactive Computer Catalogue (Albani et al. 2001) and the illustrations are also from that catalogue as well as from a number of publications (Albani, 1968, 1970, 1974, 1978, 1981; Albani and Yassini, 1989, 1994, Lewis, 2006).

## 5 – Conclusions and Recommendations

The distribution of the benthic foraminiferal species reflects the predominant hydrodynamic behaviour of the water masses flowing along the Georges River and its Bays and tributaries. The patchiness of the “rare” and “frequent” species responds to the variability of the environmental conditions.

The overall distribution supports the geographical subdivision of the river course into middle and lower sections; however, the section downstream from Bald Face Point reflects more the input of the tidal waters from Botany Bay with the consequent enrichment of the benthic fauna (Inner Marine Biotope).

In the most outer portion of the estuary some pelagic foraminifera, which are transported by the marine currents, have been found (Fig. 13).

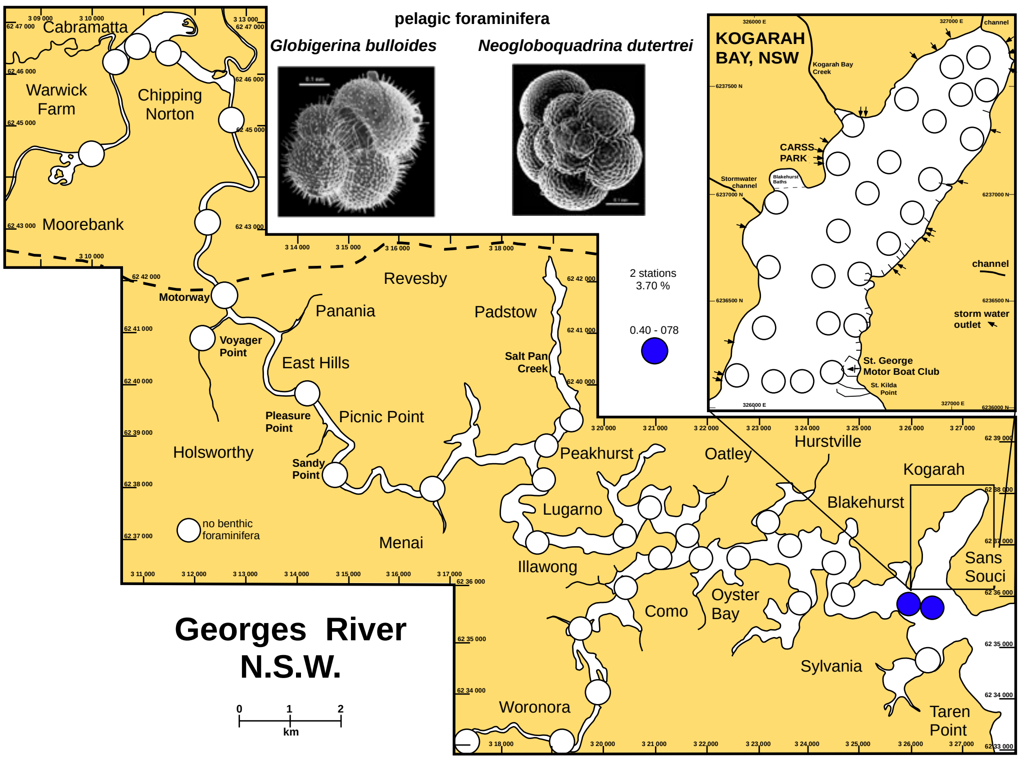


Figure 13 – Distribution of some pelagic foraminifera

The restricted circulation within Sylvania Waters is also reflected in the distribution of the foraminiferal fauna that assume a character typical of the most inner sections of the estuary.

A number of sampling sites did not record any benthic foraminifera and, while some are closely related to anthropogenic local inputs (GR7, GR31, GR34, GR46 and GR58) one, GR51 off Little Moon Bay, requires a closer attention. In case of Gungah Bay it should be noted that a study of Kyle Bay (Albani, 2007) did not find benthic foraminifera, possibly suggesting that these shallow bays may often assume brackish conditions. It is recommended that these localities be examined further and a re-sampling program carried out as soon as practicable.

Low diversity, compared with nearby samples, occur at GR60, just off the railway bridge at Como and GR72 in the downstream section of Oatley Bay. At these locations additional sampling should be considered to verify these findings.

This study forms a baseline data set that should be considered an initial point for time related assessment of the Georges River. If the hydrodynamics of the water flow within Georges River are modified in response to the potential sea level rise. Also if the hydrodynamics and water quality of the estuary is altered, as a result of the treatment of stormwater pollution (quality and quantity) from urban development or, conversely, if urban densification occurs without improving stormwater treatment, a comparison between the distributions of benthic foraminifera from this study and a new future sampling program may offer an understanding of the effects and consequences of these events or changes in management practices.

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# 7 – Appendix

Thematic maps representing the distribution of all the species recorded in the study area. The species are listed in their taxonomic order (= identifiers, see Tables 1 and 2); identifications and illustrations are based on the Interactive Computer Catalogue (Albani, 2001).

The number of stations represents the number of sampling sites.

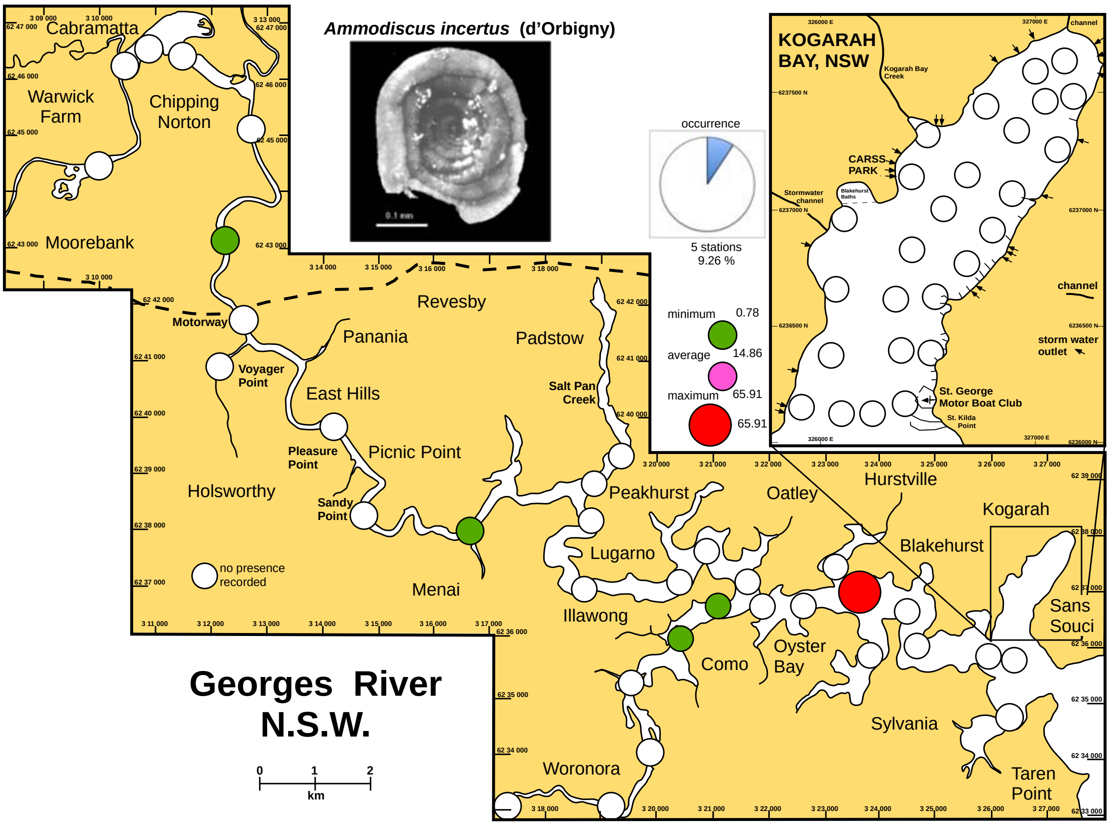


Figure 14 – Distribution of *Ammodiscus incertus* (d'Orbigny) [species 1]

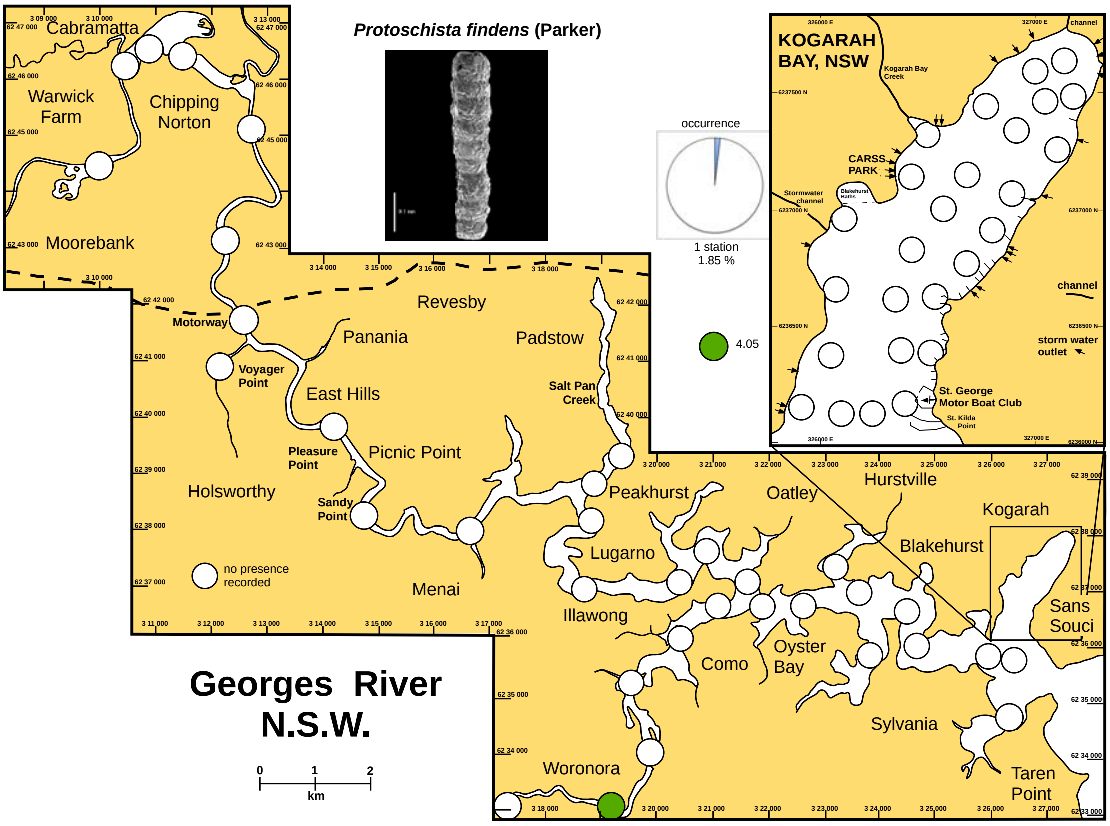

Figure 15 – Distribution of *Protoschista findens* (Parker) [species 2]

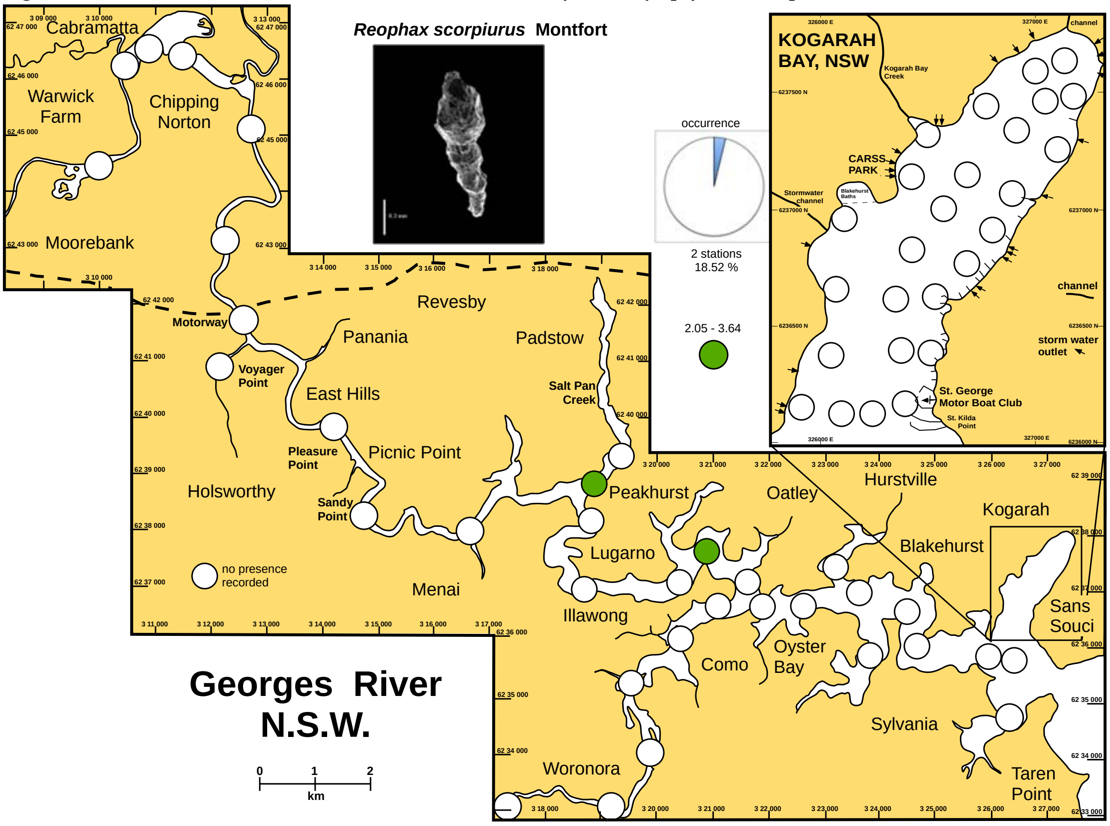


Figure 16 – Distribution of *Reophax scorpiurus* Montfort [species 3]

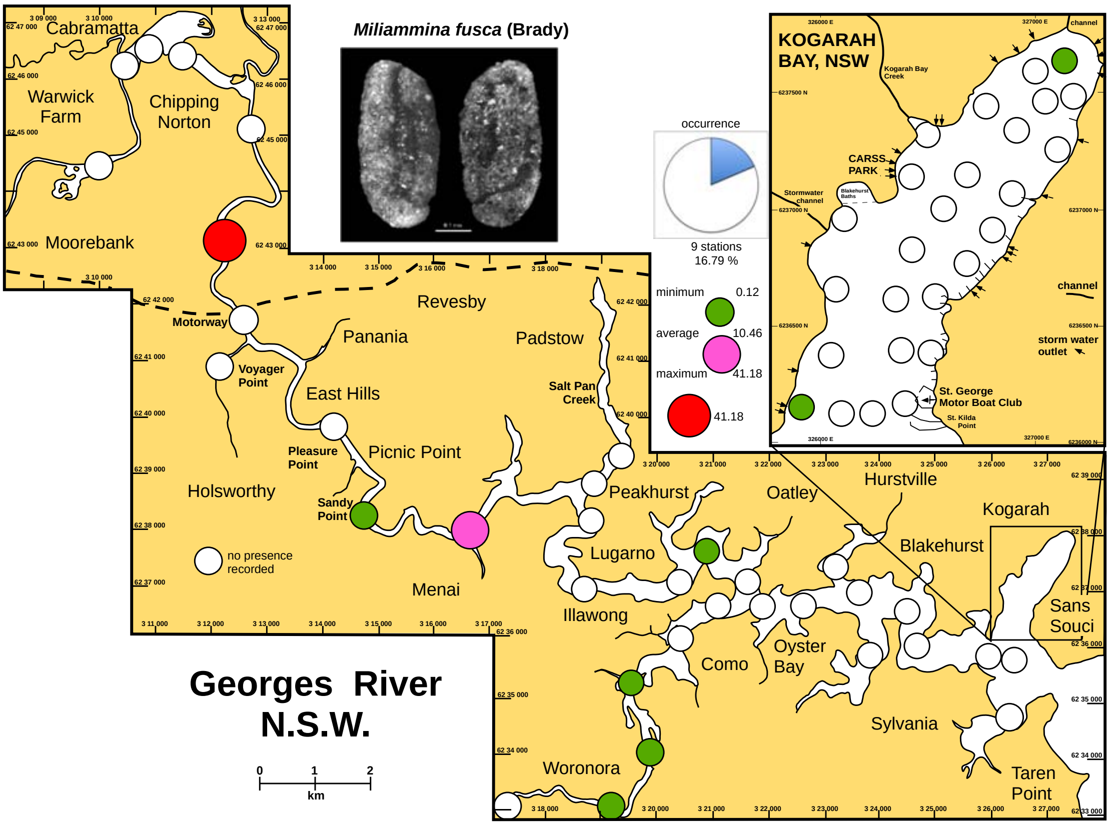


Figure 17 – Distribution of *Miliammina fusca* (Brady) [species 4]

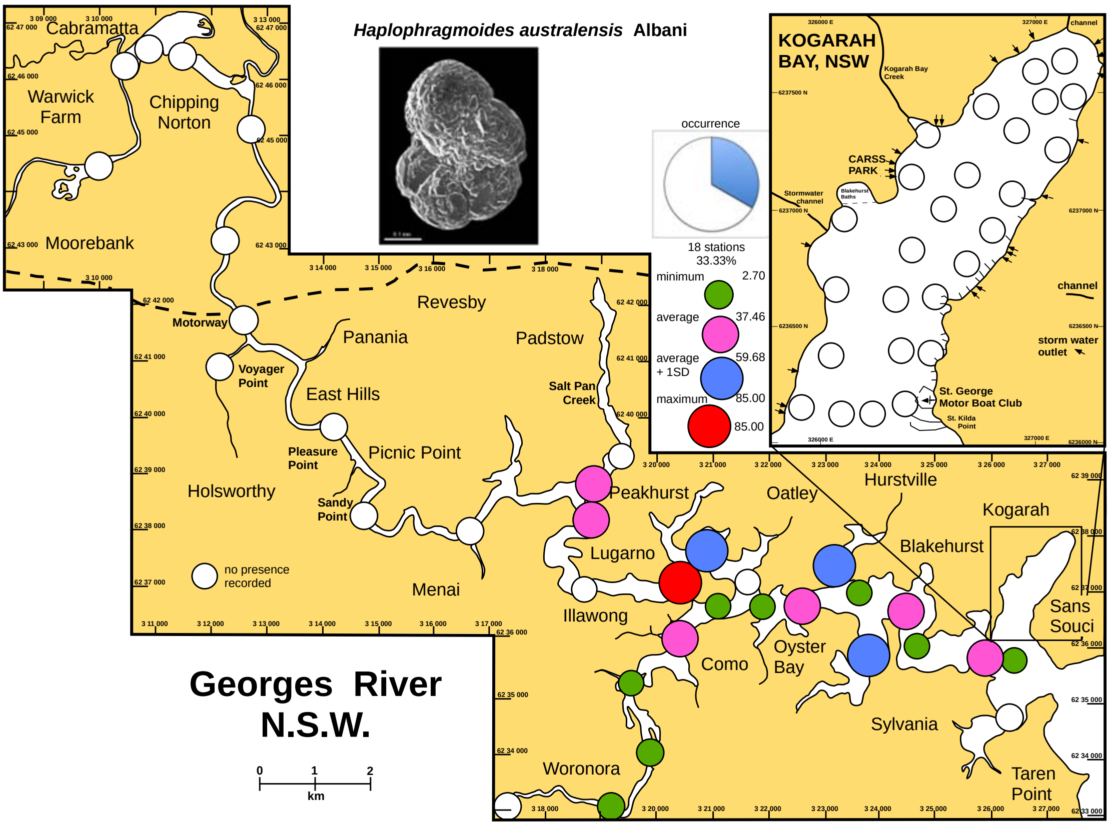


Figure 18 – Distribution of *Haplophragmoides australensis* Albani [species 5]

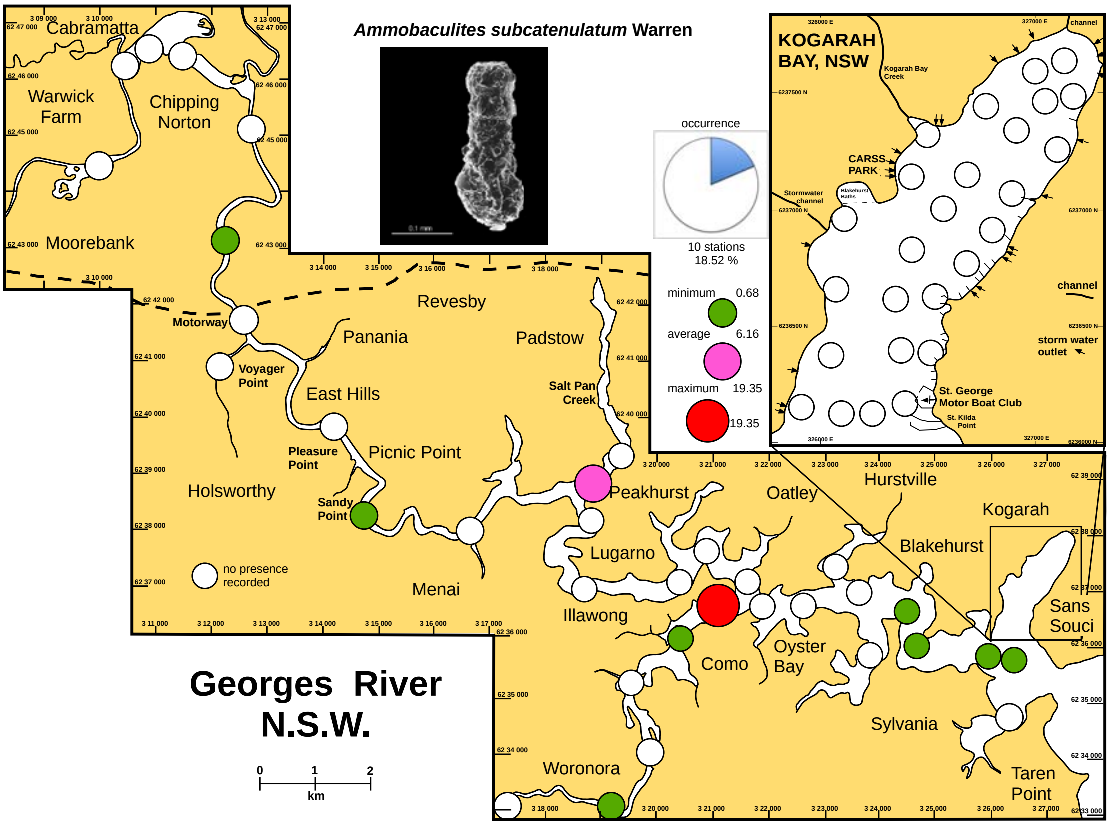


Figure 19 – Distribution of *Ammobaculites subcatenulatum* Warren [species 6]

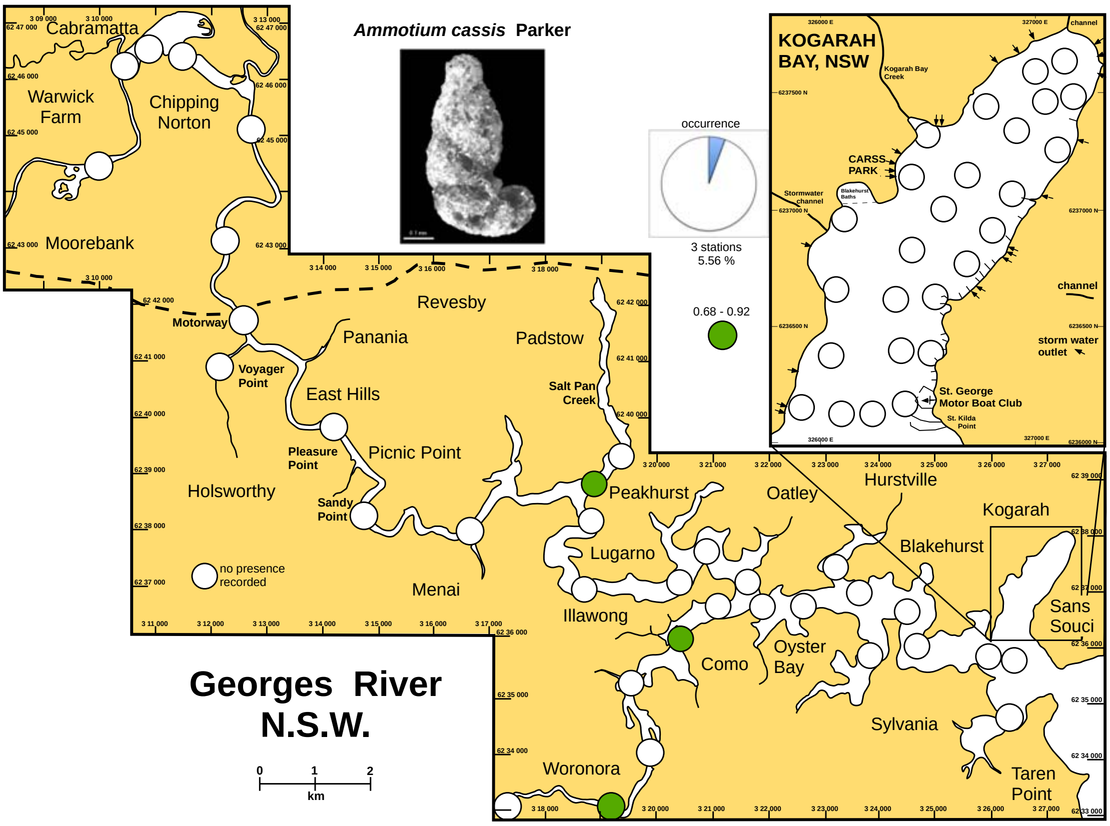


Figure 20 – Distribution of *Ammotium cassis* Parker [species 7]

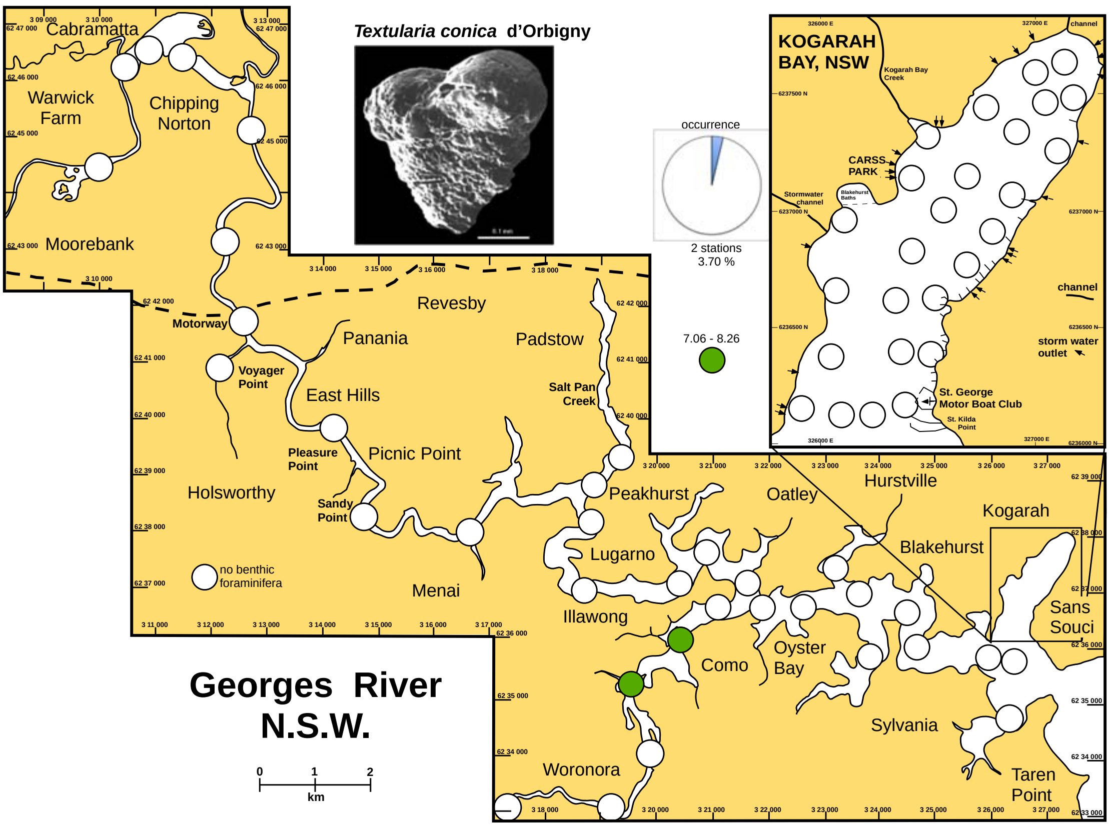


Figure 21 – Distribution of *Textularia conica* d'Orbigny [species 8]

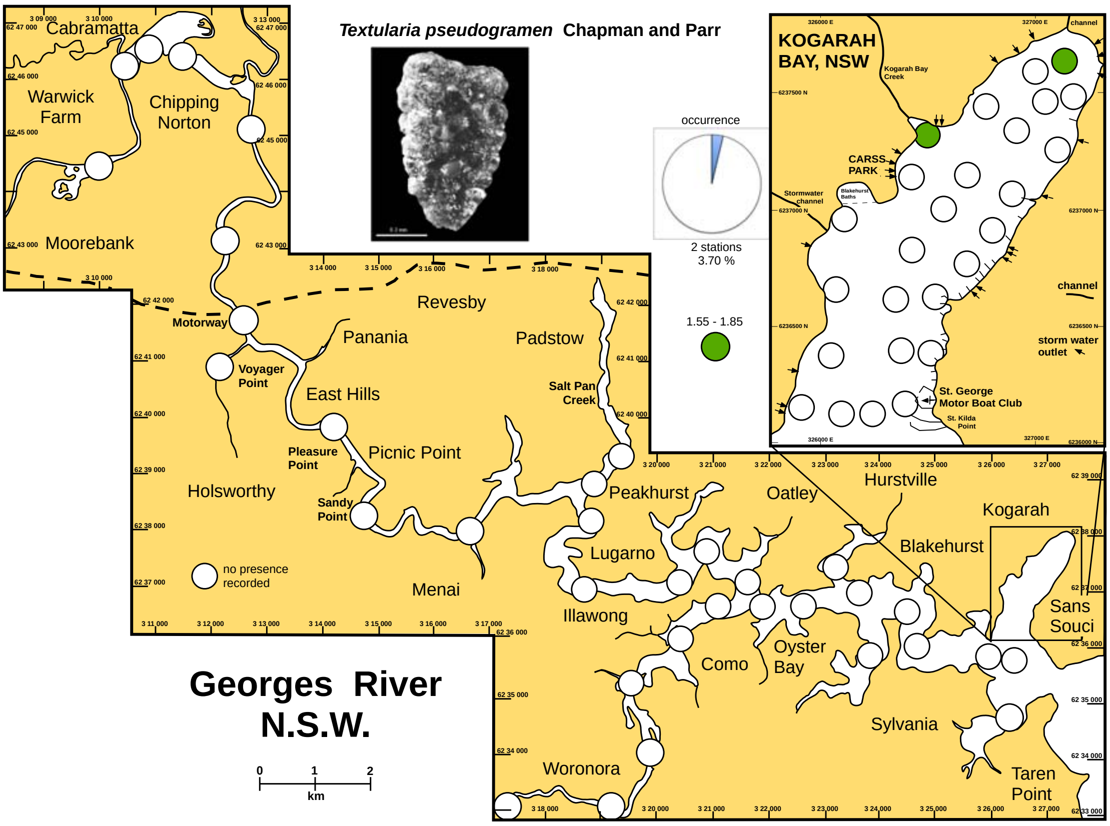


Figure 22 – Distribution of *Textularia pseudogramen* Chapman and Parr [species 9]

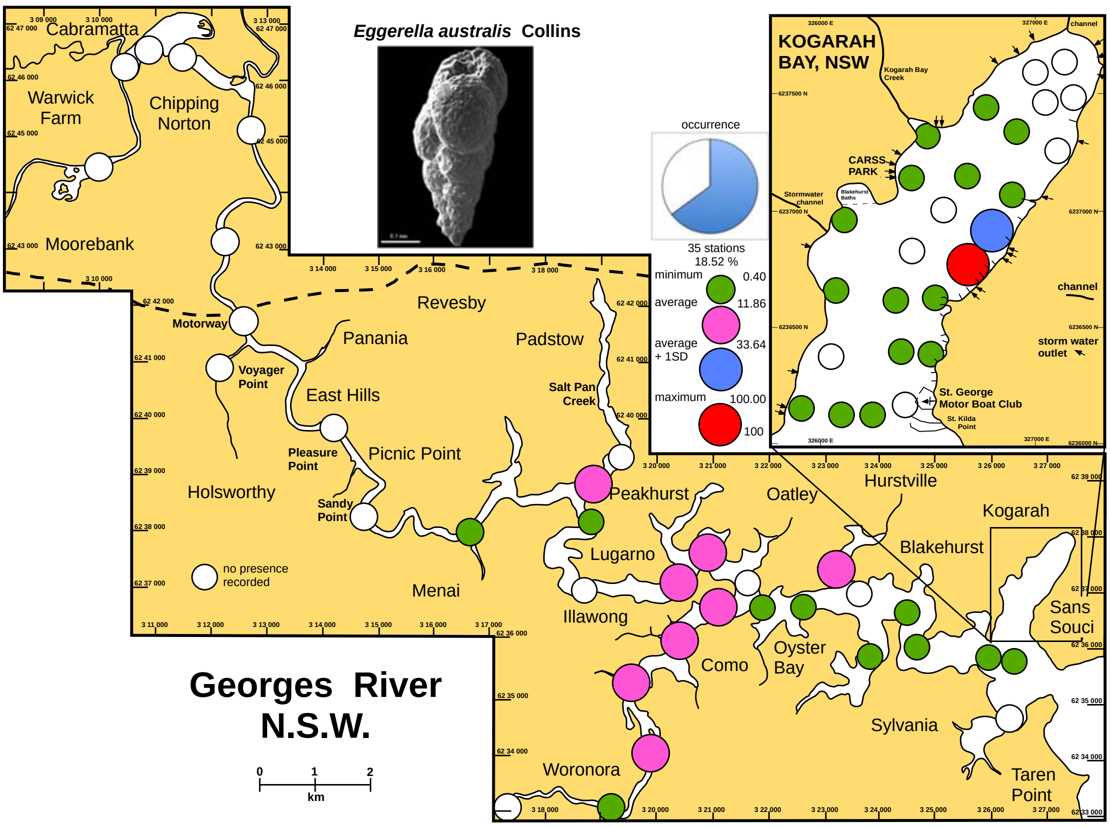


Figure 23 – Distribution of *Eggerella australis* Collins [species 10]

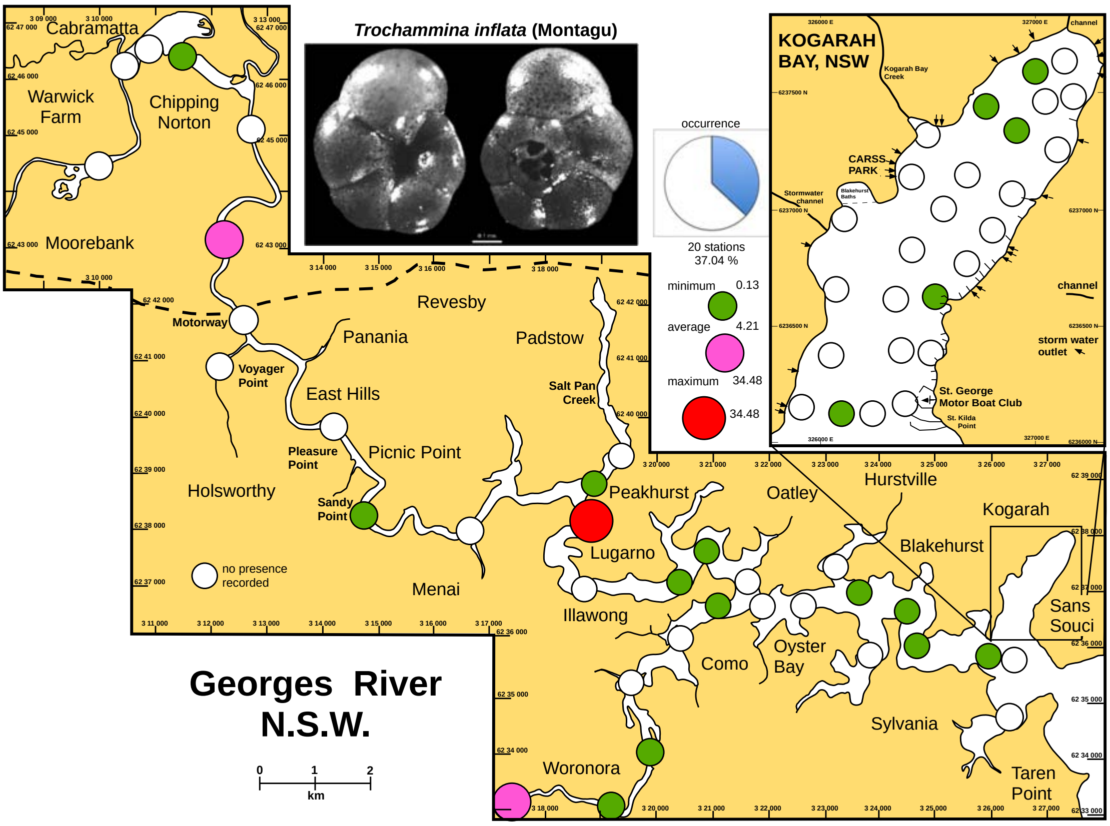


Figure 24 – Distribution of *Trochammina inflata* (Montagu)   [species 11]

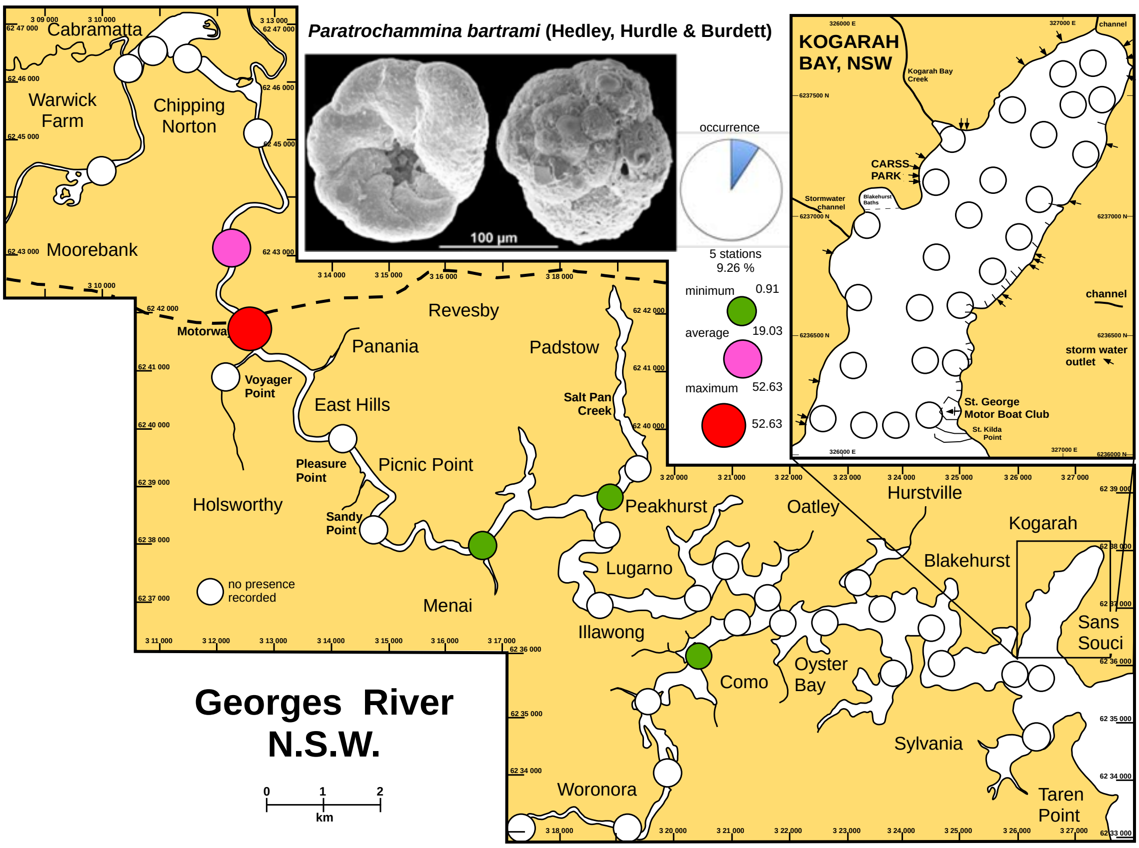


Figure 25 – Distribution of *Paratrochammina bartrami* Hedley, Hurdle & Burdett  [species 12]
(Image after Lewis 2006)

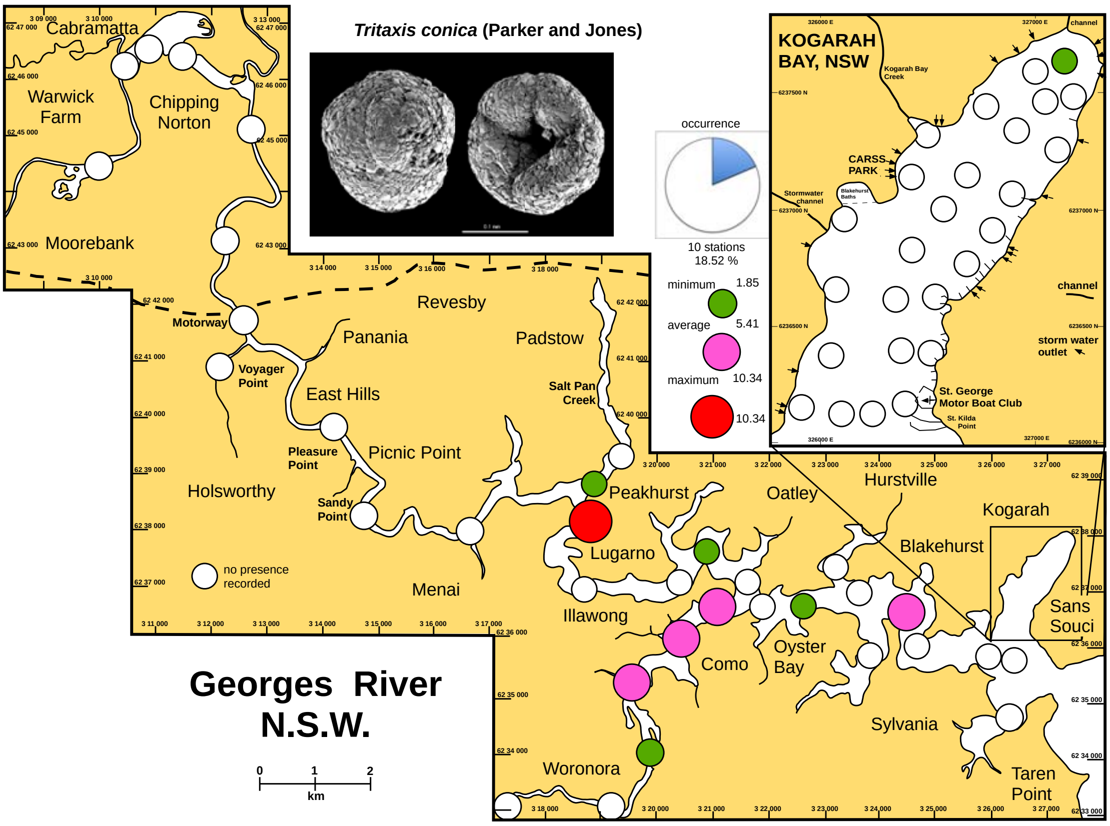


Figure 26 – Distribution of *Tritaxis conica* (Parker and Jones) [species 13]

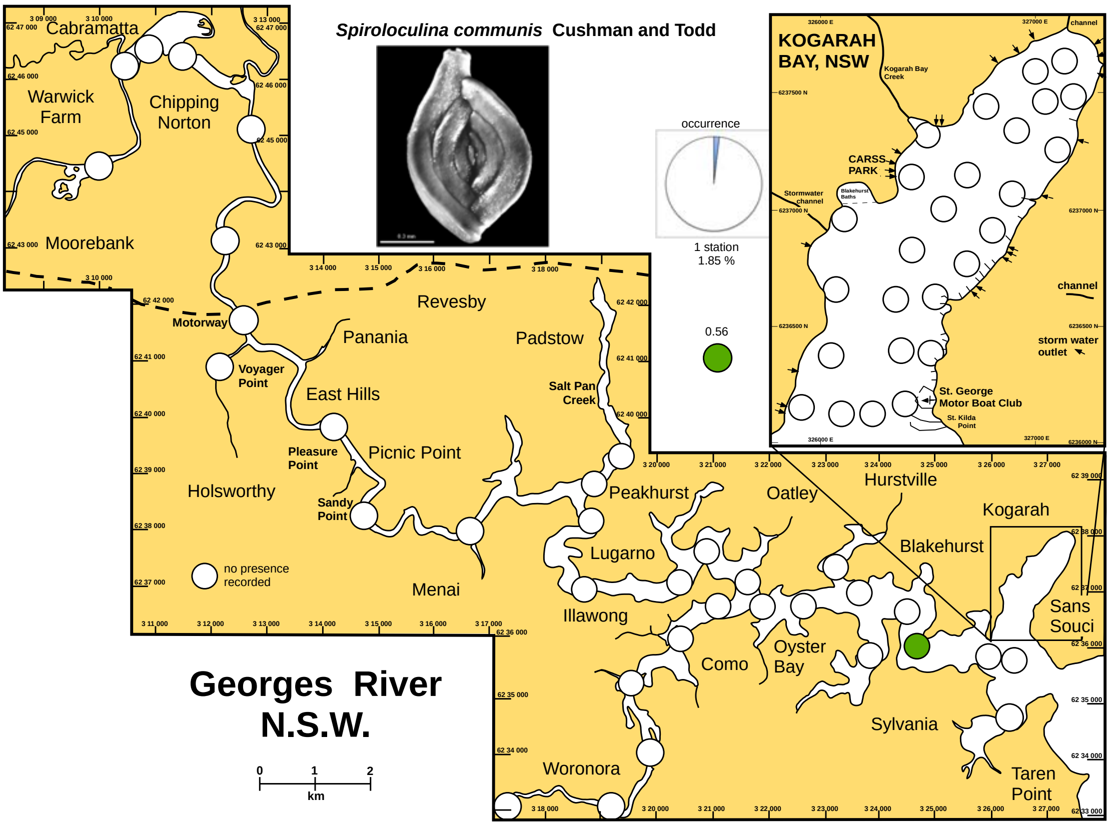


Figure 27 – Distribution of *Spiroloculina communis* Cushman and Todd [species 14]

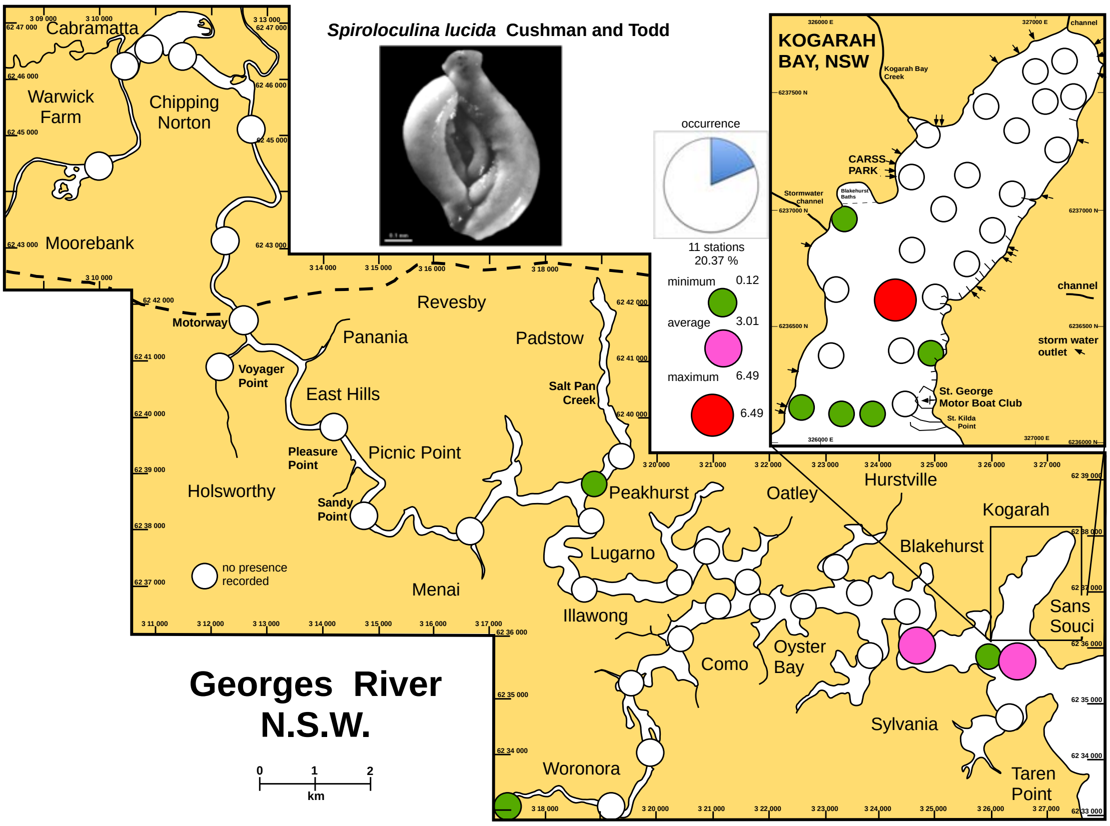


Figure 28 – Distribution of *Spiroloculina lucida* Cushman and Todd [species 15]

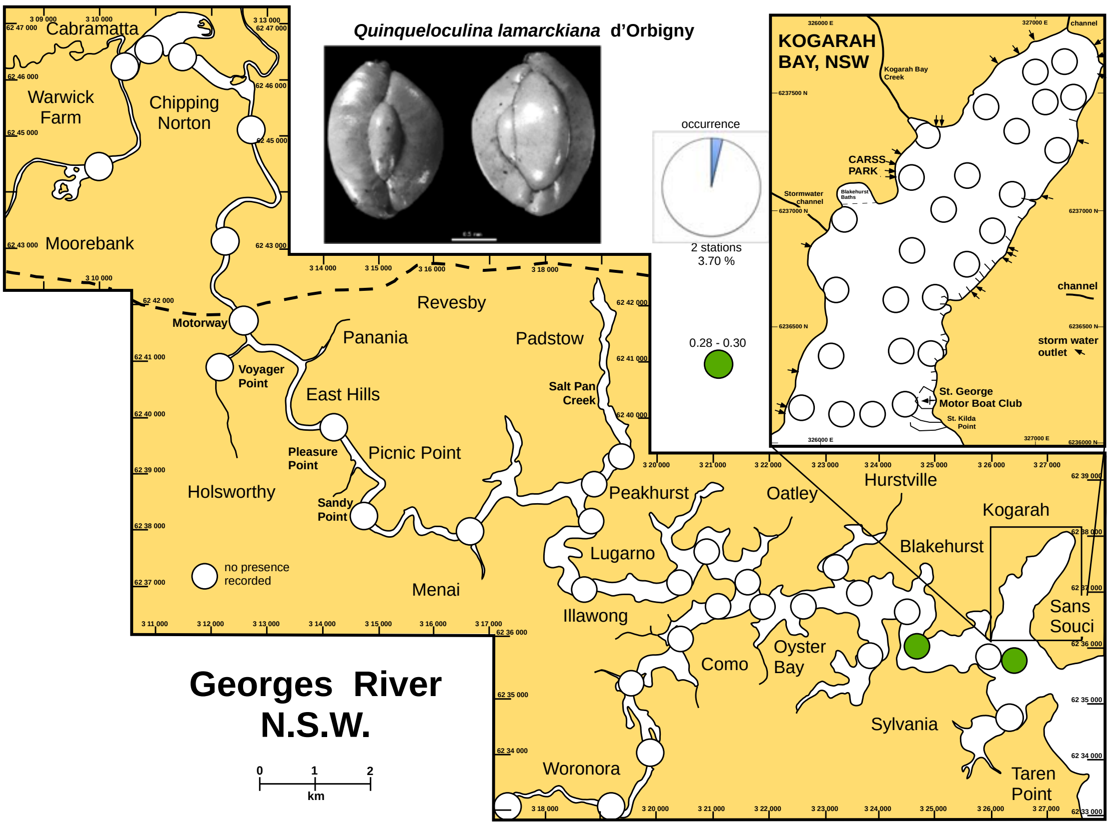


Figure 29 – Distribution of *Quinqueloculina lamarckiana* d'Orbigny [species 16]

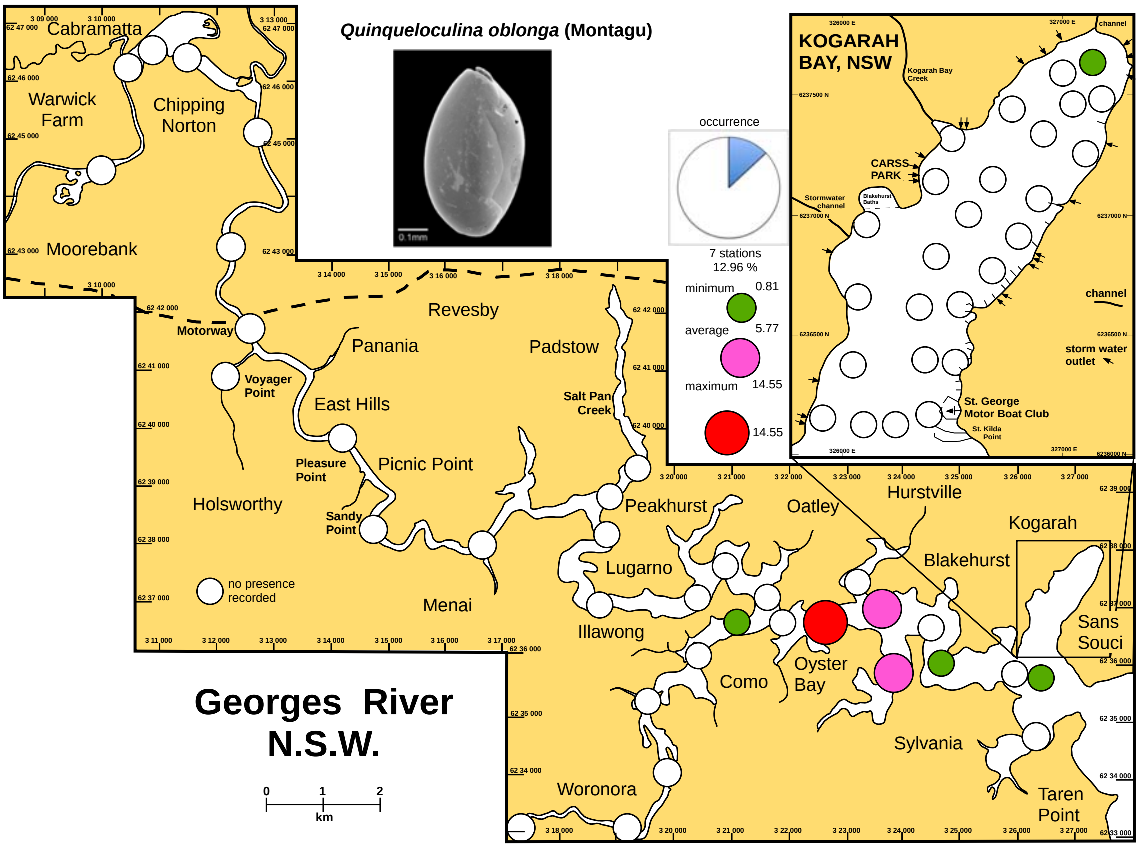


Figure 30 – Distribution of *Quinqueloculina oblonga* (Montagu) [species 17]

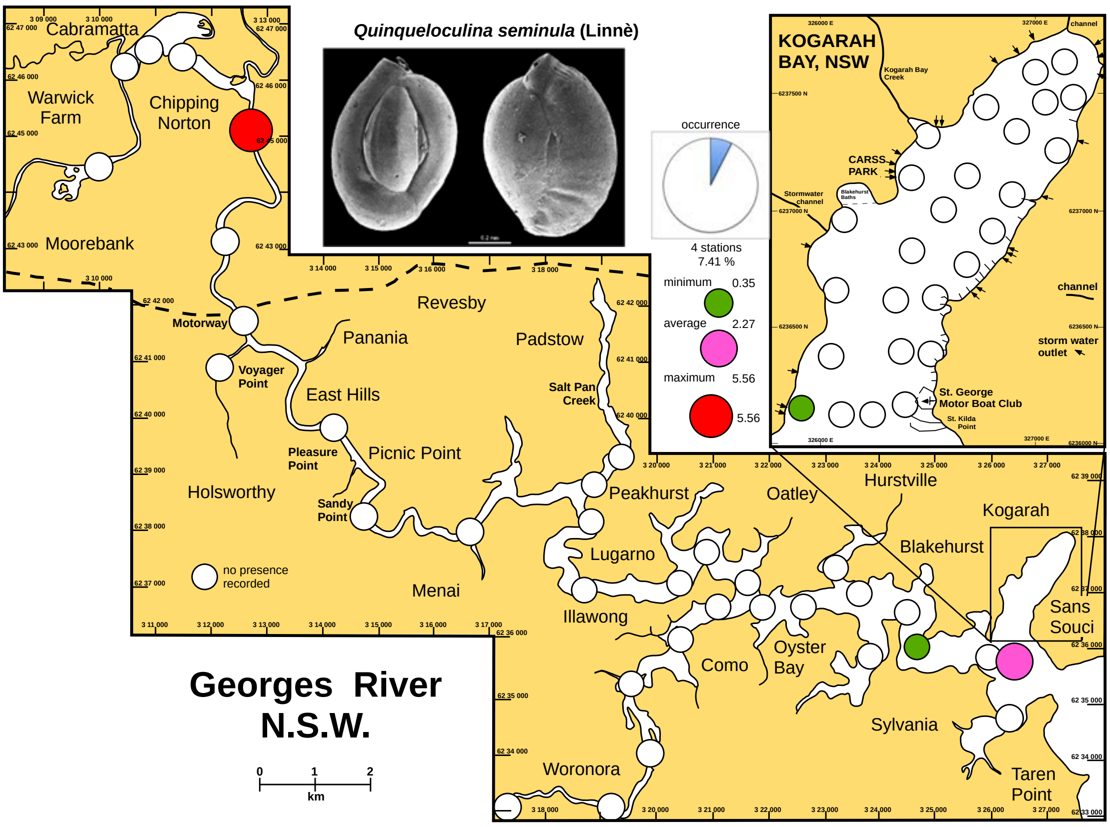


Figure 31 – Distribution of *Quinqueloculina seminula* (Linnè) [species 18]

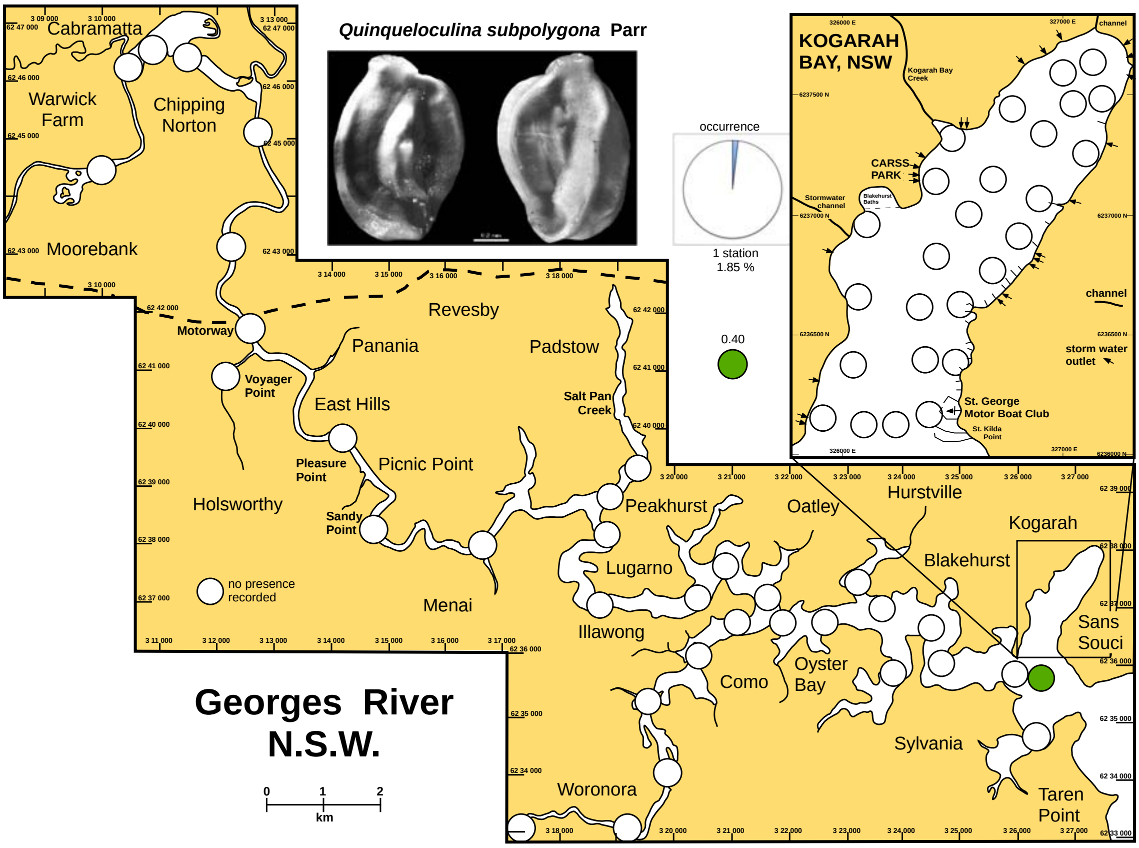


Figure 32 – Distribution of *Quinqueloculina subpolygona* Parr [species 19]

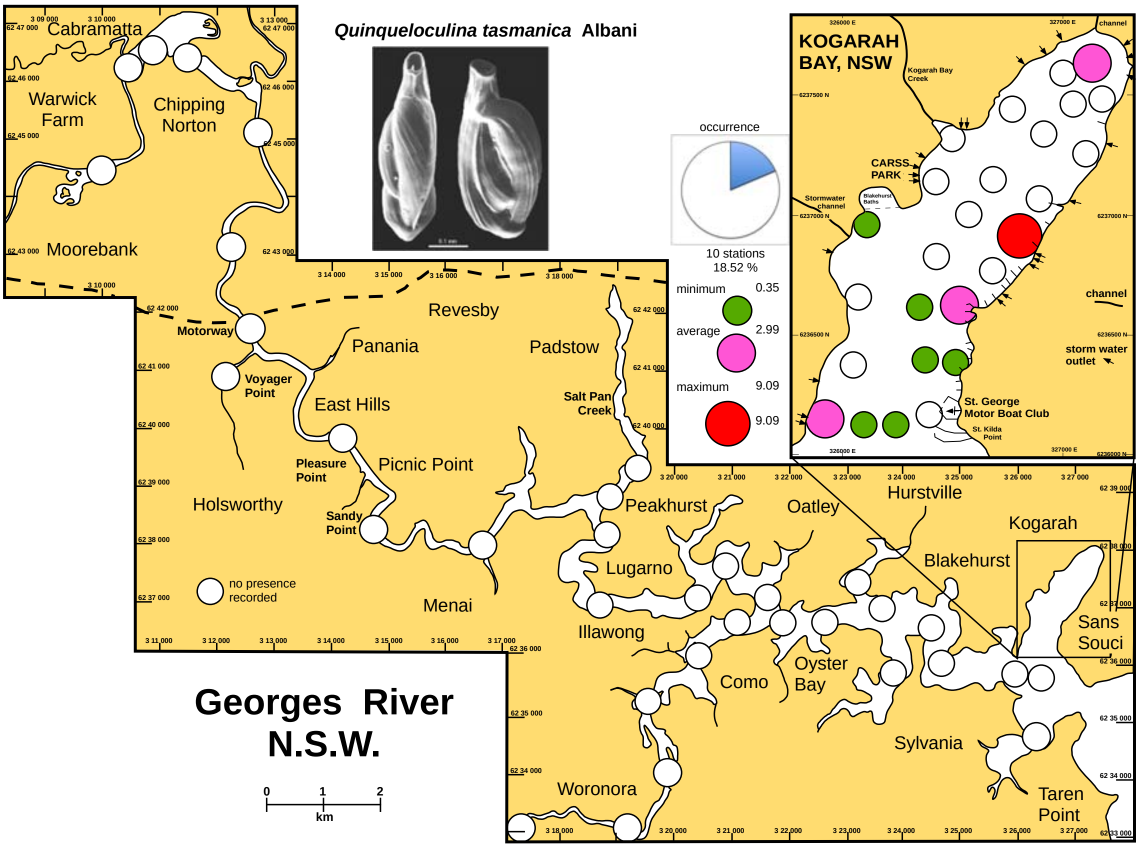


Figure 33 – Distribution of *Quinqueloculina tasmanica* Albani [species 20]

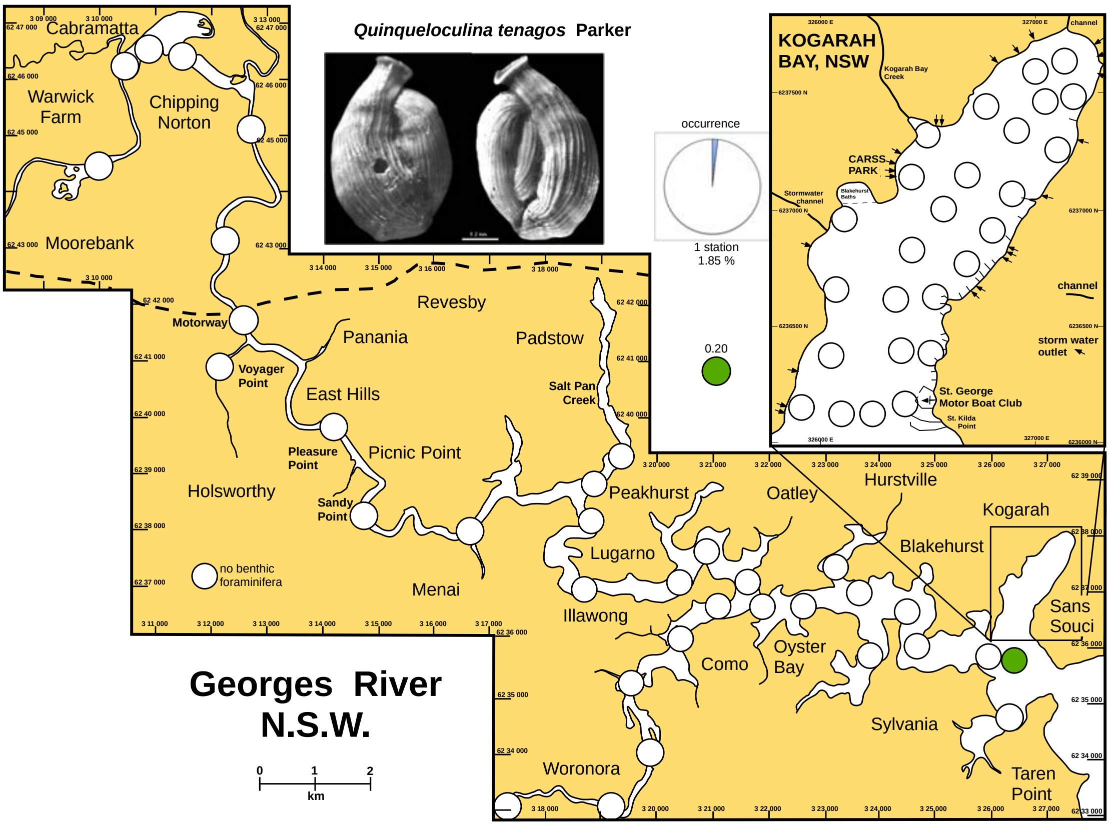


Figure 34 – Distribution of *Quinqueloculina tenagos* Parker [species 21]

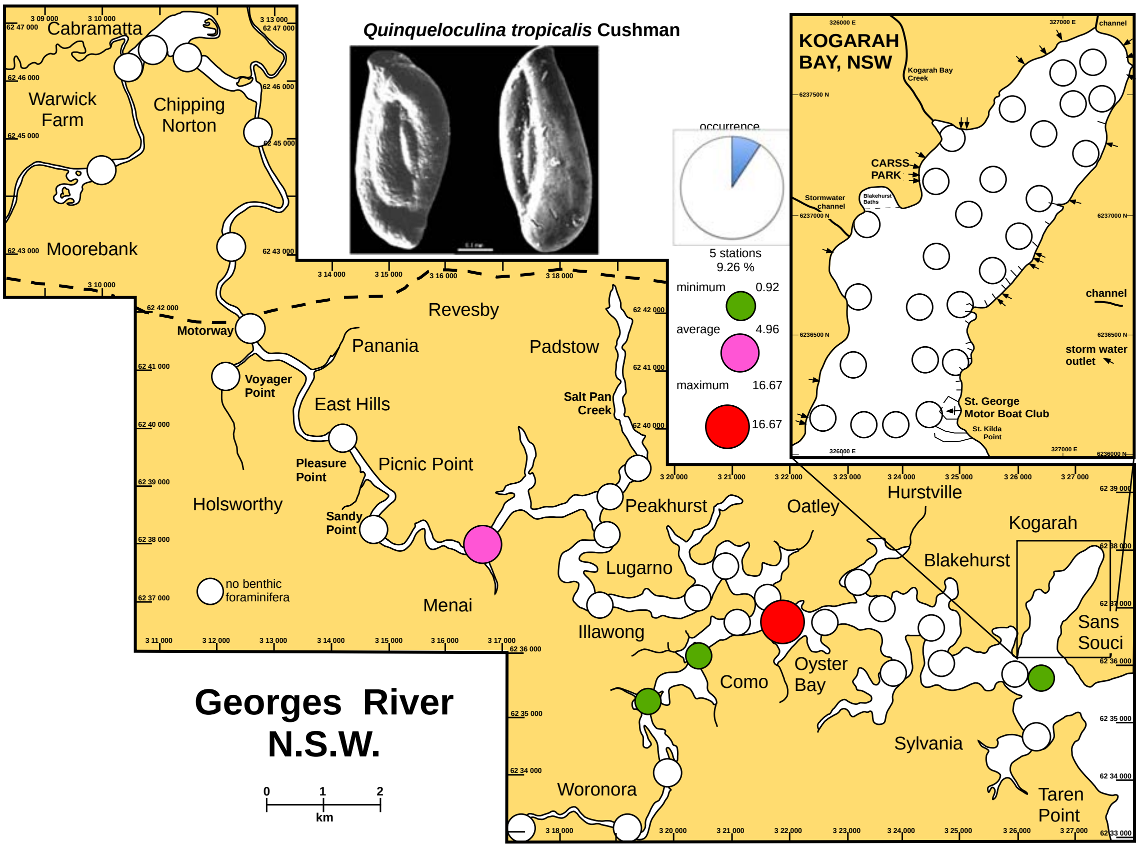


Figure 35 – Distribution of *Quinqueloculina tropicalis* Cushman [species 22]

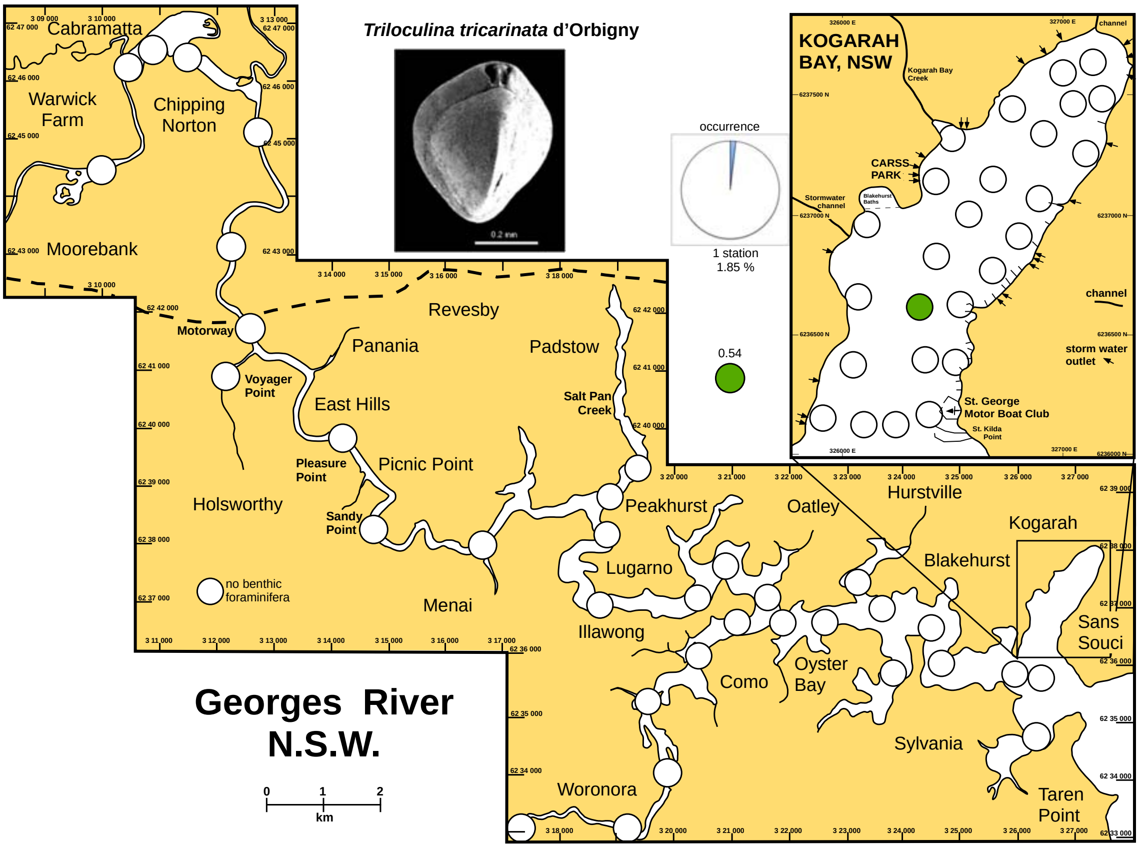


Figure 36 – Distribution of *Triloculina tricarinata* d'Orbigny [species 23]

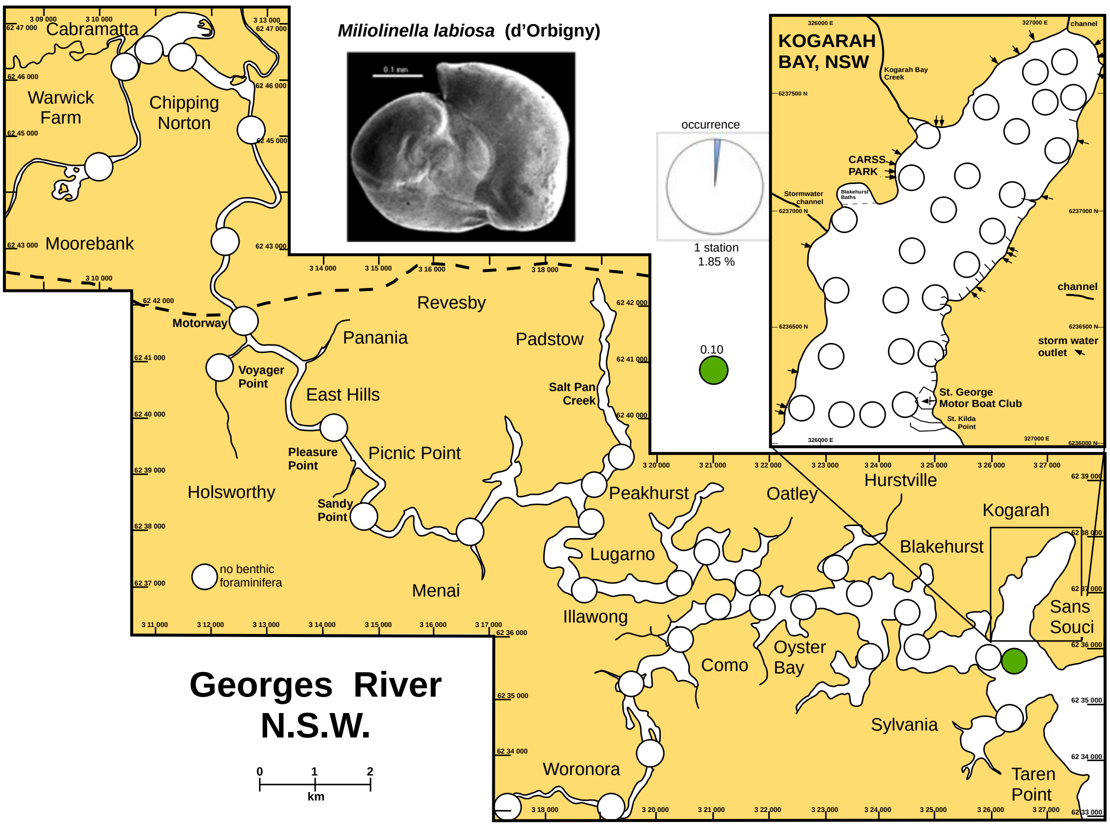


Figure 37 – Distribution of *Miliolinella labiosa* (d'Orbigny) [species 24]

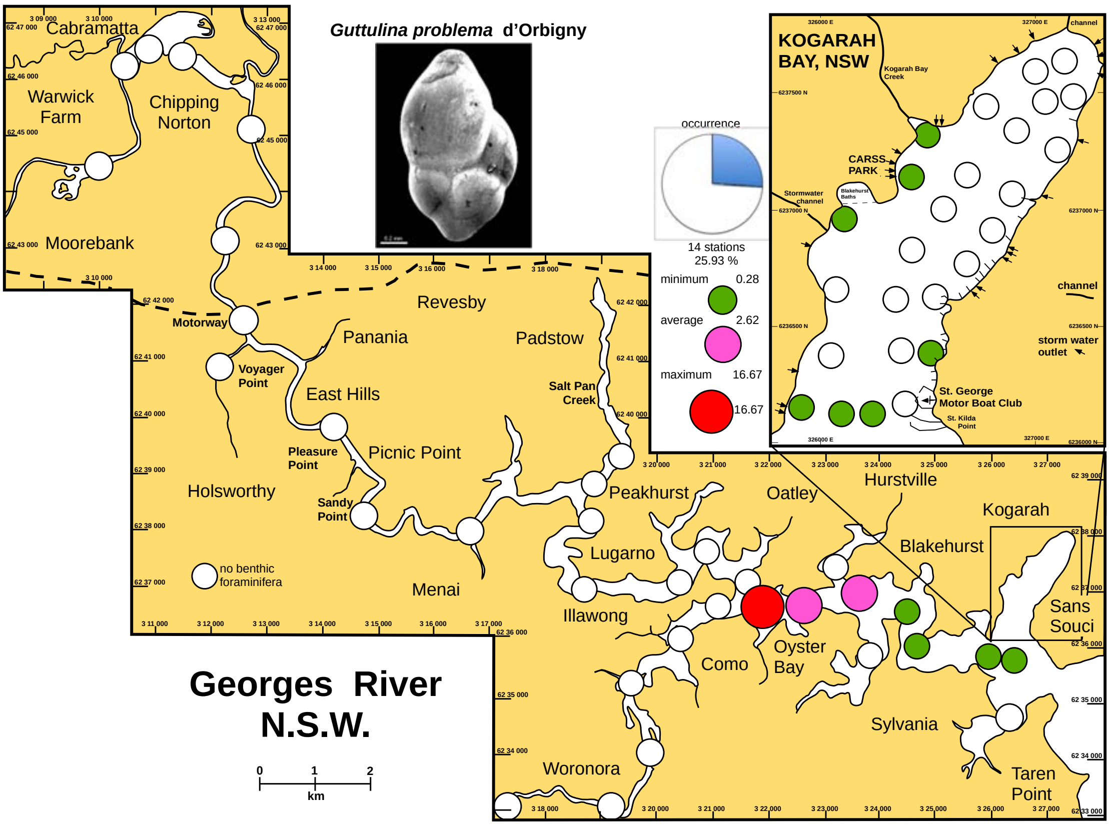


Figure 38 – Distribution of *Guttulina problema* d'Orbigny [species 25]

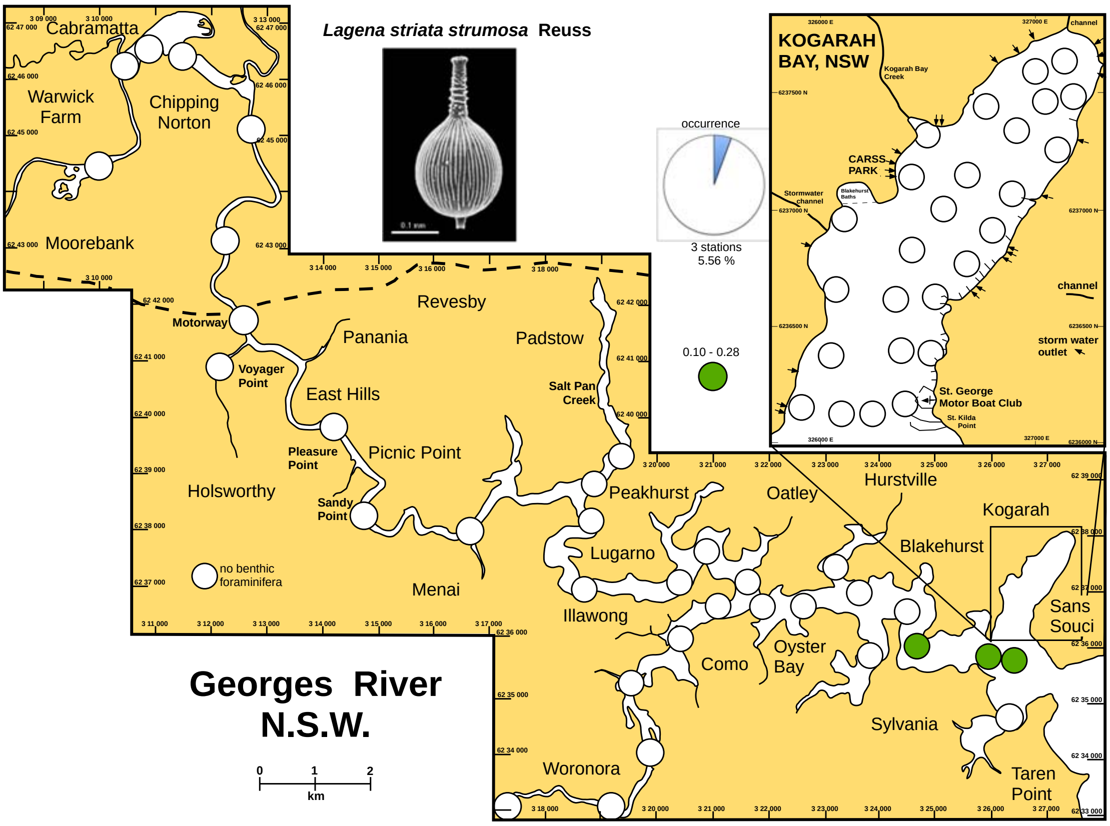


Figure 39 – Distribution of *Lagena striata strumosa* Reuss [species 26]

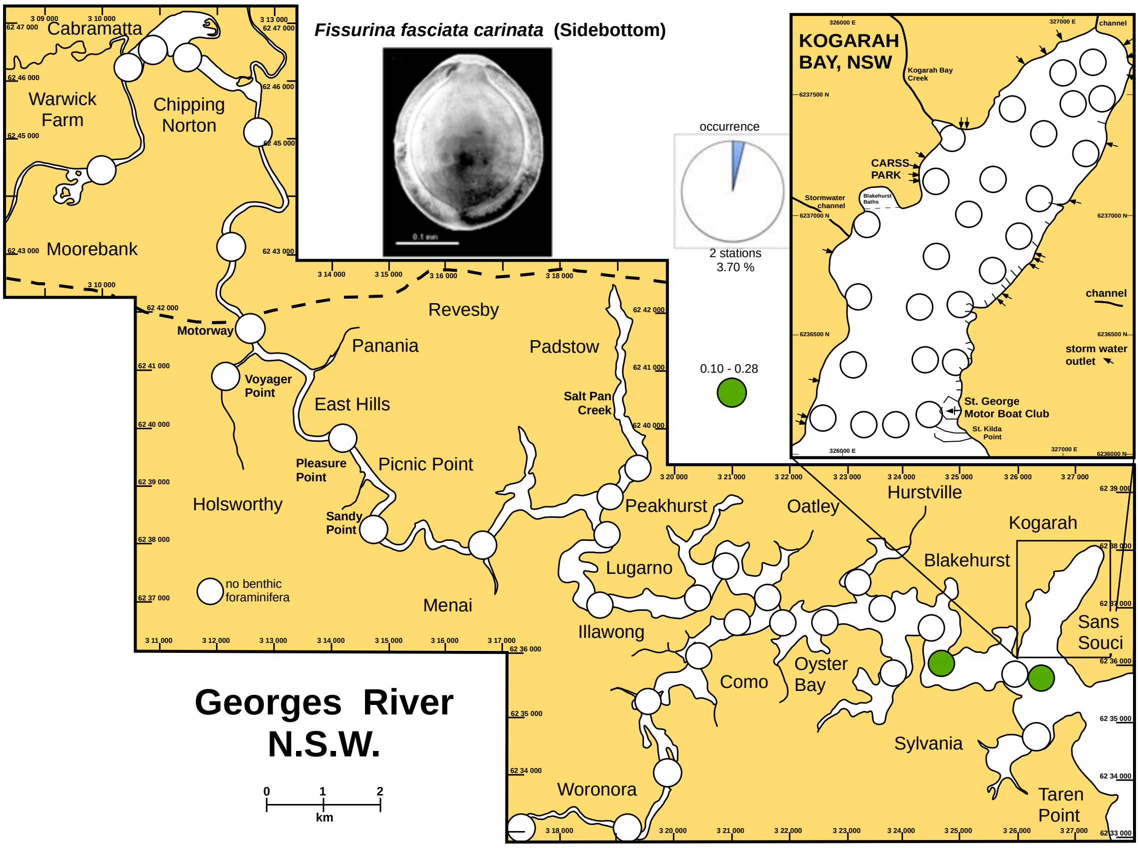


Figure 40 – Distribution of *Fissurina fasciata carinata* (Sidebottom) [species 27]

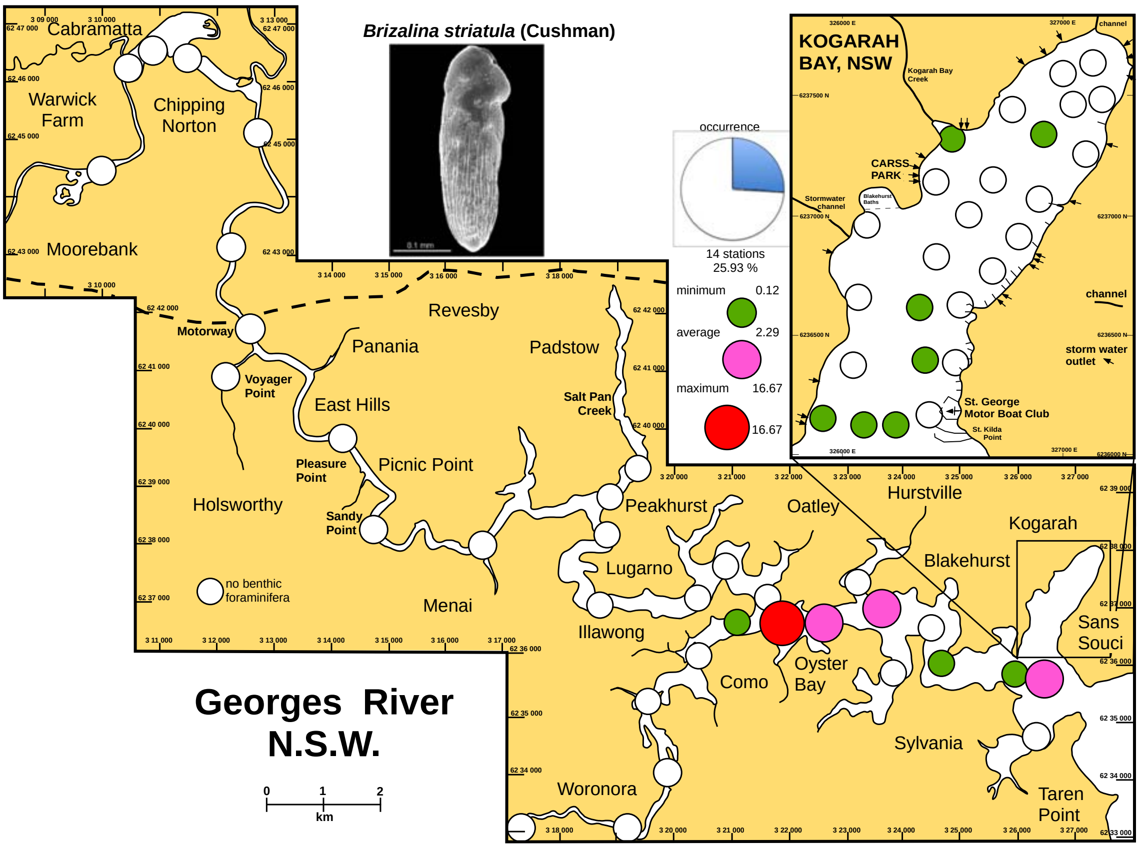


Figure 41 – Distribution of *Brizalina striatula* (Cushman) [species 28]

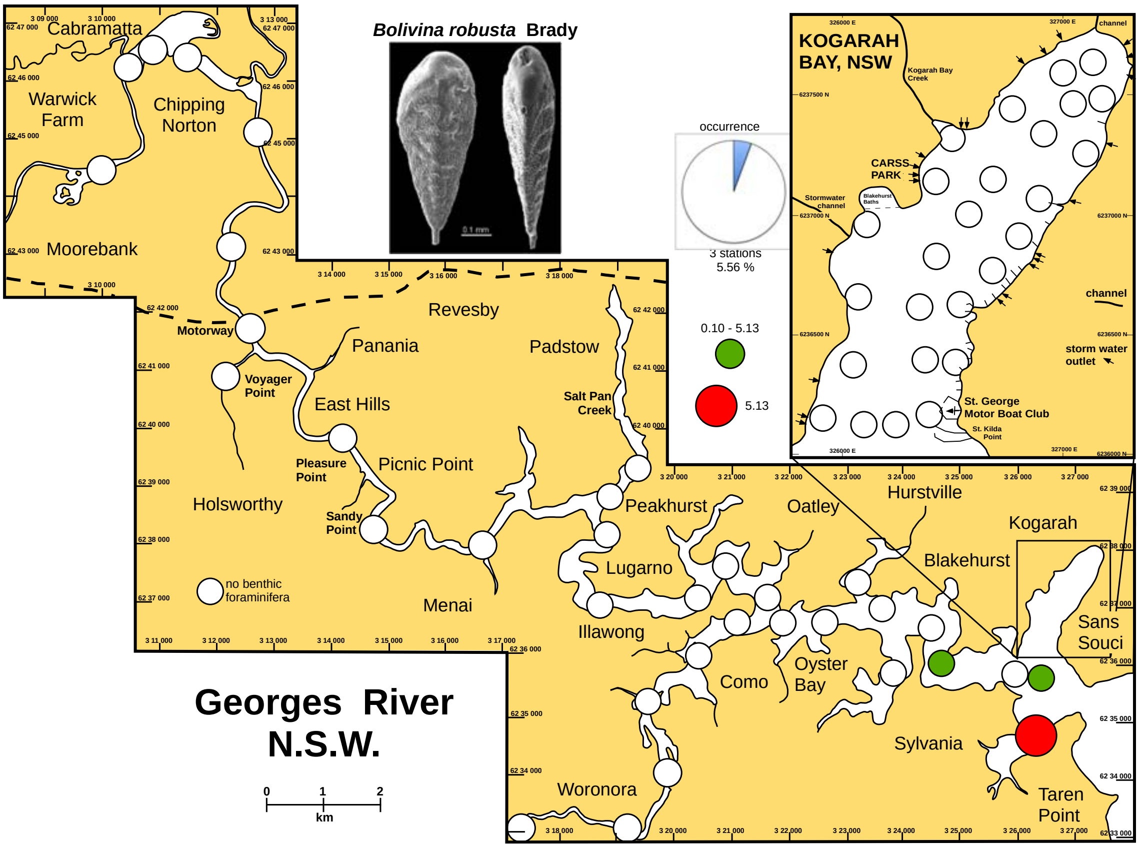


Figure 42 – Distribution of *Bolivina robusta* Brady [species 29]

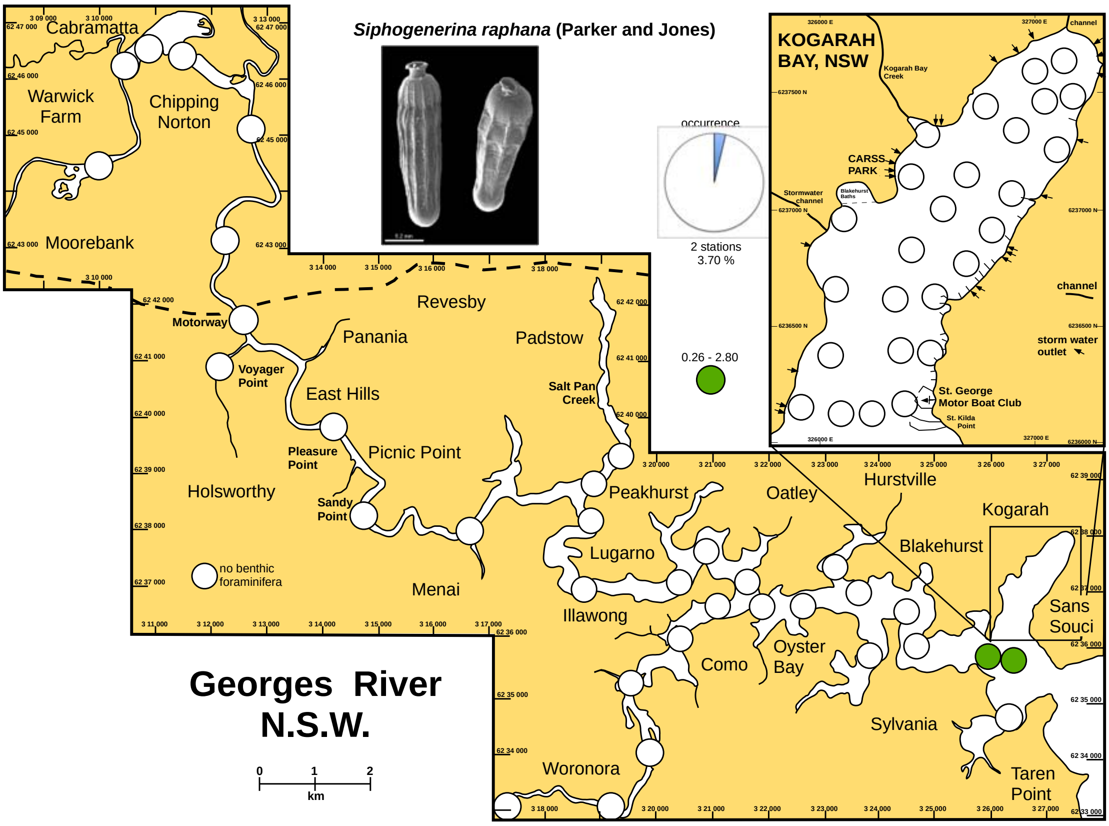


Figure 43 – Distribution of *Siphogenerina raphana* (Parker and Jones) [species 30]

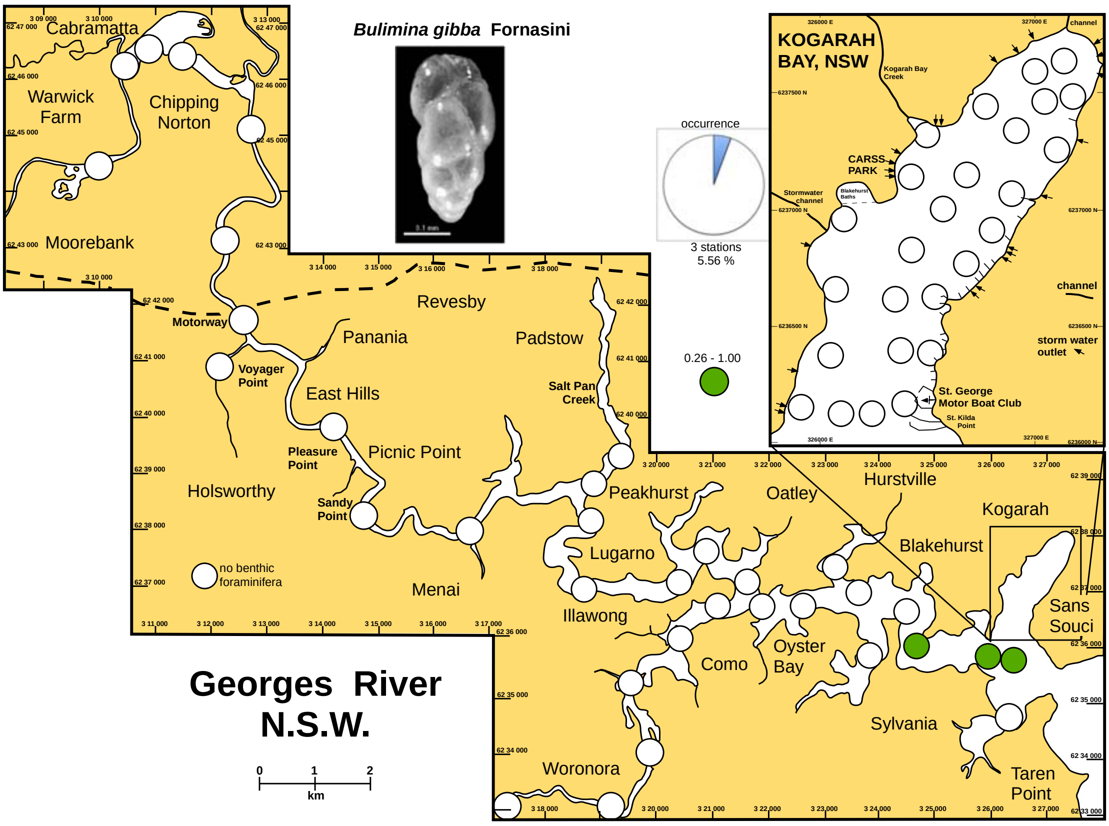


Figure 44 – Distribution of *Bulimina gibba* Fornasini [species 31]

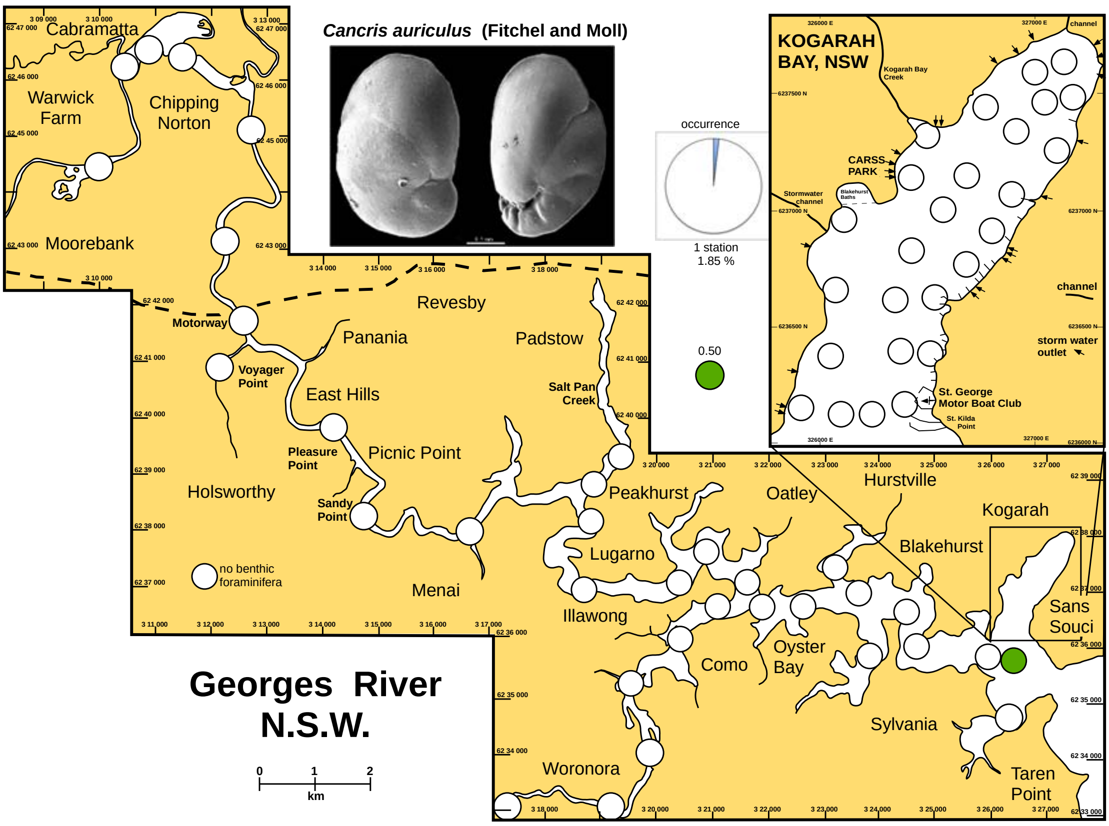


Figure 45 – Distribution of *Cancris auriculus* (Fitchel and Moll) [species 32]

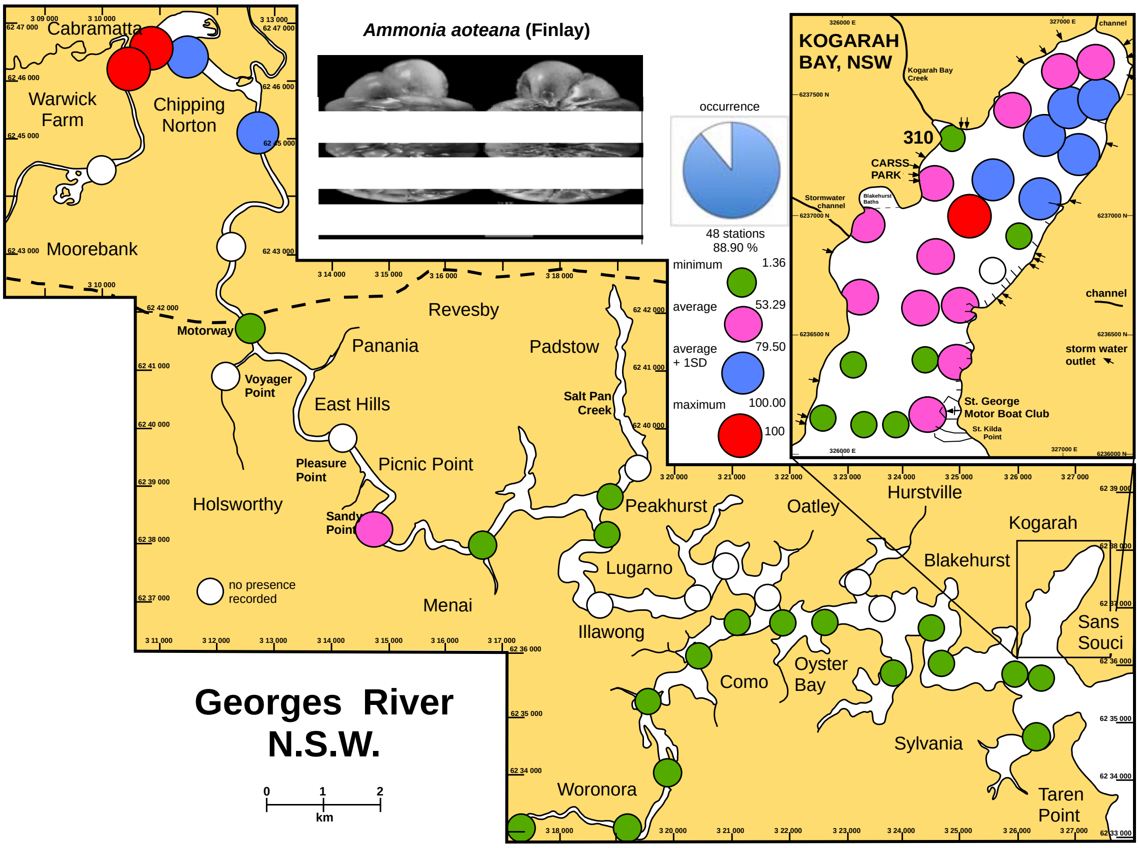


Figure 46 – Distribution of *Ammonia aoteana* (Finlay) [species 33]

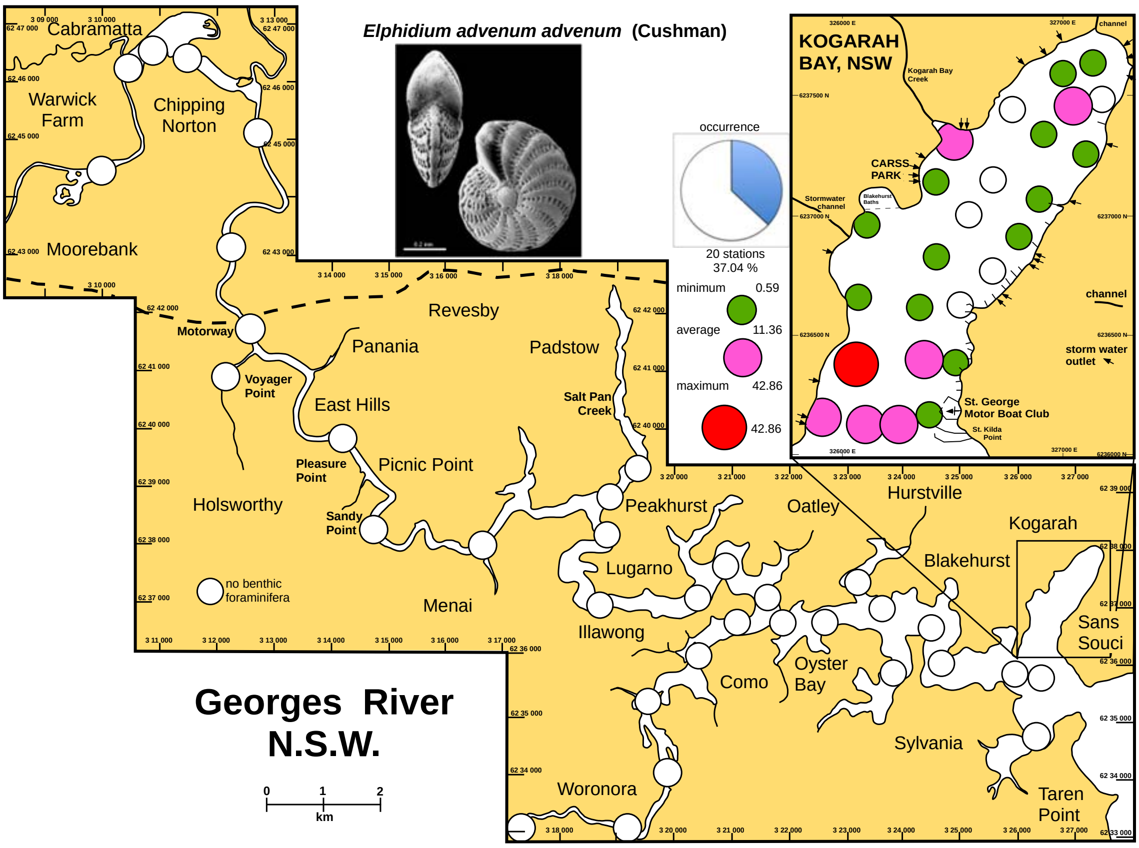


Figure 47 – Distribution of *Elphidium advenum advenum* (Cushman) [species 34]

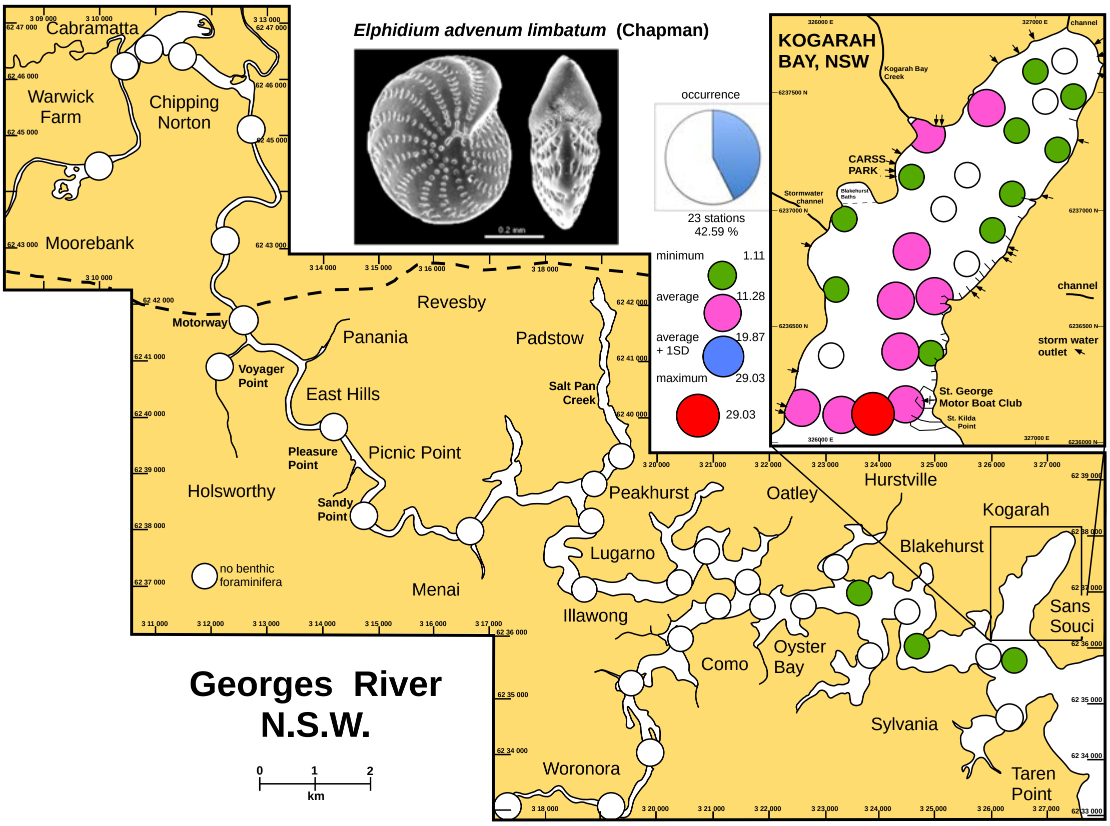


Figure 48 – Distribution of *Elphidium advenum limbatum* (Chapman) [species 35]

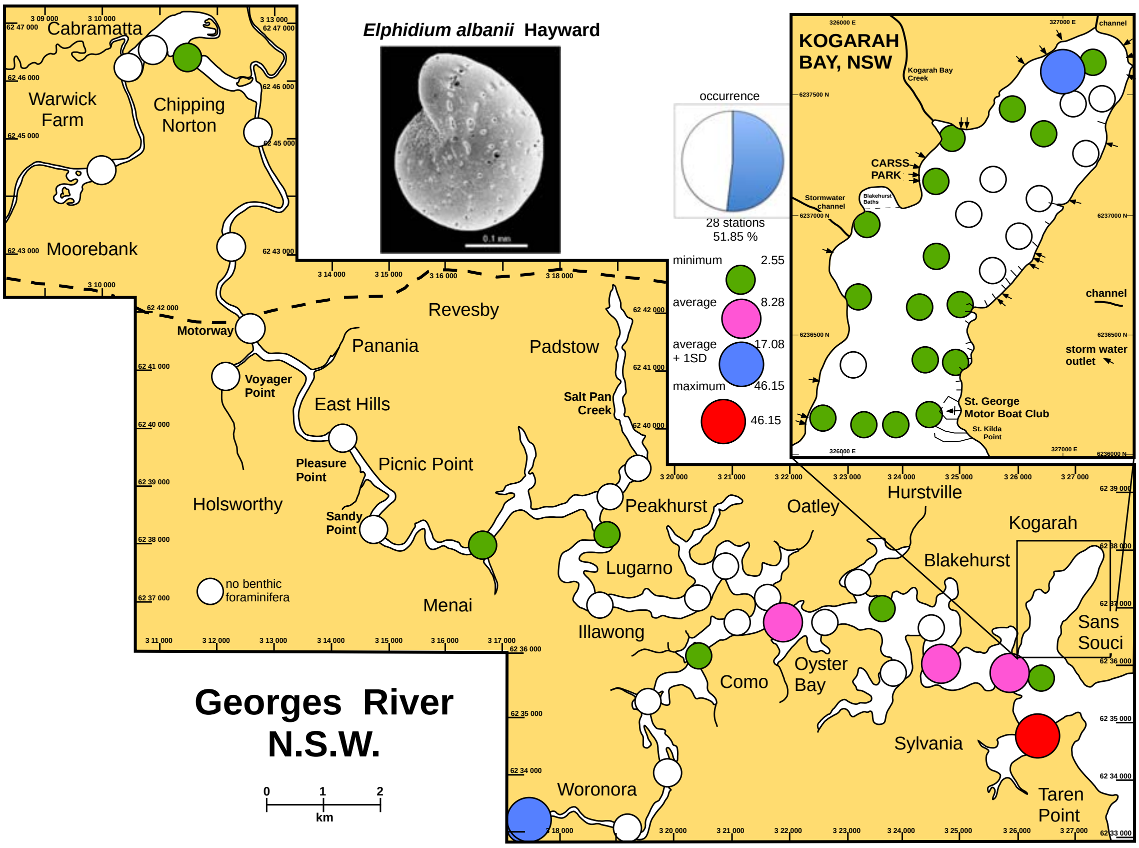


Figure 49 – Distribution of *Elphidium albanii* Hayward [species 36]

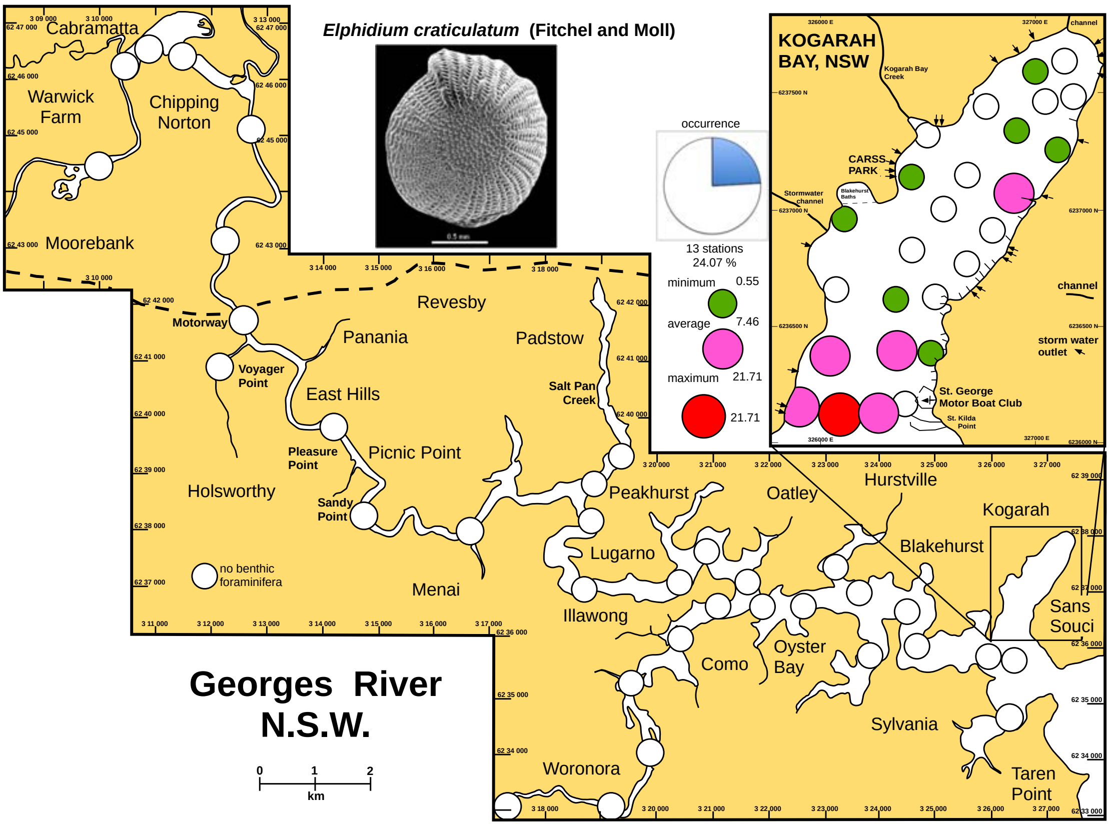


Figure 50 – Distribution of *Elphidium craticulatum* (Fitchel and Moll) [species 37]

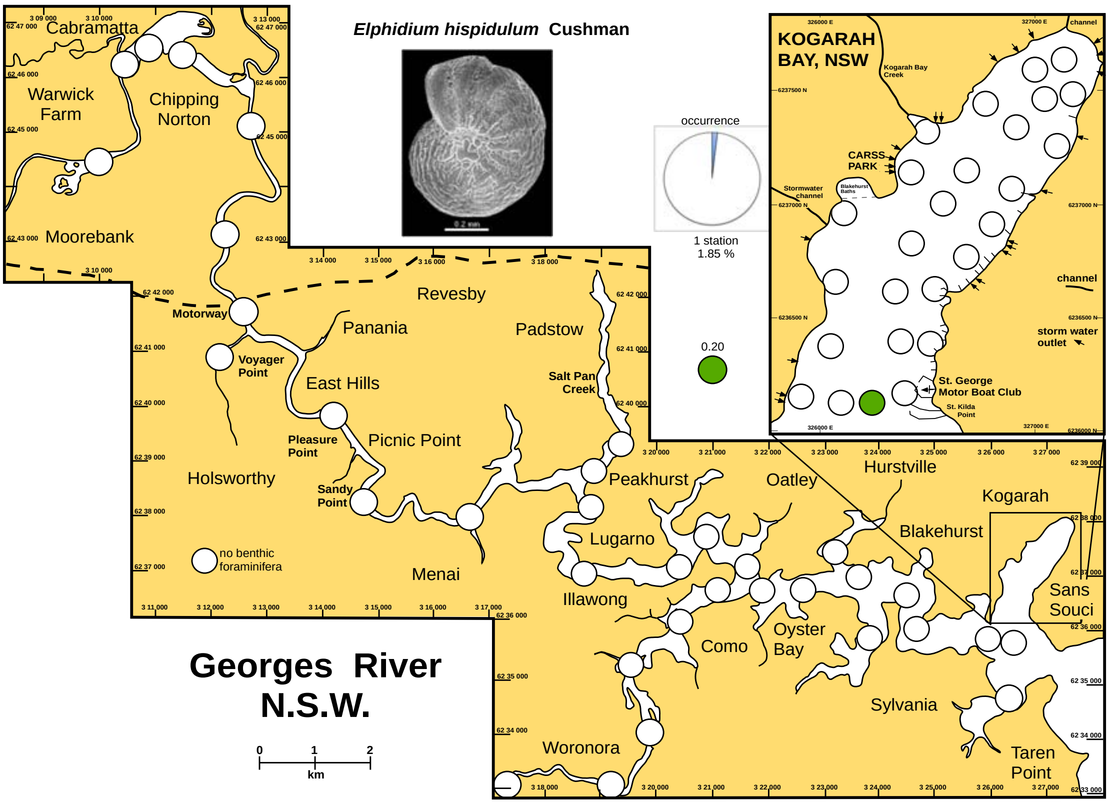


Figure 51 – Distribution of *Elphidium hispidulum* Cushman [species 38]

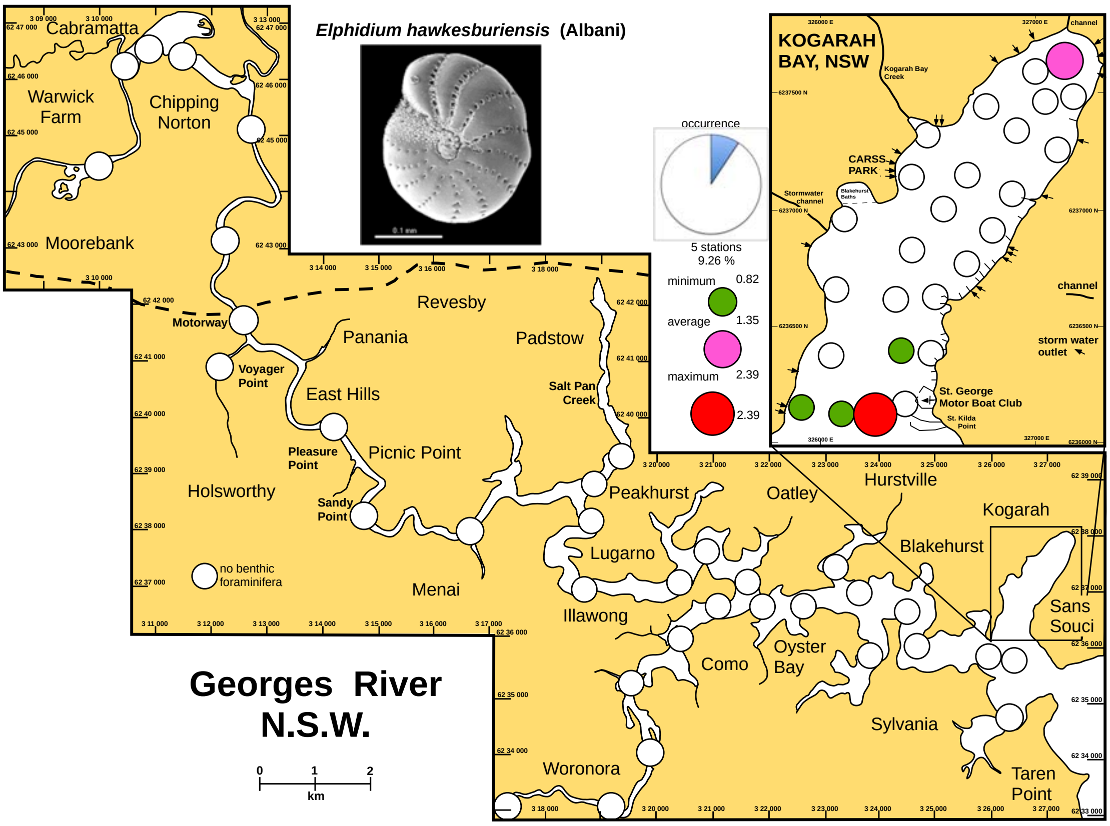


Figure 52 – Distribution of *Elphidium hawkesburiensis* (Albani) [species 39]

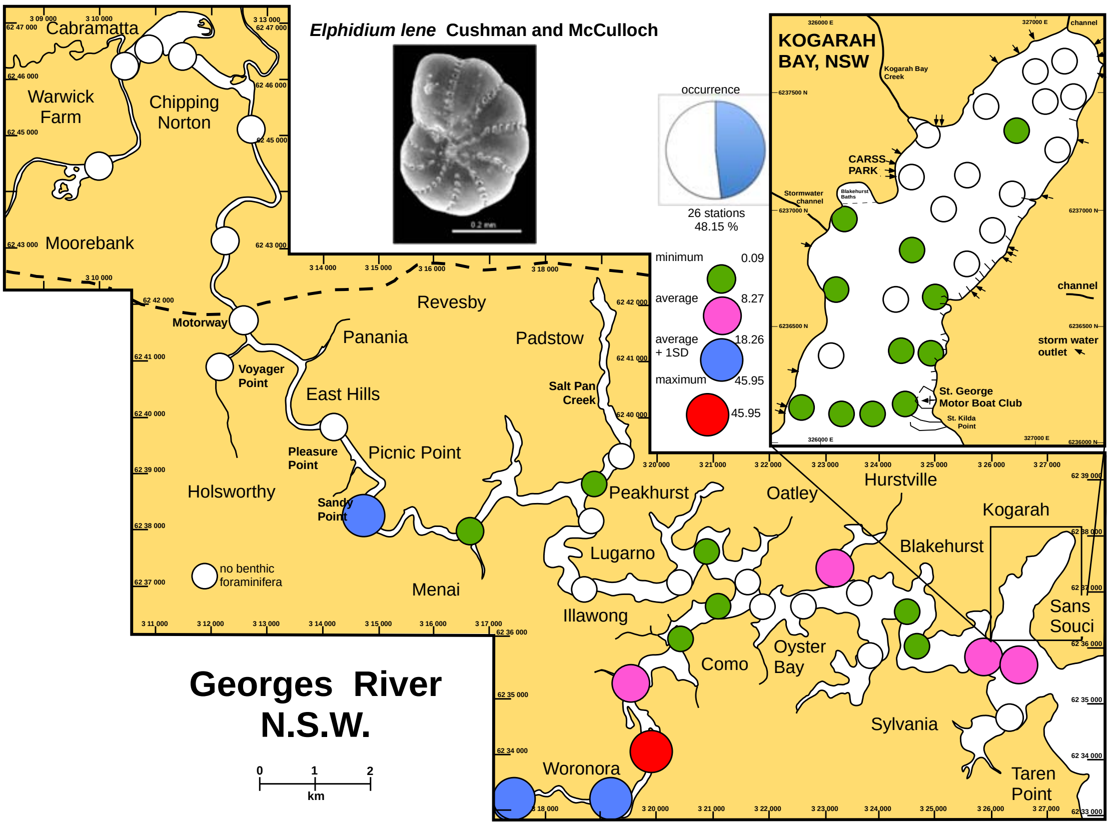


Figure 53 – Distribution of *Elphidium lene* Cushman and McCulloch [species 40]

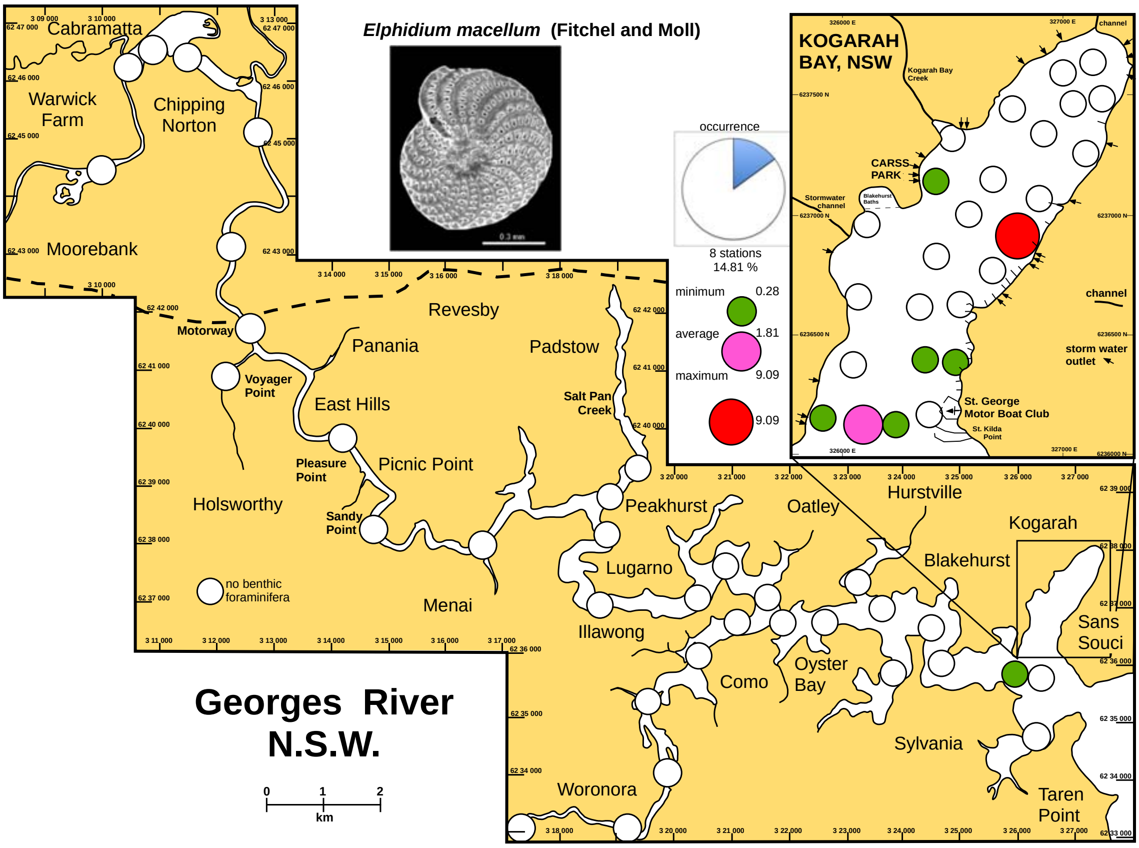


Figure 54 – Distribution of *Elphidium macellum* (Fitchel and Moll) [species 41]