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Ms Carol Oates
Assistant Director
Monitoring and Audit Section
Compliance & Enforcement Branch
Environment Assessment and Compliance Division
Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787
CANBERRA ACT 2601

Dear Ms Oates,

Gladstone-Fitzroy Pipeline Project
DSWP&C Reference 2007/3501

I refer to commitments made by the Gladstone Area Water Board GAWB to the Department to undertake a study into Yellow Chat bird population in Central Queensland. This commitment was made in the period of late 2009 and actioned over the ensuing time period.

The Yellow Chat (small native bird) is considered to be under threat and has been termed as an endangered species. The extent of the population, their actual locations and their breeding patterns required further field analysis and understanding during this current period of infrastructure development in Central Queensland.

Mr Wayne Houston from Central Queensland University was engaged by GAWB and undertook the field study, commencing in July 2010 and completed in December 2011, capturing two breeding seasons for the birds.

A final report has now been received by GAWB, **"Ecological Drivers of Breeding and Habitat Use of Yellow Chats"** – Report for the Gladstone Area Water Board, *Wayne Houston, Robert Black, Rod Elder, Leif Black.* (January 2012). A copy of this report is attached for your information. The material in the report may be useful to your department in assessment of GAWB's and other projects in Central Queensland.

If you require further explanatory details, please call either, Ralph Woolley, Senior Project Manager, on (07) 3020 8013, or Anthony Ottaway, Chief Financial Officer, on (07) 3020 8059

Yours sincerely,

Jim Grayson
Chief Executive Officer

Attach.

BE WHAT YOU WANT TO BE.

CQUniversity AUSTRALIA

Ecological Drivers of Breeding and Habitat Use in Capricorn Yellow Chats

Report to the Gladstone Area Water Board

Wayne Houston, Robert Black, Rod Elder and Leif Black

Terrestrial Ecology Programme

Centre for Environmental Management

Central Queensland University

Rockhampton 4702

January 2012

Centre for Environmental MANAGEMENT

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Summary

The Capricorn Yellow Chat *Epthianura crocea macgregori* is currently listed as 'Critically Endangered' while the species, *E. crocea*, is listed as 'Vulnerable' under the Queensland *Nature Conservation Act 1992*. "Lack of knowledge regarding key aspects of Capricorn Yellow Chat ecology and habitat requirements" was identified as one of the main threats to the persistence of the subspecies in the recovery plan. This plan also identified modification of the hydrological regime, particularly reduction of unregulated surface flows into habitat as one of the main threats.

CQUniversity has been undertaking research into Yellow Chat ecology since 2001. Early studies focussed on their natural history at the then only known population at Curtis Island. Based on information gained on habitat requirements, further populations were found at Torilla Plain and the Fitzroy River, thus re-establishing their historical range. Chats were found in relatively small patches of suitable habitat, particularly in the Fitzroy River delta, embedded in extensive marine plains; typically where substantial inundation occurs into low lying wetland areas during the wet season. Although substantial progress has been made in increasing the ecological knowledge base of the Capricorn Yellow Chat, there are some knowledge gaps, particularly the influence of a wetter climatic phase on their ecology. The above average wet seasons of 2010-11 coincided with the span of the current research programme (July 2010-December 2011), enabling a preliminary evaluation of the influence of prolonged flooding on breeding success, habitat requirements and seasonal patterns of habitat use in the Fitzroy Delta. This research relates to Recovery Actions 2.8 (Undertake research and monitoring of chat ecology) and 2.10 (Research genetic structure, demographics and dispersal of the Capricorn Yellow Chat; identify linkages between chat breeding and productivity including key food requirements).

All sites where chats occurred showed seasonal increases in salinity of pools as these dried, reflecting an association with lowland plains of marine origin. No further sites were located during 2010-11, although the area of occupied habitat has been expanded at some sites. This probably reflects the influence of the current wet climatic cycle in prolonging the time of inundation for marginal areas of these wetlands, allowing suitable vegetation to develop. This, in combination with successful breeding and an increase in the numbers of birds requiring breeding habitat, has led to an expansion in habitat occupied. These site expansions corresponded to the same wetland habitat types and remnant Regional Ecosystem vegetation types of importance to Capricorn Yellow Chats (REs 11.3.27x1c, x1a; 11.1.3, 11.1.2b and 11.1.1). Numbers in the Fitzroy River delta are currently stable but there are not enough data to evaluate the effect of a wetter climatic cycle on the population at this stage. However, expansion of existing breeding habitat suggests that the influence may be favourable.

Chats have continued to show a seasonal pattern of habitat use, using saltmarshes to breed but requiring other sites, particularly saltfields, as non-breeding dry season habitat. However, during the current wetter climatic phase, chats appear to use additional sites such as Raglan Ck Oxbow in the dry season. It is also possible that some chats stayed at the breeding sites, particularly Twelve Mile Ck which remained inundated and with unusually low salinities during the drier months (i.e. less than 20 ‰; seawater is approximately 35 ‰ or parts per thousand).

During the critical period when chats move from the breeding grounds to the dry season sites, there is much more spider and fly food available in the fringing vegetation of the saltfields than at Twelve Mile Ck. These taxa are known to be important components of the diet of chats. Both foliage-associated and semiaquatic macrobenthic invertebrate food resources were abundant at Inkerman Ck Saltfield in the transition period (April to July). These resources appear to be relatively constant; whereas those at Twelve Mile Ck declined rapidly as it dried. While chats choose natural wetlands for breeding due to the presence of a range of resources (food, shelter, protection from predation), food availability in the drier months may be of some importance in determining dry season habitat use. Identification of potential habitat can be achieved but only with appropriate understanding of the limitations of the existing Regional Ecosystem mapping, and a protocol for this mapping was developed.

Findings in this study back-up earlier research that found a positive correlation between Capricorn Yellow Chat breeding success and rainfall, reinforcing the need to protect current levels of surface flows into chat breeding habitats. The relatively low population size and the fragmented nature of Capricorn Yellow Chat sites (and of suitable habitat) indicate a subspecies that is vulnerable to extinction. In this situation, all populations and the habitat at sites where they occur are of conservation significance and require protection.


Acknowledgements

We thank the many landholders/managers who willingly allowed their properties to be surveyed including the Christiansen family (Ian, Margaret and Adrian), Ray Smith, Frank Titmus, Cheetham Salt (Richard Segal in particular), Ralph and Lorraine Bartlem, Craig and Latisha Mace, Lachlan and Trudi Mace, Lawson and Linda Geddes, Peter Naylor and his manager Gary Hall, Simon and Garry Nolan, Graham McCamley, George and Joy Wilson. Specifically, we would like to thank Birds Australia (Andrew Silcocks) for providing Australia-wide Yellow Chat records, Gail Tucker for preparation of Figure 4, Wayne Boyd for his expertise in NDVI mapping and Lorelle Campbell for her assistance at Curtis Island.

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1. Introduction

1.1 Background

There are five species of endemic Australian chats: the Gibberbird *Ashbyia lovensis,* the Yellow Chat *Epthianura crocea*, the Orange Chat *E. aurifrons*, the Crimson Chat *E. tricolor* and the White-fronted Chat *E. albifrons*). The epthianurine chats were once considered a separate family, but the presence of a brush tongue (Parker 1973), together with results of protein and DNA analysis, has led to the chats now being classified with the honeyeaters in the Family Meliphagidae (Sibley and Ahlquist 1990; Christidis *et al.* 1993; Driskell and Christidis 2004; Christidis and Bowles 2008). Matthew (2007) has described their morphology in detail.

The Yellow Chat *E. crocea* (Castelnau and Ramsay 1877) is a small insectivorous passerine (approximately 11-12 cm long and an average adult weight of 9 g). Like all chats, it is adapted for foraging on the ground and over low vegetation (Schodde 1982) and has relatively long legs and toes (Keast 1958; Matthew 2007). Yellow Chats are sexually dimorphic (Fig. 1). The plumage of breeding Yellow Chat males is predominantly yellow (yellow-olive on back) with a brighter orange-yellow head and a diagnostic, usually crescent-shaped blackish band in the centre of the upper chest (Higgins *et al.* 2001). Adult females are a more citrine yellow on the underparts and lack the breast band. All Yellow Chats, including young newly fledged birds, have a yellow rump in flight.

Figure 1: Capricorn Yellow Chat – male (left, photo by Robert Black) and female (right)

There are three subspecies of Yellow Chat: the Inland or Gulf subspecies (*E. c. crocea*), the Alligator Rivers (*E. c. tunneyi*) and the Capricorn or Dawson (*E. c. macgregori*) (Keast 1958). The geographical criteria (isolation and land barriers) used by Keast (1958) for separating subspecies remain valid (Fig. 1-1). The two outlying subspecies (the Alligator Rivers and Capricorn) occur in coastal catchments that are separated by large distances (at least 400 km) from the more widespread Inland subspecies (*E. c. crocea*) (Schodde and Mason 1999; Higgins *et al.* 2001) (Fig. 2). The Inland subspecies is found patchily across northern Australia with apparent strongholds in the Kimberley region (where it reaches the coast near Broome), Barkly Tableland, the Gulf of Carpentaria and the Lake Eyre Basin. The Alligator Rivers Yellow Chat (*E. c. tunneyi*) is found only in the Alligator Rivers region of the

Northern Territory, hence its common name. The Capricorn Yellow Chat (*E. c. macgregori*) is found only in coastal and sub-coastal central Queensland and is isolated from the Inland subspecies by the Great Dividing Range. The latter subspecies occurs in inland flowing Eyre basin catchments to the west of the divide and the Capricorn subspecies only to the east of the divide on a few coastal plains.

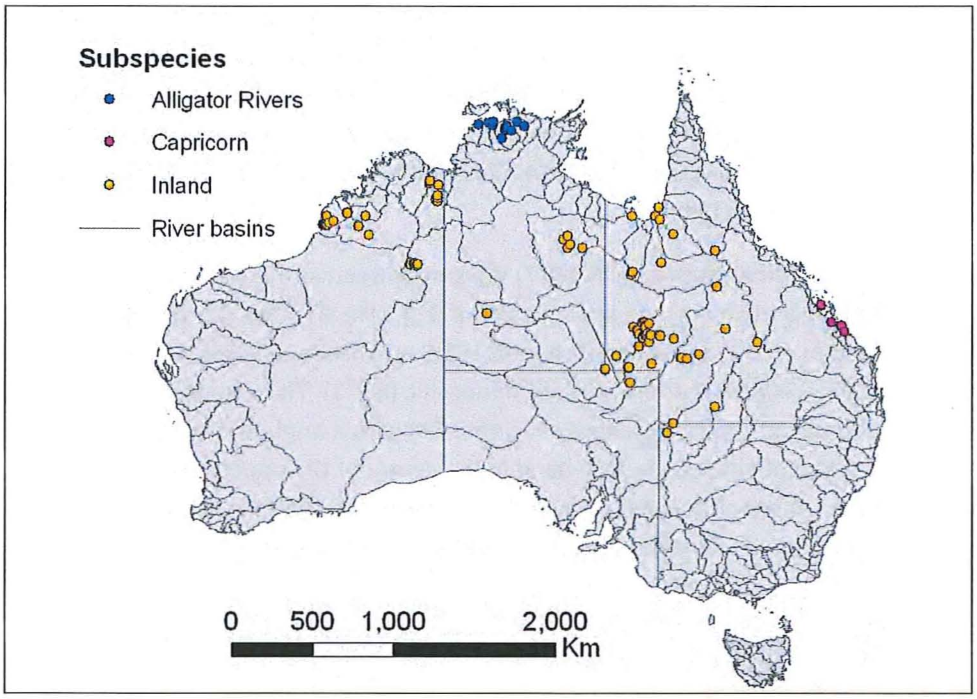

Figure 2: Australian distribution of the three subspecies of Yellow Chats in August 2005 based on WildNet (DERM 2010) and Birdata (Birds Australia 2005-07).

Prior to 1992, the Capricorn Yellow Chat was thought to be extinct (Schodde and Mason 1999; Higgins *et al.* 2001). However, in 1992 a small sub-population of less than 50 birds was found on the marine plain in the north-east part of Curtis Island, east of the Fitzroy River mouth (Arnold *et al.* 1993). It is currently listed as 'Critically Endangered' while the species, *E. crocea*, is listed as 'Vulnerable' under the Queensland *Nature Conservation Act 1992*. The Alligator Rivers subspecies *E. c. tunneyi* is 'Endangered' under the EPBC Act, while the Inland subspecies *E. c. crocea* is not considered to be threatened nationally.

1.2 Current ecological understanding

Successful recovery plans are based on sound ecological knowledge, which in turn permits threats to be evaluated and defined. Important ecological parameters include distribution, population size and habitat requirements, particularly for breeding. Information such as foraging ecology and habitat use provides relevant information on defining key habitats for conservation, identifying threatening processes and formulating conservation strategies (Dorfman *et al.* 2001), while population monitoring gives data needed in order to identify species under threat (Clarke *et al.* 2003). The latter authors noted that long term monitoring data are necessary to gauge the effectiveness of recovery actions taken, and such datasets have been given a high priority by recovery planning agencies (Garnett and Crowley 2000). In summary, ecological risk management depends on sound in-depth ecological knowledge.

Unfortunately such knowledge about many endangered species is lacking. The Capricorn Yellow Chat is one such subspecies. "Lack of knowledge regarding key aspects of Capricorn Yellow Chat ecology and habitat requirements" was identified as one of the main threats to the persistence of the subspecies in the recovery plan (Houston and Melzer 2008). This plan also identified modification of the hydrological regime, particularly reduction of unregulated surface flows into habitat as one of the main threats. This research relates to Recovery Actions 2.8 (Undertake research and monitoring of chat ecology) and 2.10 (Research genetic structure, demographics and dispersal of the Capricorn Yellow Chat; identify linkages between chat breeding and productivity including key food requirements).

CQUniversity has been undertaking research into Yellow Chat ecology since 2001. Early studies focussed on their natural history at the then only known population at Curtis Island (Houston *et al.* 2004b). Based on information gained on habitat requirements gained in this study, further populations were found at Torilla Plain and the Fitzroy River delta (Houston *et al.* 2004; Jaensch *et al.* 2004; Houston *et al.* 2009; Houston 2010), thus re-establishing their historical range (Fig. 3).

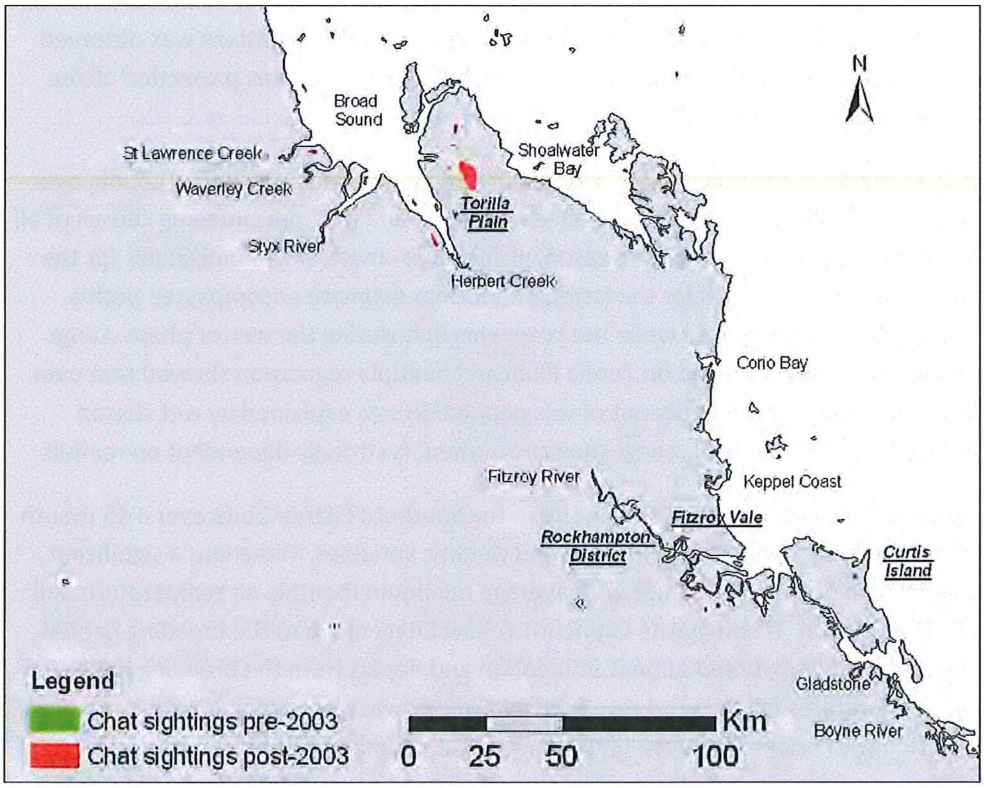

Figure 3: Summary of the sites of chat occupancy found since July 2003 compared with historical locations (Torilla Plain, Rockhampton District, Fitzroy Vale and Curtis Island; confirmed location data was only recorded for the latter)

This earlier research was completed in June 2010 and the findings reported in Houston (2010). This component showed that:

> "....Capricorn Yellow Chats occupy seasonally inundated treeless marine plains, comprising six coastal plains, between Broad Sound and the southern part of the Fitzroy River delta and Curtis Island. Suitable habitat was limited with an extent of occurrence of less than 6000 ha. Breeding was observed at 11 sites, always in grass-sedge swamps and tall saltmarshes with nests located in *Schoenoplectus litoralis*, *Halosarcia pergranulata* and *Sporobolus virginicus*, and likely in *Cyperus alopecuroides*, confirming their dependency on wetlands for breeding. However, only four sites (including two saltfields) were confirmed as being currently used by Capricorn Yellow Chats during the drier months.
>
> An important finding was that the breeding season was labile which, although summer-autumn dominant corresponding to the wetter months, allowed them to breed in any season or month following substantial rainfall. From observations of nesting and the presence of dependent young, breeding commencement of Capricorn Yellow Chats was immediately following rain at one complex and significantly correlated with rainfall two months earlier at another. In one complex there was a seasonal pattern of habitat use with breeding at saltmarshes during the wetter summer months and a movement to nearby saltfields (less than 10 km distant) during the drier months. A similar but less well defined pattern was observed at another complex showing that conservation of this subspecies requires protection of site complexes rather than individual sites.
>
> Population size of Capricorn Yellow Chats was estimated by: (i) maximum annual counts over seven years using regular surveys of standard search effort and (ii) a pre-breeding census of all known sites coinciding with the mid dry season, giving an estimate of 248 individuals for the former and a range of 298 to 386 for the latter. The former estimate encompassed both a drought and a relatively wet phase while the latter was only during the wetter phase. Large annual changes in density occurred on Torilla Plain and multiple regression showed that over 90% of the variation in annual chat count of this population was explained by wet season rainfall of the preceding two years, suggesting recruitment is strongly dependent on rainfall.
>
> Monthly observations at the main breeding site in the Southern Fitzroy Delta over a 45 month period were regressed against environmental and climatic variables. There was a significant positive relationship of chat abundance with average minimum monthly air temperature and the extent of inundation. This suggests Capricorn Yellow Chats move to the breeding habitat as the temperatures warm, breed at peak inundation and depart from the breeding habitat as it dries and temperatures fall. Invertebrate food availability was also sampled at this complex. Cross correlation with prior monthly rainfall showed that abundance of flies, bugs, lepidopterans and semiaquatic invertebrates peaked one to two months following large rainfall events, coinciding with peaks in presence of dependent young of Capricorn Yellow Chats. In general, these findings suggest that the Capricorn Yellow Chat relies on proximate seasonal cues (such as increasing temperature and inundation or rainfall) to prepare for and commence breeding, while food availability is the ultimate factor."

Houston (2010) provided the first evidence of a relationship between breeding and rainfall as hypothesised for Yellow Chats by earlier researchers, and thus confirms the need to protect surface flows into breeding habitats. A standard methodology allowing population data to be gathered was developed which will permit evaluation of long-term trends of Capricorn Yellow Chat abundance; key data for conservation planning.

1.3 Aims and objectives

Although substantial progress has been made in increasing the ecological knowledge base of the Capricorn Yellow Chat, there are some knowledge gaps, particularly the influence of a wetter climatic phase on their ecology. The above average wet seasons of 2010-11 coincided with the span of the current research programme (July 2010-December 2011), enabling a preliminary evaluation of the influence of prolonged flooding on breeding success, habitat requirements and seasonal patterns of habitat use in the Fitzroy Delta. These evaluations are preceded by a re-examination of the distribution and general habitat associations of the Capricorn Yellow Chat in order to provide context for the following sections.

The previous component of the research had shown that, in the Delta, there were only two sites which provided reliable dry season habitat for Capricorn Yellow Chats and these were both artificial wetlands created for salt production (although both had portions of saltmarsh habitat embedded within them) (Houston 2010). The relatively few sites occupied by chats during the dry season in the Delta elevated their importance as Capricorn Yellow Chat habitat, and an understanding of habitat attributes that differ from the wet season breeding sites was sought.

Finally, a protocol for mapping of potential areas of Capricorn Yellow Chat habitat was developed based on known habitat requirements. Such information will lead to an improved understanding of threats to survival of this critically endangered subspecies, and key planning information to assist both land management agencies and development proponents.

2. Description of the Study Area

2.1 Location and geophysical framework

The known locations of the Capricorn Yellow Chat straddle the Tropic of Capricorn between latitudes 22.2°S to 23.7°S on coastal plains to the north, south and east of Rockhampton (Fig. 4a). The port city of Gladstone lies just to the south and St Lawrence to the north. Biogeographically, much of the region lies within the Brigalow Belt in the central and northern sections but bordered to the south by the South-east Queensland bioregion (including Curtis Island) and the much wetter Central Coast bioregion to the east and north-east (e.g. Byfield and the eastern part of Shoalwater Bay) (Sattler and Williams 1999). There are several wetlands of national significance including Broad Sound, the Fitzroy Lagoons, Fitzroy Delta, Hedlow, Shoalwater and Corio Bay (DEHWA 2009). Some of these are recognised as wetlands of international significance (the Ramsar sites of Shoalwater and Corio), and others have been identified as important bird areas including Torilla Plain.

The main tributaries of the Fitzroy River delta include Nankin Creek on the northern side and Raglan Creek on the southern (Fig. 4b). The Fitzroy River mouth is contiguous with a complex passage known as The Narrows lying between the mainland and Curtis Island, and is one of only three such systems in eastern Queensland.

There are extensive coastal plains in the Broad Sound and Fitzroy River delta areas including the north-eastern end of Curtis Island. Coastal plains formed by marine sedimentation processes are known as marine plains, and correspond to land zone 1 mapped in Figures 2-2, 2-3. They are typically of slight gradient and low relief, mostly less than 10 m.

Based on stratigraphic evidence, the Fitzroy River delta (i.e. the estuarine component downstream of Rockhampton) was flooded in the Holocene with sea levels stabilising at present levels around 7000 years ago (Jardine 1923; Brooke *et al.* 2006). Since then, considerable deposition of both estuarine and fluvial sediments has formed the present day floodplain and coastal saltflats. This floodplain is bordered by several mountain ranges, including the Berserker and Flat Top Ranges to the north, the Rundle, Mount Larcom, Redan and Dee Ranges to the south and the hills of Curtis Island to the southeast (Bostock *et al.* 2006). Saltflats are extensive in the southern part of the estuary around Port Alma and the Casuarina Creek areas. Land is generally of low gradient, especially the saltflats, and much is less than 10 m height above sea level. The extent of estuarine related habitats in the Fitzroy River is about 630 km^2, dominated by saltflats (275 km^2) but including substantial areas of mangroves (130 km^2) and intertidal flats (13 km^2) (Bostock *et al.* 2006).

A small outlying marine plain lies in the north-eastern corner of Curtis Island. Mangrove deposits underlie the modern surface and it is likely that it has similar geomorphology and formation to that of the Torilla Plain.

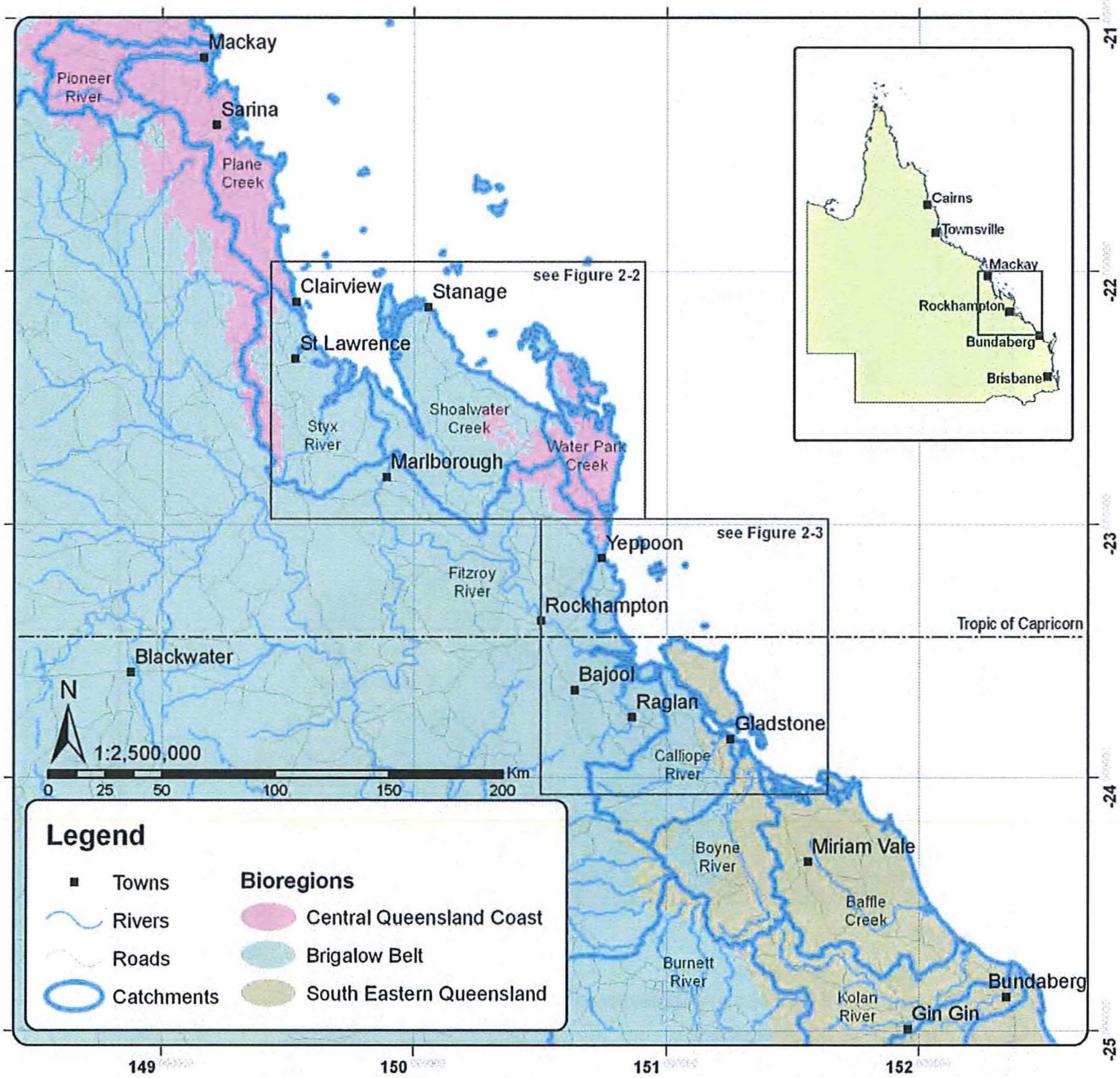
Mackay
Pioneer River
Sarina
Plane Creek
Clairview
Stanage
see Figure 2-2
St Lawrence
Styx River
Shoalwater Creek
Water Park Creek
Marlborough
Yeppoon
see Figure 2-3
Fitzroy River
Rockhampton
Tropic of Capricorn
Blackwater
Bajool
Raglan
Gladstone
Calliope River
N
1:2,500,000
0 25 50 100 150 200 Km
Legend
Towns
Rivers
Roads
Catchments
Bioregions
Central Queensland Coast
Brigalow Belt
South Eastern Queensland
Boyne River
Miriam Vale
Baffle Creek
Burnett River
Kolan River
Gin Gin
Bundaberg
Cairns
Townsville
Mackay
Rockhampton
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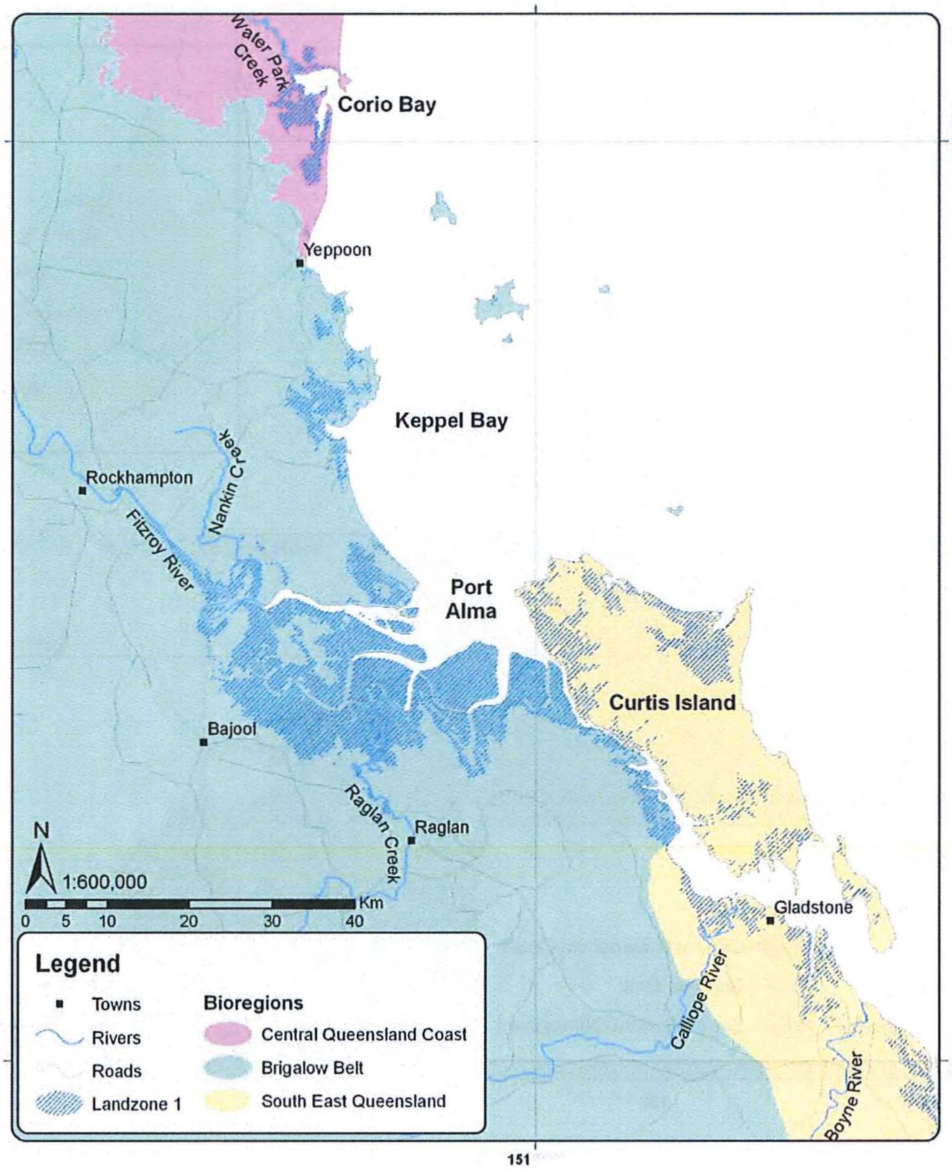
Figure 4a



b

Figure 4: (a) Location map of the study area; (b) Southern section of the study area encompassing the Keppel Coast, Fitzroy River delta and Curtis Island

2.2 Climate

The region is in the dry subtropics with temperatures and rainfall typical of a humid summer rainfall dominant climatic zone. The climate is classified as hot, seasonally wet/dry but with relatively cool winters; category I3 in the scheme of Hutchinson *et al.* (2005). Using data from three weather stations in the north (St Lawrence), centre (Rockhampton Airport) and to the south (Gladstone

Airport) of the study area, average maximum summer temperatures are typically just above 30°C while winter minima average around 10 to 14°C. The wet season occurs from December to March, during which average monthly rainfall is greater than 100 mm when averaged across the three stations. This pattern is more pronounced in the north (St Lawrence) where annual rainfall is slightly greater than Rockhampton and Gladstone (annual average rainfall of 1013 mm compared to 796 and 876 mm respectively) and December to March accounts for 65%, 59% and 58% of annual rainfall.

The coastal region occupied by the Capricorn Yellow Chat is typified by highly variable annual rainfall, with a variability index of 1.25-1.5 (Fig. 5) (BOM 2010). This level of variability resembles that of the region occupied by the Inland Yellow Chat which is high or greater. Another index of seasonality was provided by Nix (1982), based on the coefficient of variation of weekly mean moisture index. The study area equates to moderately seasonal (i.e. a coefficient of variation of 30-60%). To the southeast lies the slightly seasonal area of southeast Queensland while further north is the highly seasonal region of western Cape York and the Gulf of Carpentaria.

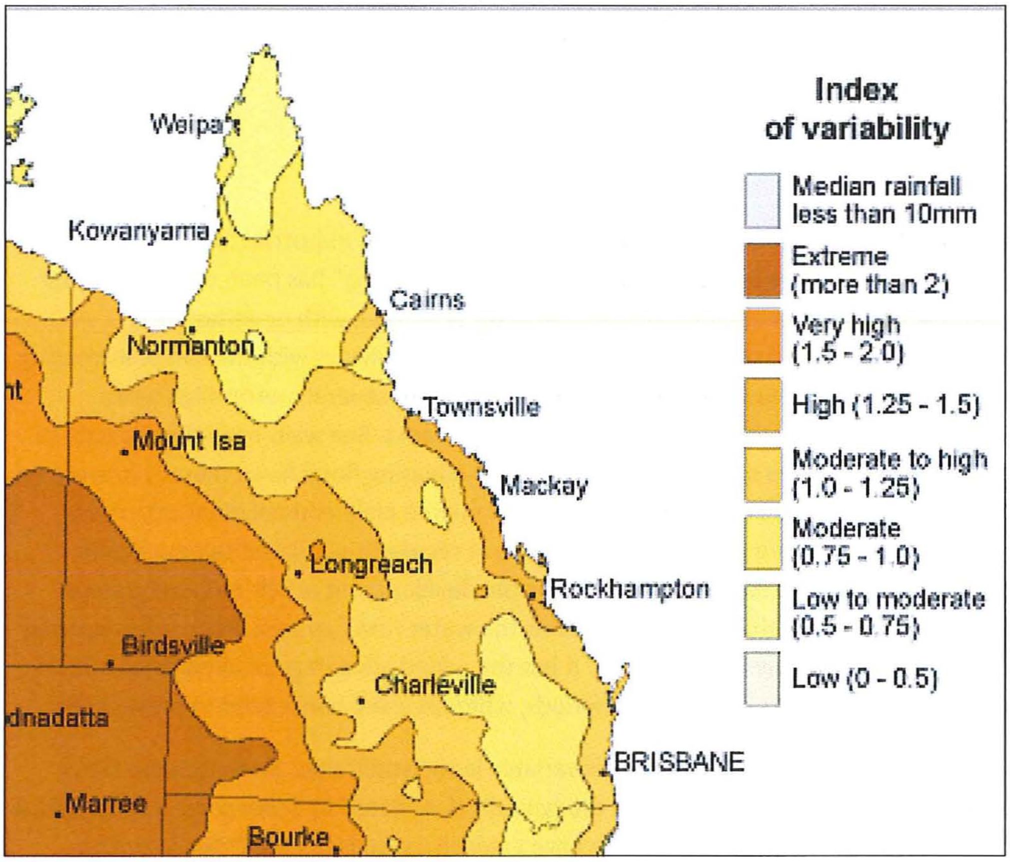


Figure 5: Index of rainfall variability in Queensland during summer (December to February), the season of most rainfall in the study area (BOM 2010)

Based on Rockhampton rainfall records (1939 to present), the early period of the study (2004 to 2007) coincided with a long period of below-average wet season rainfall (Fig. 6). The later part, 2010 to 2011 coincided with well above-average rainfall.

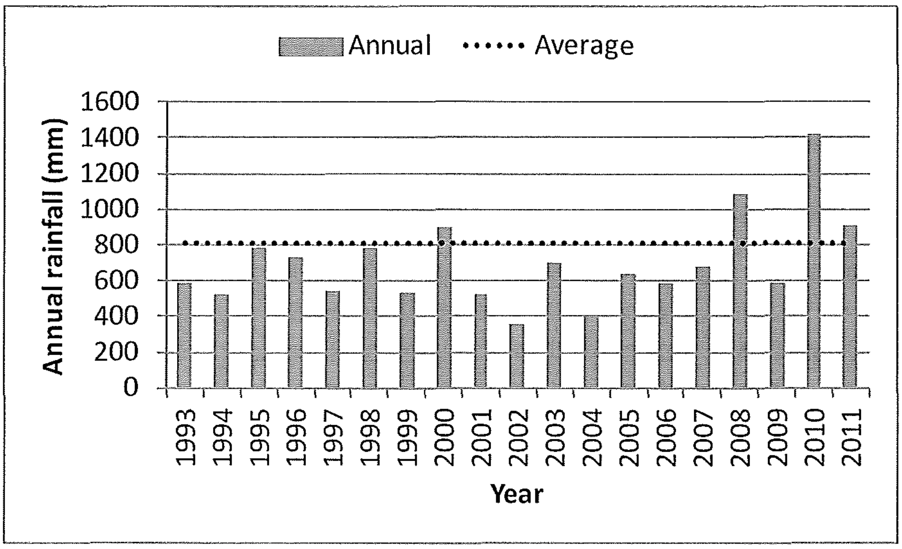


Figure 6: Annual rainfall at Rockhampton since 1993 compared with long-term average (1940-2011).

2.3 Land-use

Cattle grazing is the dominant land-use in the region. Other important industries include mining and salt production (Houston and Melzer 2008). On marine plains, "banking" has been carried out with the aim of excluding tidal flows and encouraging freshwater retention, with or without the deliberate addition of introduced semiaquatic pasture grasses, but always with the aim of increasing the area of pasture for cattle production. These banks can be up to several metres high when constructed as sea walls. Smaller versions are known as levee banks. Sea walls have the capacity to support vehicles and usually have one-way gates capable of releasing flood flows thereby preventing or reducing the potential for flood damage. A third type of marine plain embankment occurs on Torilla Plain: small check banks are placed at the interface of regularly inundated saltmarsh and surpratidal flats. These prevent tidal ingress and favour the development of salt-tolerant grasses. The advantage of check banks is that in flood situations the water flows around them, thus reducing the potential for structural damage during floods. It has the added advantage of allowing the plains to be flushed of accumulated salts during flood periods, whereas levee banks tend to prevent this.

The development of introduced pasture grasses is variable in the study sites. Some banked areas develop little additional introduced grasses and are typically dominated by *Schoenoplectus litoralis*, a salt-tolerant sedge. Some portions of Torilla Plain have extensive stands of Para Grass *Urochloa mutica* while others are dominated by native or naturalised species (e.g. Water Grass *Paspalum distichum* or Bermuda Grass *Cynodon dactylon*).

2. Methods

2.1 Distribution and general habitat associations

Methods for this section are described in Houston (2010). In general, the areas of potential chat habitat (land zones 1 and 3) were systematically searched between 2003 and 2010 resulting in the location of 15 chat sites within six coastal plains (aggregations of wetlands within easily definable features such as creeks and rivers, or other obvious landmarks, were used to define target areas; Houston 2010). Vegetation of these sites was described (Houston 2009, 2010) and the salinity of surface pools measured, using an optical refractometer, during both periods of extensive inundation (wet season) and as pools dried (dry season). Capricorn Yellow Chat sightings were overlaid onto the Queensland Government's Regional Ecosystem mapping (Queensland Herbarium 2009) and matched to land zone and Regional Ecosystem types. This dataset was supplemented by additional data gathered in this study (July 2010-December 2011).

2.2 Population Trend

For long-term recovery planning, an index of population abundance that can indicate trends is essential for gauging the 'status' of endangered fauna (Clarke *et al.* 2003). Populations of the six coastal plains where chats occur (Houston et al. 2009, Houston 2010) were estimated in two ways: a sampling approach and a census approach. The former has the advantage of being long-term and encompassing a range of climatic cycles, but the disadvantage of combining site estimates from both breeding and non-breeding periods, so that some include immature birds but others do not. Another disadvantage is that some sites were sampled more frequently than others so the precision of the mean differs. The census approach has the advantage of being a simultaneous count (i.e. within the same month) of all sites at the same time in each year, but has the disadvantage that if it is undertaken during a favourable climatic cycle it may over-estimate the long-term average size of the population. However, over a longer time frame, such problems will diminish.

Sites were surveyed either on foot or by vehicle depending on site size. Foot surveys were not possible in larger sites due to their extent (e.g. almost 30 km^2 at the largest site, Torilla Central) and the relatively low densities of chats (e.g. most surveys of this site recorded densities of only 1 individual per 30 ha). In both types of survey, once the extent of chat occurrence within a site had been determined, surveys were standardised for effort (person-hours) and search area. In addition, for larger sites such as Torilla Central, the same paddocks were searched each time. Effort per paddock varied slightly because of seasonal differences in accessibility, but, overall the same amount of search time was devoted to each site. For smaller sites (e.g. Twelve Mile Ck), the entire area was surveyed using the same route each time and all main channels and bordering flats were assessed. At all sites, great care was taken to avoid double counting and only experienced observers were used.

Population trend sing the sample approach

In order to achieve an evaluation of each coastal plain over the longest possible time period, the following approaches were taken to provide standardised annual data for each. First, where data were limited, the maximum count in each calendar year was used (commencing in 2006 for St Lawrence – Waverley, 2007 for Western Herbert and 2008 for the Northern Fitzroy Delta). Second, for the Southern Fitzroy Delta, the maximum breeding season count was based on the combined total of the only two delta sites for which long term data were available, Twelve Mile Ck and Inkerman Ck (commencing 2004). Third, for Curtis Island, all data were used including the October counts for 2001, 2002, 2009, 2011 plus July 2005 and April 2008. Fourth, for Torilla Plain, the October or November counts for the combined total of three sites: Torilla South, Torilla West plus the western portion of Torilla Central (commencing 2004) was used because data from the eastern portion were not available in these months for 2004-2006. As the western portion accounts for approximately two-thirds of the site in area and is influenced by all the main creeks that run onto the marine plain at Torilla Central, it is representative of the site as a whole.

Census approach

This was based on a single contemporary count within the late dry season (September, October or November) of all Fitzroy River delta sites in 2010 and 2011, adding to the pre-existing data from 2008-09 (Houston 2010). Effort was standardised at each site so that the same routes were sampled and the same amount of total time was spent per site each year.

As outlined in Houston (2010), a dry season census date was chosen for the following reasons:

1. It is before the main breeding season and thus, in most years, is a census of adults. This approach was used to assess changes in abundance of silvereyes on Heron Island (Kikkawa and Wilson 1983). By delaying the census until well after the wet season breeding period, problems associated with including young birds in the count are mostly avoided (except in years with unseasonal winter or early spring rainfall). The months of August and September are the driest in coastal Central Queensland so the probability of avoiding a post-breeding period is also maximised. Large flocks of mixed adults and immature birds were rarely seen in September and October (Houston 2010).

2. Abundance counts during the early to late dry season (July to November) had the lowest variability in the mean based on monthly surveys of Torilla Central (the site with most chats) from 2004 to 2008 (Houston 2010).

3. Accessibility is more likely in the late dry season, whereas in some years the marine plain at Torilla remains inaccessible to vehicles well into the early dry season period due to prolonged inundation as a consequence of either a long wet season or very high wet season rainfall. The dry season was also suitable for surveys of saltfield sites in the delta and, in past years, chats had been present in relatively high numbers at Curtis Island at this time of year, although no seasonal data were available for this site.

However, the well above average wet seasons of 2010 and 2011 resulted in a prolonged deep inundation of the marine plain on the Torilla Peninsula (and the western Broad Sound in 2010), preventing surveys from being undertaken at these sites. Some data were obtained from a few sites in this area but the main site at Torilla Central was inaccessible.

2.3 Seasonal Habitat Use

Earlier research had found a regular pattern of abundance in Delta sites with peaks during the wetter months at breeding sites such as Twelve Mile Ck but with the reverse pattern at the two saltfield sites. This was best explained by Capricorn Yellow Chats seasonally moving between saltmarsh breeding sites and the saltfields. The wetter climatic period of 2010-2011 provided an opportunity to evaluate if seasonal movements were maintained under these conditions.

Following the 'discovery' of Capricorn Yellow Chats at the Twelve Mile Ck site in February 2004, monthly surveys (of 1 day duration) were undertaken until August 2010, except for June and August 2005 and July 2006 (75 in all). Another site, Inkerman Ck saltmarsh, was added in January 2005 and two more, Inkerman Ck Saltfield and Pelican Ck Saltfield, in September 2008 following discovery of the Capricorn Yellow Chat at these sites in June and July 2008 respectively.

Routine sampling of these four Delta sites continued until August 2010, from which time sampling was undertaken at two-monthly intervals except in March 2011 (one month) and after September 2011 when there was a three month interval in order to capture the commencement of breeding at Twelve Mile Ck. Thus, samples were taken in July, August, October, December 2010 and February, March, May, July, September, December 2011. Overall, there were 85 surveys from which to evaluate habitat use at Twelve Mile Ck.

Supplementary data were obtained by surveys of the Raglan Ck Oxbow (Christiansen's) site in March, June, July and September 2004, January, April and October 2005, October 2006, June 2007, May 2008, May 2009, April and August 2010, May, August, September, October and December 2011. Additional observations were obtained following the discovery of the Capricorn Yellow Chat at Fitzroy Vale (Nankin Ck Oxbow) in the Northern Fitzroy Delta in November 2008, with further surveys in July, August, October 2009, May 2010, July and October 2011.

At Twelve Mile Ck, In addition to counts of chat abundance, an optical refractometer was used to measure the salinity of the pools within the supratidal saltmarsh where chats nested. Because supratidal pools dried out in typical years, the salinity of a permanent pool immediately upstream of the saltmarsh was also recorded. However, this meant that some data for the pools of the supratidal saltmarsh were unavoidably missing. To allow for cautious analysis, these were represented in the dataset with values of extreme high salinity (just greater than the highest recorded, 200 parts per thousand (‰)).

Inundation extent of the supratidal area was ranked according to the following scheme:

- 0 - totally dry;
- 1 - some water in pools but less than 1/3 full;
- 2 - pools 1/3 to 2/3 inundated;
- 3 - lagoons full but saltmarsh flats are dry

- 4 – some flooding (or post flooding and drying out), lagoons full and there is extensive mud under the saltmarsh vegetation;
- 5 – extensively flooded including the saltmarsh flats.

2.4 Ecological drivers of habitat use of the Capricorn Yellow Chat

2.4.1 Background

When breeding, Capricorn Yellow Chats forage over low saltmarsh vegetation (including shrubs of the bordering alluvial edges) and the mud beneath the saltmarsh for small invertebrates (Fig. 7). Previous studies have shown that breeding at Twelve Mile Ck correlates with peaks in food availability, particularly of flies, bugs and spiders within the saltmarsh vegetation fringing the supratidal pools at Twelve Mile Ck (Houston 2010, in prep.). It was not necessary to evaluate the food availability of the muddy substrates below the saltmarsh vegetation as these areas dry out and peaks obviously coincide with the breeding season. Thus, the months when chats move from the breeding grounds at Twelve Mile Ck and Inkerman Ck saltmarshes (March to May) coincide with a drying out of these wetlands and a decline in food resources. What is not known is the availability of invertebrate food at the saltfields during this period.

Other factors which may influence movement to the saltfields may be differences in resources such as freshwater. However, permanent freshwater was available within a kilometre of the core breeding area at Twelve Mile Ck but chats were not observed using this lagoon during a year of monthly surveys (Houston *et al.* 2006) or in incidental surveys associated with long-term monitoring of the adjacent downstream saltmarshes. One of the saltfield sites had a small freshwater dam near it but the other, Inkerman Ck Saltfield, had no obvious freshwater (the nearest was more than 3 km distant; further than the distance of the freshwater pool at Twelve Mile Ck from their nesting area).

Other potential sources of freshwater are dew-fall as chats have a brush tongue and may be able to obtain water from this source. It is possible that differences in the availability of dew may influence choice of dry season habitat. Thus, dew formation was evaluated at Twelve Mile Ck and the two saltfield sites. Previous studies had suggested that there were no difference between these habitat types although the data was equivocal (one saltfield site with more days of potential dew-fall, the other with less) but only one year's data was available (Houston 2010). This study will complement that earlier work.

a

b

Figure 7: Foraging habitat of chats (a) low saltmarsh vegetation (b) mud under and near samphire and grass-sedge vegetation (photo by Rod Elder)

2.4.1 Food availability

Saltfield samples were taken in March, late April and July 2011 to evaluate food availability during the period corresponding to the movement of Capricorn Yellow Chats from Twelve Mile Ck to the saltfields. Food availability was compared with those at Twelve Mile Ck based on the earlier dataset gathered between 2007 and 2009 (Houston 2010). Invertebrates from both the supratidal saltmarsh and that of the tidally influenced creek flats were sampled and designated as subsites for comparison to the saltfield data.

Capricorn Yellow Chats foraged both in the narrow band of low vegetation fringing the saltfield pools (dominated by grasses, succulents, shrubs or mangrove shrubs) and the moist substrate of mud, algae or rocks at the pool edges (Fig. 8). Thus, two sampling methods were required, one for terrestrial habitats and one for pool edges. At Twelve Mile Ck, vegetation had been sampled with a suction device and the same method was used at the Inkerman Ck Saltfields (Fig. 9a). A single suction sample from a 1 m^{-2} quadrat was taken from the same location at each pond in March, late April and July 2011. The suction sampler was operated at high speed and the nozzle of the suction sampler was passed repeatedly across the vegetation and substrate surface at a distance of 0 to 2 cm within a 1 m^2 quadrat for 30 s. Invertebrates were trapped by a stocking placed in the opening of the nozzle (an elliptical opening with dimensions of 11 by 12 cm). This method is efficient in capturing smaller less mobile invertebrates but less so for larger more mobile insects such as grasshoppers and therefore provides reliable density estimates for the former, but only an index of abundance for the latter (Hill *et al.* 2005).

Semiaquatic macrobenthic invertebrates (surface infauna and surface active invertebrates) of the mud margins were collected at three points from each pond using a shovel (20 x 25 cm) to scrape off the top centimetre of substrate (volume 500 cm^{-2} or 0.05 m^{-2}; Fig. 9b). When sorting, each sample was first washed through a 1 mm sieve. Invertebrates were sorted to Order (Naumann 1991), Class or Phylum and the abundance of each taxon recorded. Several taxa of insects were subdivided into adults and larval stages (beetles, flies, moths and butterflies).

a b

Figure 8: (a) Chat foraging in fringing vegetation (Rhodes Grass, Guinea Grass, samphire, other succulent plants, Myoporum and mangroves) (b) pool bank showing the fringing vegetation (sampled for foliage associated invertebrates) plus the muddy/rocky pool edge at the bottom right (with algal cover) sampled for semiaquatic macrobenthos (infauna and surface active invertebrates)

Figure 9: (a) suction sample at Twelve Mile demonstrating the use of the sampler in low vegetation and substrates within a 1 m^{-2} quadrat (b) scrape left by the semiaquatic macrobenthic invertebrate sampler (shovel)

2.4.2 Dew availability in the post-breeding period (April to July)

The climatic variables of air temperature, relative humidity and dew-point temperature were monitored over an 11 month period from February 2011 to December 2011 using Hobo Pro U21 data loggers. A data logger was placed at one breeding site (Twelve-mile Ck in the supratidal habitat) and two dry season sites (the Inkerman Ck and Pelican Ck Saltfields). An additional one was placed at Inkerman Ck Saltfield to evaluate accuracy of the data loggers (no difference in the two loggers was found).

To reduce the likelihood of loss through flooding and submersion, data loggers were placed on patches of elevated ground. All loggers were placed under densely foliaged bushes, 20 cm above ground level (Fig. 10).

Figure 10: Data logger positioned under a dense bush, location is in the middle of the red oval

2.5 Data Analysis

The influence of Habitat Type and Month (and their interaction) on total invertebrate abundance, abundance of dominant food groups (spiders, flies, bugs and beetles) was evaluated using analysis of variance (ANOVA).

3. Results

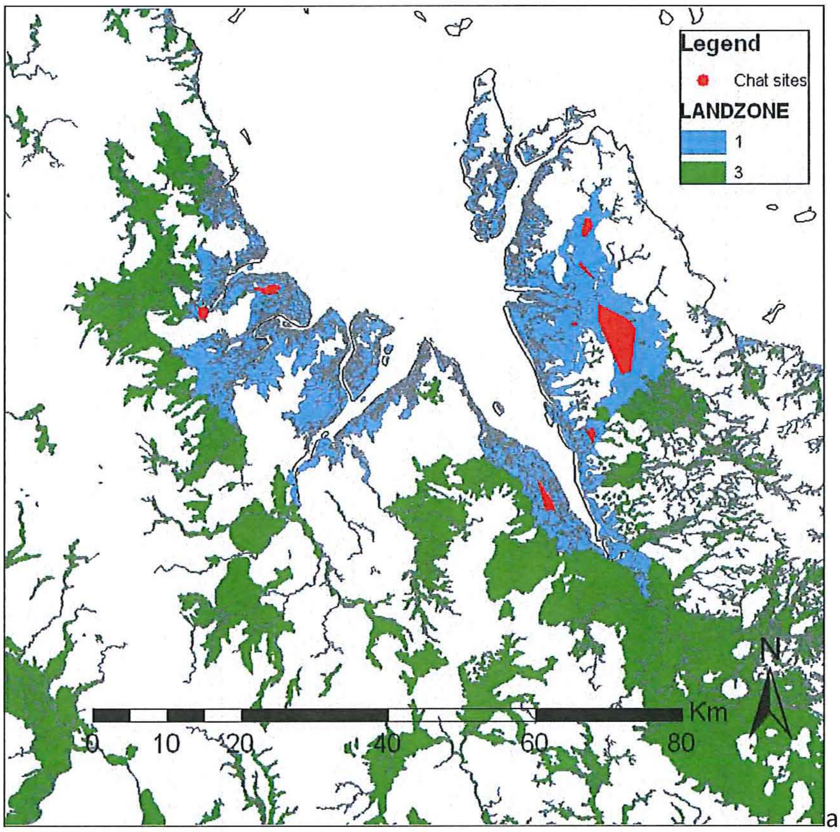
3.1 *Distribution and general habitat associations*

3.1.1 Overview

All natural sites where chats occurred (Fig. 11) were grass-sedge or saltmarsh wetlands (Table 1). The former mostly without current tidal influence except from occasional storm surges, although many had occasional tidal or storm surge influence until banks prevented tidal flows in recent times. The saltmarsh sites were at the upper end of tidal influence in the ecotone between land zone 1 and land zone 3 - the supratidal region reached only by king tides. For example, the habitat at Twelve Mile Creek receives about 4 tides in a year (Sheaves and Johnston 2008). There were also two artificial wetland sites associated with saltfields, both with associated saltmarsh habitat.

A map of known sites has been made in relationship to land zone 1 and 3 (Figure 11). A consistent relationship with marine plains (defined by land zone 1 of the government's regional ecosystem mapping) has been demonstrated (Houston 2010, Houston, in prep.). Over 96% of sightings were on marine plains (i.e. coastal plains formed by marine sedimentation processes). The remaining 4% were associated with alluvial plains but only where these bordered sites on marine plains associated with supratidal saltmarsh habitat (Twelve Mile Ck and Port Alma Saltfield, Table 1).

Marine plains are prone to elevated salinity levels due to their origin by marine sedimentation processes, drying of windblown sea spray, evaporation of sea water that seeps upward from shallow saline water tables and occasional tidal influences at some sites. Typically, all natural wetland sites where chats occurred, including the supratidal saltmarshes, received substantial freshwater inundation in the wet season and then dried out completely. Thus, these sites alternated between fresh or almost fresh in the wet season and elevated salinities in the drier months (Table 1). Salinity peaks ranged from brackish to hypersaline (i.e. more than 70 ‰; seawater is approximately 35 ‰). There was also a relationship between salinity peaks and the dominant vegetation of the grass-sedge swamps. Sites which experienced salinities greater than 18 ‰ (i.e. metasaline, saline or hypersaline) were *Schoenoplectus litoralis* dominated while the relatively low salinity sites were either *Cyperus alopecuroides* or *Eleocharis* dominated. The three broad site types (fresh to brackish grass-sedge swamps, metasaline to hypersaline grass-sedge swamps and supratidal saltmarshes) are illustrated in Figures 12 to 14 respectively.



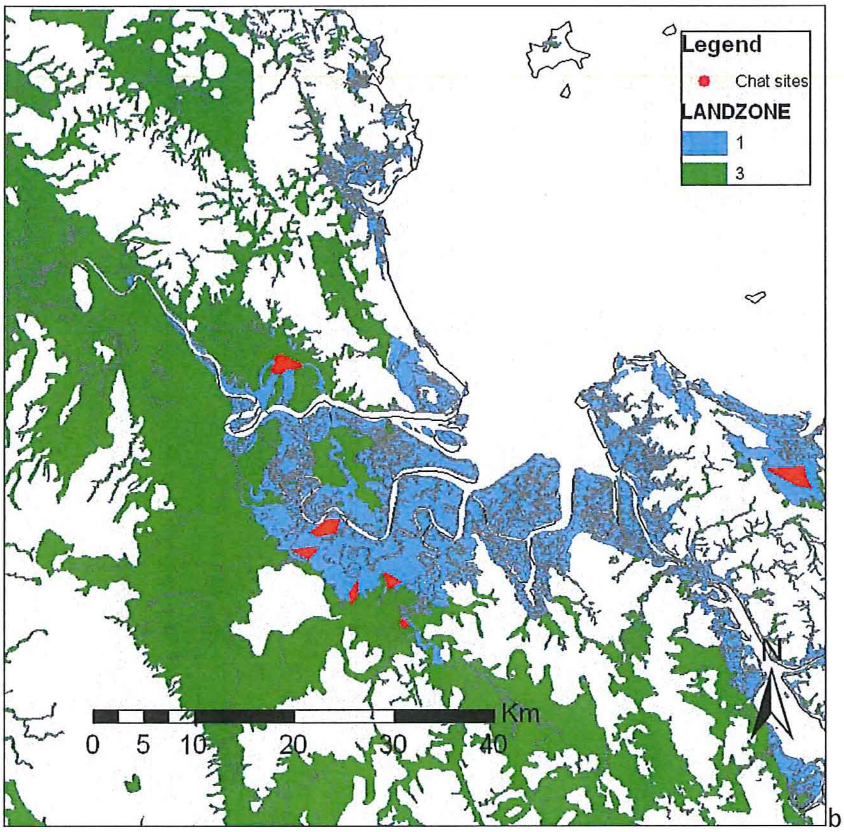


Figure 11: Chat sites mapped using "extent of occurrence" overlaid onto regional ecosystem mapping (land zone) for (a) Broad Sound and (b) Fitzroy River delta areas (Queensland Herbarium 2006 pre-European dataset) (Houston 2010)

Table 1: Description of chat sites (note that seawater is approximately 35 ‰)

Type/Site/Salinity range (‰)	Chat use	Minimum salinity ‰	Maximum salinity ‰	Hydroperiod	Tidal influence	Dominant tall cover	Mapped RE	Actual RE based on ground-truthing
Grass-sedge wetlands								
Fresh (0 to 5 ‰)								
St Lawrence West (0)	occasional	0	0	permanent	historical	*Eleocharis* & *Schoenoplectus*	11.1.1	11.3.27x1c
Torilla North (0-5)	regular	0	5	seasonal	historical	*C. alopecuroides* & *Eleocharis*	11.3.27x1a, x1c	11.3.27x1a, x1c
Brackish (6-18 ‰)								
Torilla Central (0-17)	regular	0	17	seasonal	storm surge	*C. alopecuroides* & Para Grass	11.3.27x1a, x1c/11.1.1	11.1.1, 11.3.27x1a, x1c
Raglan Ck Oxbow (0-12)	episodic	0	12	semi-permanent	storm surge	Para Grass, *S. litoralis, Eleocharis*, samphire & Marine Couch	non-rem. land zone 3	11.1.1, 11.3.27x1c
Saline (19-35 ‰)								
Herbert West (0-26)	regular	0	26	semi-permanent	storm surge	*S. litoralis* & samphire	11.1.2a/ non-rem. land zone 1	11.1.3
Torilla West (2-35)	regular	2	35	seasonal	storm surge	*S. litoralis*, samphire & Marine Couch	11.1.2b, 11.1.2a/11.3.27x1c, 11.1.2b	11.1.3

Type/Site/Salinity range (‰)	Chat use	Minimum salinity ‰	Maximum salinity ‰	Hydroperiod	Tidal influence	Dominant tall cover	Mapped RE	Actual RE based on ground-truthing
Metasaline (36-70 ‰)								
St Lawrence East (2-70)	regular	2	70	seasonal	storm surge	*S. litoralis* & samphire	11.3.27x1c /11.1.2a	11.1.2b, 11.1.3, 11.3.27x1c
Hypersaline (>70 ‰)								
Torilla Northwest (2-116)	regular	2	116	seasonal	storm surge	*S. litoralis* & samphire	11.3.27x1a, x1c/ 11.1.1, 11.1.2, 11.3.27X1c	11.1.1, 11.1.2b, 11.1.3
Torilla South (0-340)	regular	0	340	seasonal	storm surge	*S. litoralis* & samphire	11.1.2b/11.1.2, 11.1.1/11.1.1, 11.1.2/ water (non-rem. land zone 1)	11.1.1, 11.1.2b, 11.1.3
Nankin Plain Oxbow (2-120)	regular	2	120	episodic	storm surge	*S. litoralis*	11.3.27x1b, non-rem. land zone 1	11.3.27x1a, x1c
Curtis Island marine plain (8-90)	regular	8	90	seasonal	storm surge	*S. litoralis* & Water Grass	12.1.2	12.1.2
Supratidal saltmarsh wetlands and saltfields								
Hypersaline (>70 ‰)								
Twelve Mile Ck (0-290)	regular	0	290	seasonal	king tides	samphire & Marine Couch	11.1.2a/ non-rem. land zone 3	11.1.2b, non-rem. land zone 3

Type/Site/Salinity range (‰)	Chat use	Minimum salinity ‰	Maximum salinity ‰	Hydroperiod	Tidal influence	Dominant tall cover	Mapped RE	Actual RE based on ground-truthing
Inkerman Ck (0-315)	regular	0	315	episodic	king tides	samphire & *S. litoralis*	11.1.1/ 11.1.2a/ non-rem. land zone 1	11.1.1, 11.1.2b, 11.1.3
Inkerman Ck Saltfield (4-220)	regular	4	220	permanent	king tides	grassy margins of saltponds & samphire, Marine Couch	11.1.2a/ non-rem., land zone 1	11.1.2b/ non-rem., land zone 1
Pelican Ck Saltfield (0-152)	regular	0	152	permanent	king tides	saltmarsh & grassy margins of saltponds	11.1.2a/ non-rem. land zone 1/ non-rem. land zone 3	11.1.2b, non-rem. land zone 1, non-rem. land zone 3

Figure 12: <u>Fresh to brackish grass-sedge wetlands</u>: typically dominated by *C. alopecuroides* (but sometimes by *E. dulcis*); dry completely in most years; other important species include Water Grass (*Paspalum distichum*), Para Grass (*Urochloa mutica*), Bermuda Grass (*Cynodon dactylon*)

Figure 13: Metasaline to hypersaline grass-sedge wetlands: typical open breeding habitat dominated by *S. litoralis*; samphire (plus species such as Marine Couch and Beetle Grass *Leptochloa fusca*) intermingles with *S. litoralis* at some sites providing additional foraging and nesting habitat; *S. litoralis* is often associated with banking, and is salinity tolerant

Figure 14: Supratidal saltmarsh and saltfields: Twelve Mile Creek is extensively inundated in the wet season. In the core breeding area tall Marine Couch (*Sporobolus virginicus*) lines the channels, with Samphire (*Halosarcia pergranulata* and *H. indica)* bushes forming the next zone; these saltmarshes dry out completely in the dry season as basins are shallow; saltfield banks and muddy edges provide habitat in the drier months

3.1.2 Evaluation of RE Mapping

There were three major inconsistencies in the RE mapping (Table 1; Fig. 15). First, all sightings of chats mapped as saltflat (RE 11.1.2, refer to Table 2 for a description of important Capricorn Yellow Chat RE types) were found to be vegetated, even if only sparsely (i.e. 10-30% cover). Although chats were sometimes seen to forage on bare substrates, these were always within a few metres of samphire saltmarsh vegetation. Vegetation at these sites corresponded mostly to samphire dominant saltmarsh vegetation equivalent to RE 11.1.2b. At Inkerman Ck, dense clumps of samphire (5-10 m wide by 10-50m long) are interspersed with bare saltflats (Fig.16). To illustrate the problem with the RE mapping, chat sightings at Twelve Mile Ck have been overlaid onto a SPOT satellite image showing vegetated areas that have been mapped as vegetation free saltflats (Fig. 17). This correction applied to the two saltmarsh Southern Fitzroy Delta sites (and parts of the two saltfield sites) and an observation at St Lawrence East. Most of these inaccuracies were a consequence of the scale of mapping; it is very difficult to detect vegetated areas of saltmarsh at a 1:100,000 scale of mapping.

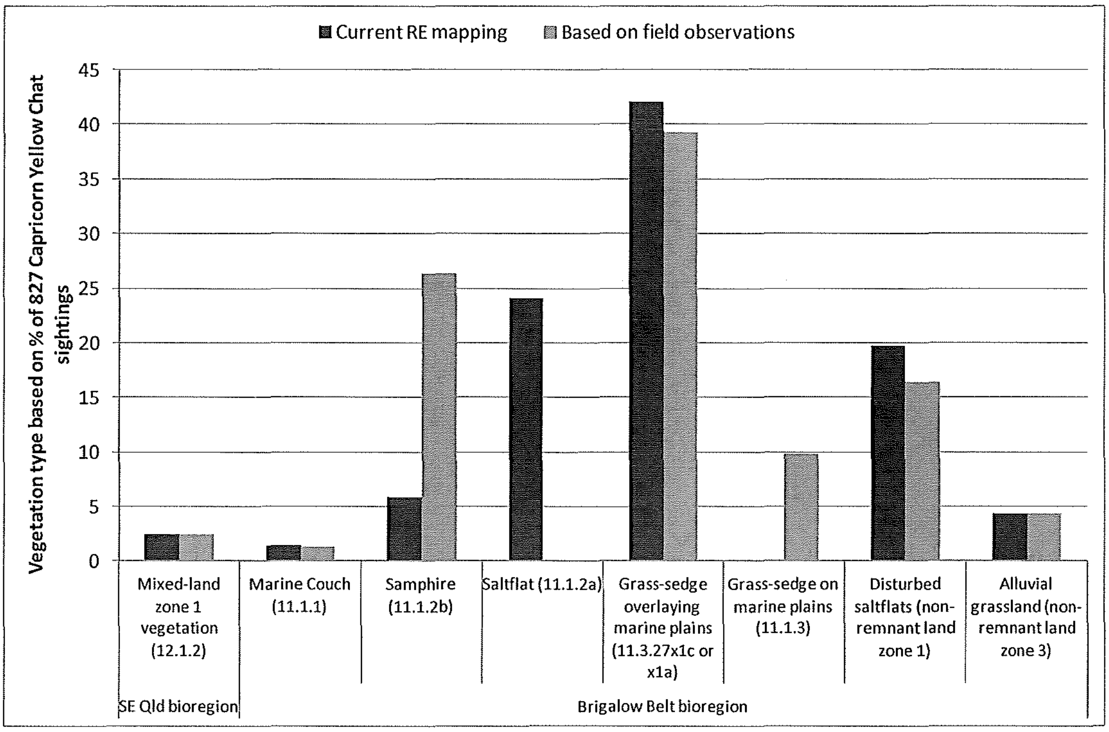


Figure 15: Summary of RE types used by Capricorn Yellow Chats based on ground-verified modifications compared with original government mapping

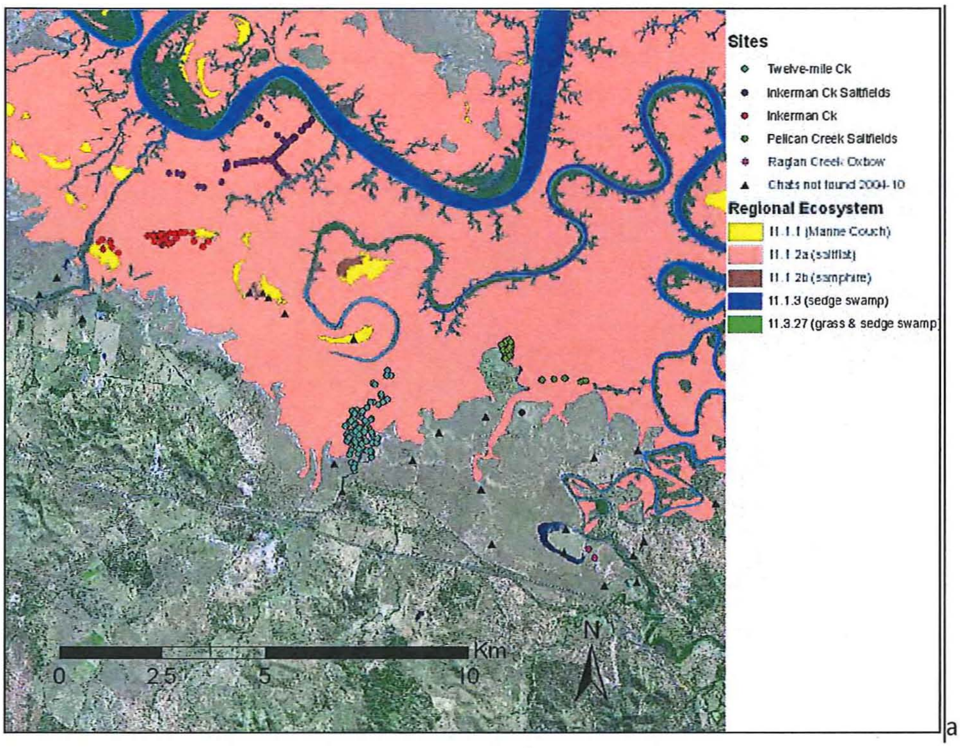
Second, some grass-sedge swamps are currently mapped by DERM as being associated with alluvium overlaying marine plains, RE 11.3. 27x1c, rather than 11.1.3 (grass-sedge swamps of marine plains), as determined by the on-ground surveys of this study. This applied to Torilla Northwest, Torilla West and some sightings at St Lawrence East. Supporting evidence for this re-classification is: (i) the grass-sedge swamps of these sites are embedded within saltmarsh vegetation (RE 11.1.2b) or saltflats (RE 11.1.2a); (ii) soils are of the grey clay type typical of marine plains in the region (Burgis 1975); and (iii) salinity levels rapidly become hypersaline during the dry season (peak salinities being 3, 1 and 2 times seawater respectively for the above three sites, Table 1) whereas at other sites where 11.3.27x1c dominates, salinities are typically brackish at the most (e.g. Torilla North and Torilla Central) although not always (e.g. Northern Fitzroy Delta).

Figure 16: Chat nest site at the Inkerman Ck saltmarsh; mapped as vegetation free saltflats; same area in the wet season, waders are sometimes abundant at these saltmarsh habitats (Houston *et al.* 2006).

Finally, an extensive *S. litoralis* swamp at Torilla South (Fig. 13) was mapped as water. This was also likely to have been an artefact of the scale of mapping. This vegetation closely matches RE 11.1.3 for the same reasons listed in the previous paragraph (peak salinities at this site were even more extreme at almost 10 times seawater).

Table 2: Description of the Brigalow Belt Regional Ecosystem types used by Capricorn Yellow Chats

RE type	General Description
RE 11.3.27 (subcategories x1c, 1a)	Palustrine wetland (e.g. vegetated swamp). Sedgelands to grasslands on Quaternary deposits. Occurs in depressions on old Quaternary estuarine deposits or marine plains. These are seasonally inundated with fresh water but become more brackish as they dry. Dry out completely before the next season's rain.
RE 11.1.3	Sedgelands on marine clay plains dominated by a range of sedges and grasses. Occurs in depressions on Quaternary estuarine deposits which are brackish to saline. These may be seasonally inundated with fresh water, but dry out completely before the next season's rain.
RE 11.1.2b	Samphire forbland on marine clay plains. Mainly saltpans and mudflats with clumps of saltbush including *Halosarcia* spp. Sedges may be common.
RE 11.1.1	Marine Couch (*Sporobolus virginicus*) grassland on marine clay plains. Occurs on supratidal flats which are often only inundated by the highest spring tides. Often occurs on the landward side of intertidal flats; seaward margins irregularly inundated with tidal waters and dissected by small tidal channels. Formed from Quaternary estuarine sediments with deep grey or black and grey saline cracking clays with occasional mottling, minor gilgai occasionally present.



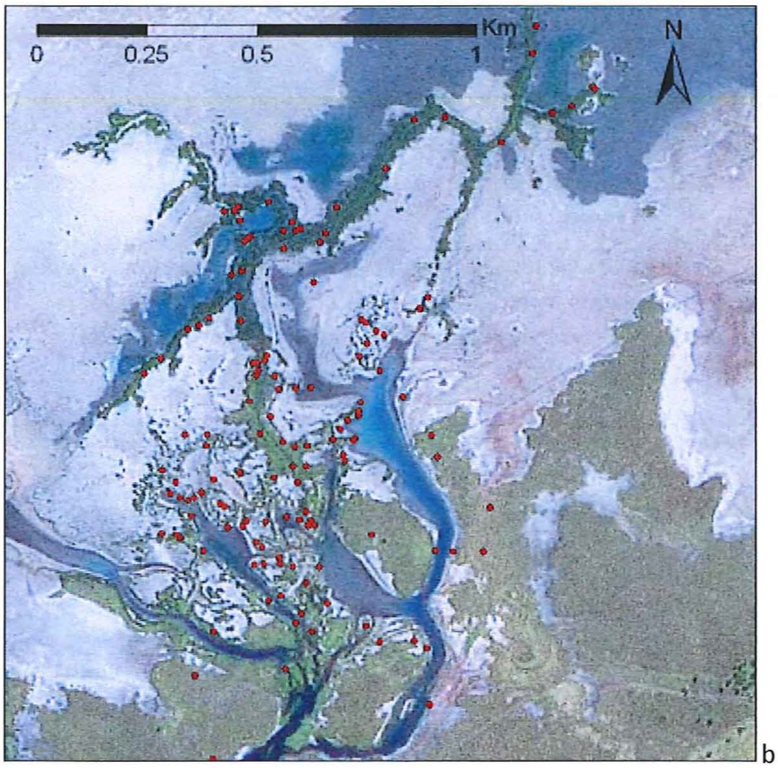


Figure 17: (a) chat sightings for Southern Fitzroy Delta overlaid onto government RE mapping showing majority mapped as unvegetated saltflats (b) Vegetated area of Twelve Mile Ck (chat sighting points in red)

3.1.3 Conclusions

No further sites were located during 2010-11. However, the area of occupancy has been expanded at some sites (Inkerman Ck Saltmarsh, Twelve Mile Ck, Herbert West, Torilla Central, Torilla West and Torilla South). This probably reflects the influence of the current wet climatic cycle in prolonging the time of inundation for marginal areas of these wetlands, allowing suitable vegetation to develop. This, in combination with successful breeding and an increase in the numbers of birds requiring breeding habitat, has led to an expansion in habitat occupied. These site expansions corresponded to the same wetland habitat types and remnant Regional Ecosystem vegetation types of importance to Capricorn Yellow Chats (REs 11.3.27X1c, x1a; 11.1.3, 11.1.2b and 11.1.1). However, due to the scale of the Government RE mapping, this does not provide a sound basis for mapping chat habitat.

3.2 Population trend

Comparing the two site groups which had been monitored since 2004 (Torilla Plain and Southern Fitzroy delta; Fig. 18), both had a similar overall pattern with counts in both areas lowest in 2007. This pattern was most pronounced for the former and corresponded to the 2006-07 failed wet season in which substantial rain did not occur until June 2007.

Numbers have been stable in the Fitzroy River delta since 2008 based on both the long-term trend data and the dry season census data (Figs 18 and 19 respectively). Over the four years between 2008 and 2011, excluding the Curtis Island data, there was a range for the maximum wet season count from almost 50 to just over 60. This compares to the dry season census of numbers which ranged from 30 to just over 50. Slightly higher wet season counts most likely reflects the presence of young birds in the counts, whereas the dry season census approach typically occurs prior to breeding and thus includes mainly adult birds.

There were no data for Torilla Plain in 2010 and 2011 due to the well above average and prolonged wet seasons of 2009-10 and 2010-11, leading to deep inundation into the dry season. A visit in September 2011 indicated that conditions were favourable for breeding and that the known extent of occupied habitat of Capricorn Yellow Chats had increased slightly compared with previous years. The count for Western Herbert was relatively low (14 compared with just under 30 in some of the previous years) but this was likely to be much higher, as at least half the known suitable habitat was unable to be surveyed in 2011. It is planned, depending on funding, to undertake further monitoring in 2012 to evaluate the breeding response of the chats to this extended wet cycle.

The decline observed at Curtis Island (Houston 2010) appears to have halted but numbers have not recovered to the pre-drought levels observed in 2001-02 (Fig. 20).

Conclusion

- Numbers in the delta are stable.
- There are not enough data to evaluate the effect of a wetter climatic cycle on the population at this stage but the apparent expansion of the existing breeding habitat suggests that the influence may be favourable.

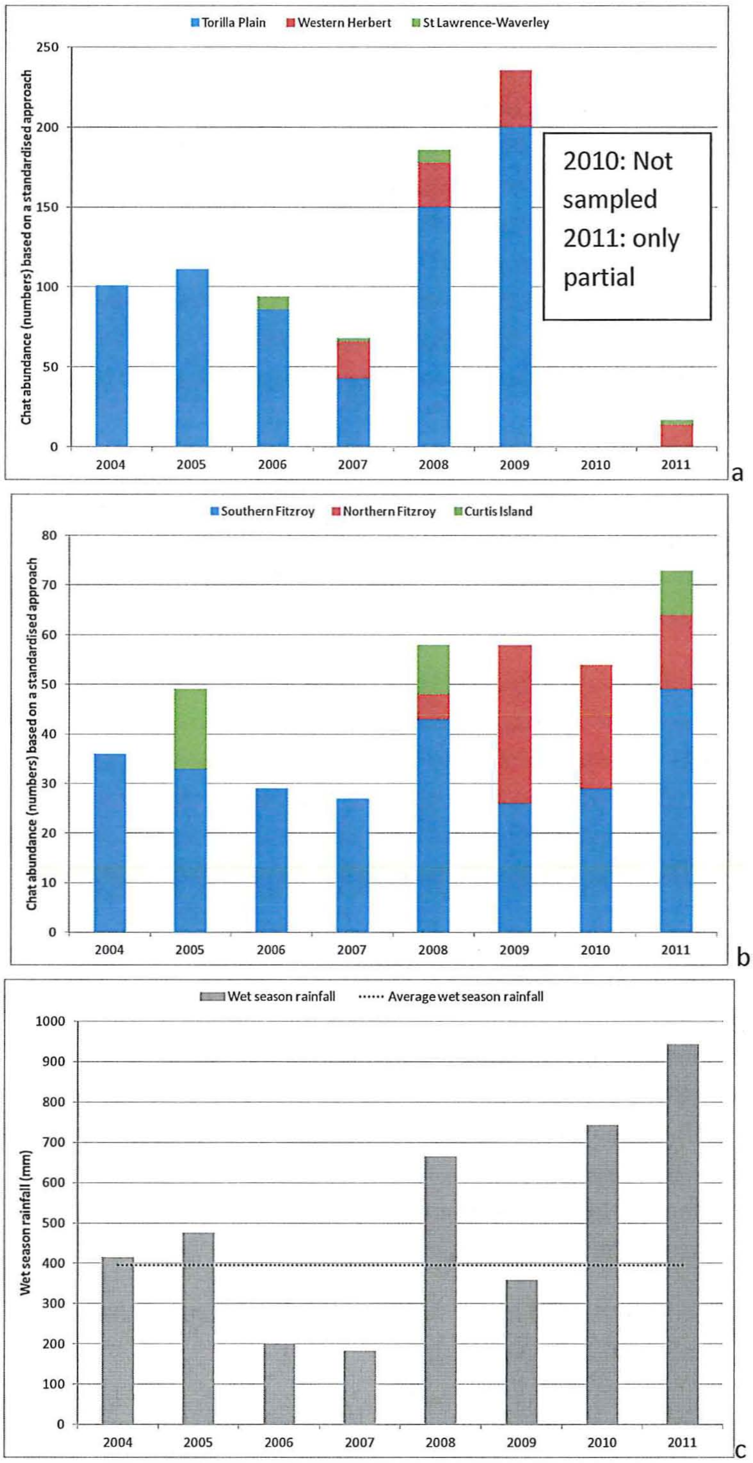


Figure 18: CYC population trend data - (a) Broad Sound area (St Lawrence-Waverley first sampled in 2006; Western Herbert in 2007); most site groups could not be accessed in 2010 and 2011 due to the wet conditions (b) Fitzroy River and Curtis Island areas (Northern Fitzroy first sampled in 2008; Curtis Island in 2005, 2008, 2009 (none were sighted) and 2011) (c) Bajool wet season rainfall December of prior year plus January, February and March (BOM)

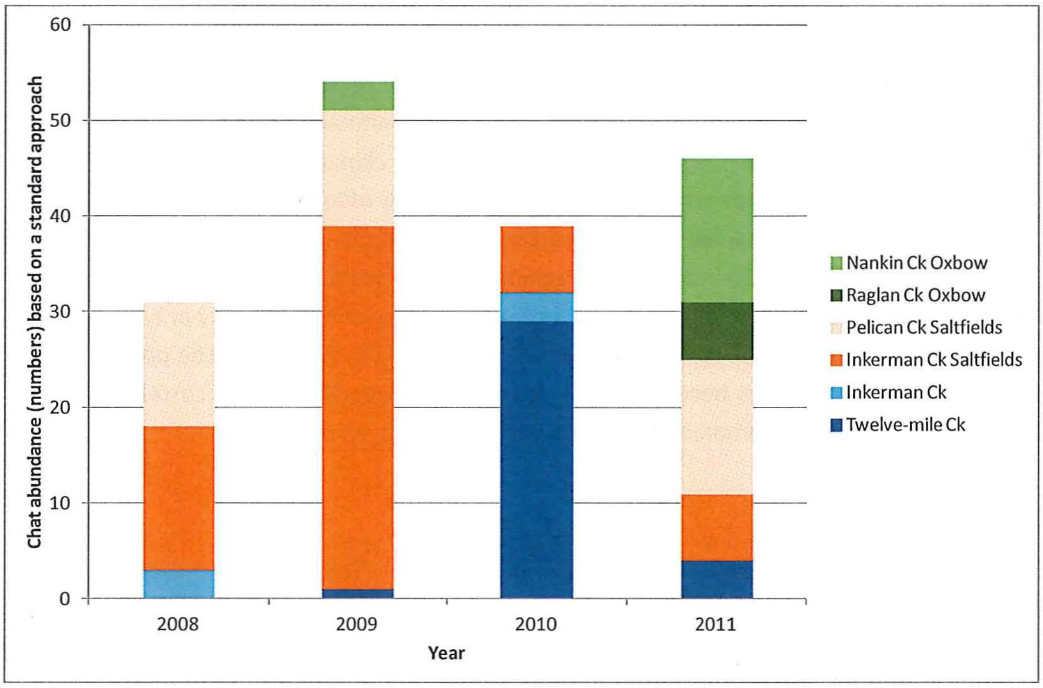


Figure 19: Population trend-dry season census surveys (census dates in Oct in 2008, 09 and 2010 and Sept 2011) based on site surveys

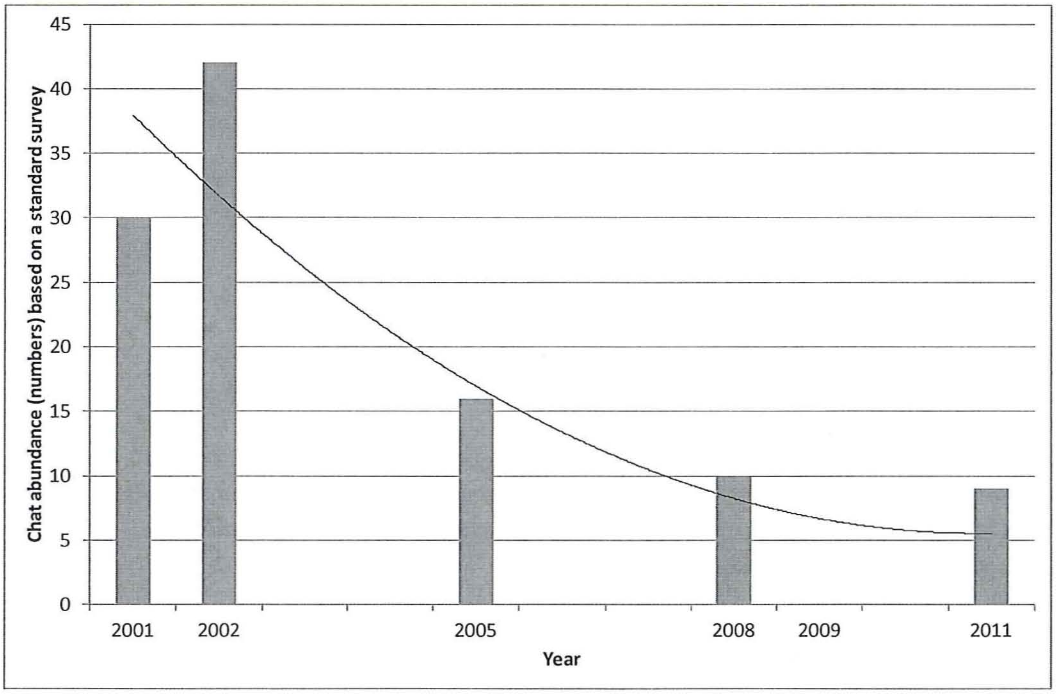


Figure 20: Curtis Island October counts for 2001, 2002, 2009 and 2011 plus July 2005 and April 2008. No chats were sighted in 2009.

3.3 *Seasonality of Habitat Use*

The aim of this section of the research was to evaluate whether the seasonal pattern of habitat use in the delta, where chats alternate between wet season breeding saltmarshes and the dry season non-breeding grounds (the saltfields), continued during the wetter climatic cycle of 2010-11. Breeding at Twelve Mile Ck (and other sites) corresponds to periods of inundation (Houston 2010). Typically, breeding sites showed marked seasonal patterns of inundation and salinity; pools fill with freshwater following early wet season storms and remain full for several months during the summer and into the autumn before drying in the post-wet period; becoming completely dry in typical years (e.g. zero for the Inundation Index in late dry season in 2008 and 2009, Fig. 21). As the pools dry (and the inundation index falls), salinities become elevated. Inundation was significantly correlated with rainfall of the previous month (Pearson coefficient *r*=0.611, P<0.001, N=35).

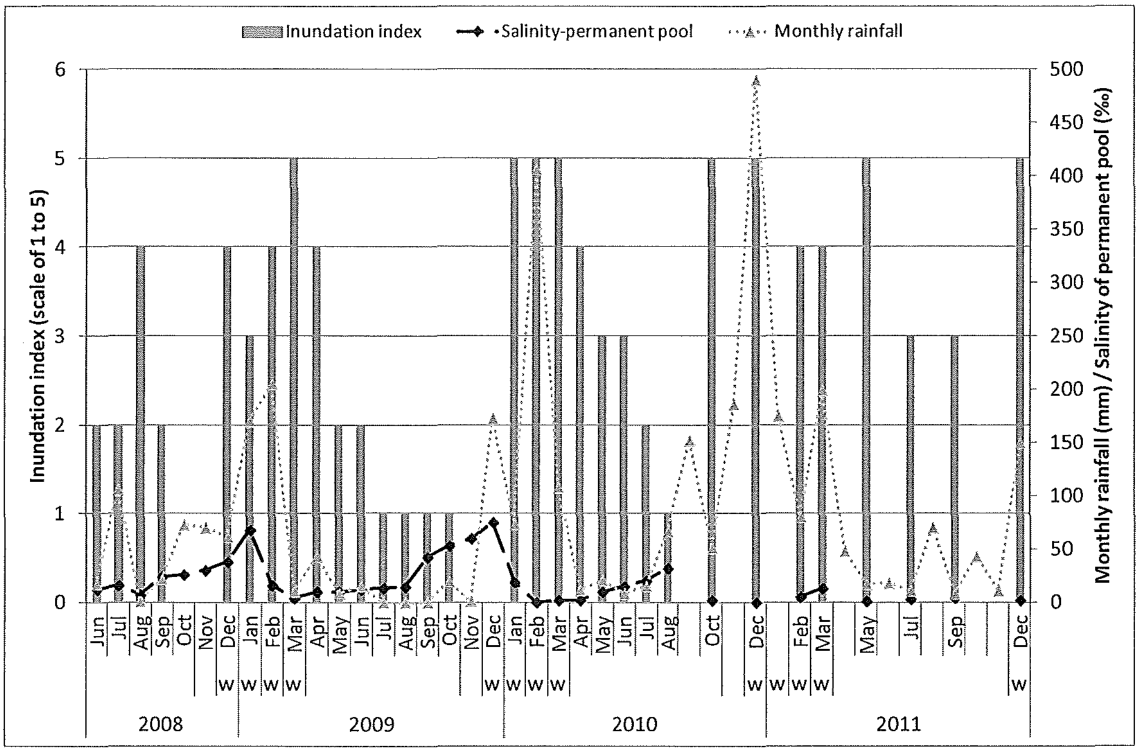


Figure 21: Fluctuations in inundation of the supratidal breeding habitat at Twelve Mile Ck and salinity of the permanent pool immediately upstream from the saltmarsh; monthly rainfall records from Bajool (Bureau of Meteorology, http://www.bom.gov.au/climate/data/) are superimposed (w=wet season months)

In general, the regular alternation of chat occurrence between the saltmarsh breeding habitats (Twelve Mile Ck and Inkerman Ck) and the saltfields (Inkerman Ck SF and Pelican Ck SF described by Houston 2010), continued in 2010-11 (Fig. 22). Occupancy at Twelve Mile Ck coincided with extensive inundation.

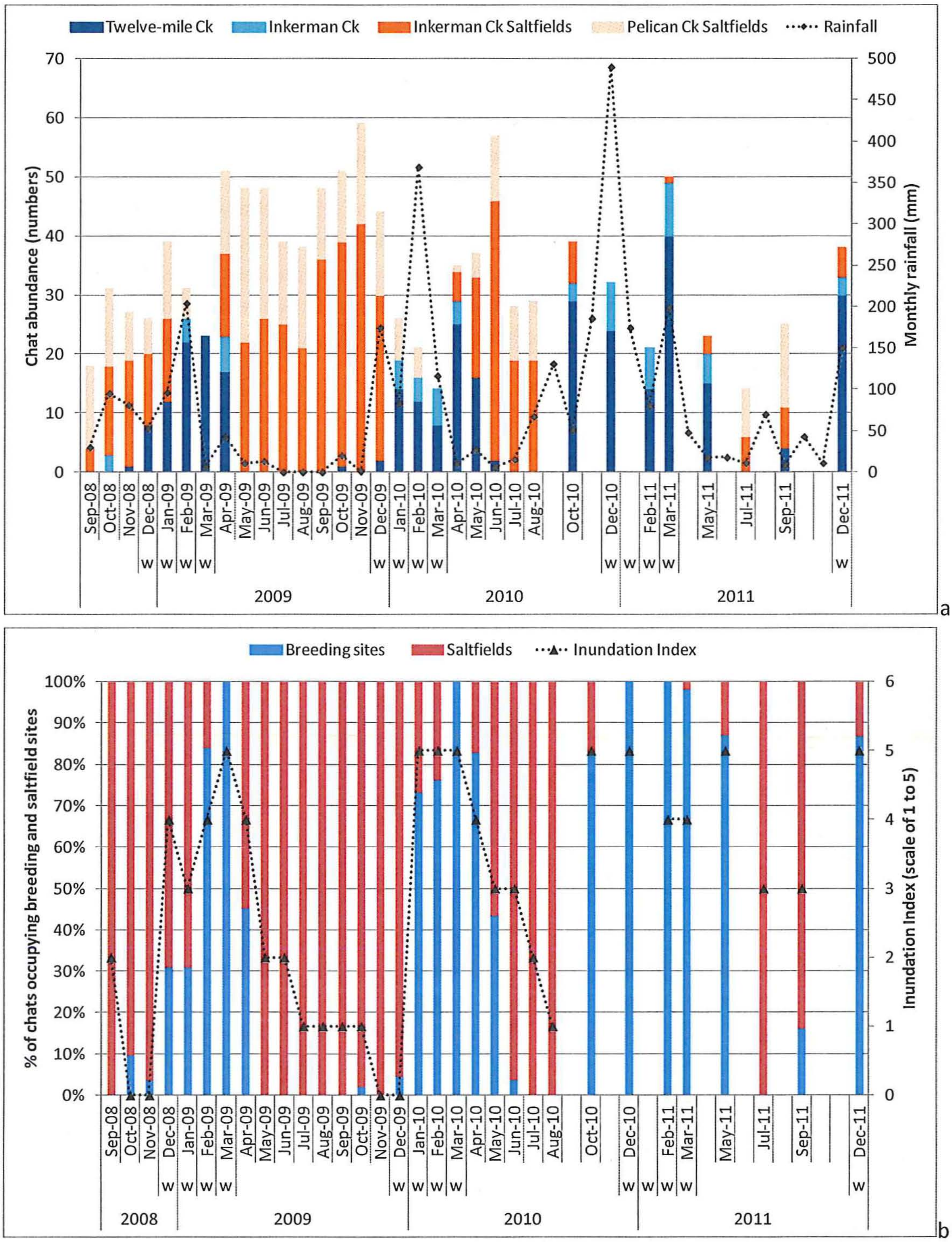


Figure 22: (a) Fluctuations in chat abundance in Fitzroy River Delta breeding sites (Twelve Mile Ck and Inkerman Ck saltmarshes) and the saltfield sites; (b) Patterns of occurrence based on the same data but pooled for the two breeding sites and the two saltfield sites and expressed as a percentage of the total monthly survey count for the 4 sites; the inundation index for Twelve Mile Ck is superimposed (w=wet season months)

The 2010-11 wet season commenced relatively early compared to typical years with a 50 mm plus rainfall event in late August 2010 followed by well above average rainfall in September, November, December, January and March (Fig. 22a). Coinciding with this was a lengthy occupancy of the two saltmarsh breeding sites between October 2010 and May 2011 (which may have been longer because the months either side were not sampled). This suggests an extended breeding period.

The pattern of occurrence at one of the saltfield sites, Inkerman Ck SF, was atypical in that relatively fewer chats, on average, were sighted at this site during the dry season of 2011 (Fig. 23). In contrast, the other saltfield site, Pelican Ck SF, had similar average numbers to previous year's dry season months. It is possible that this relatively low count at the Inkerman Ck Saltfield was due to chance and that numbers were actually higher (the reduced frequency of surveys in 2011 would have increased the probability of this happening).

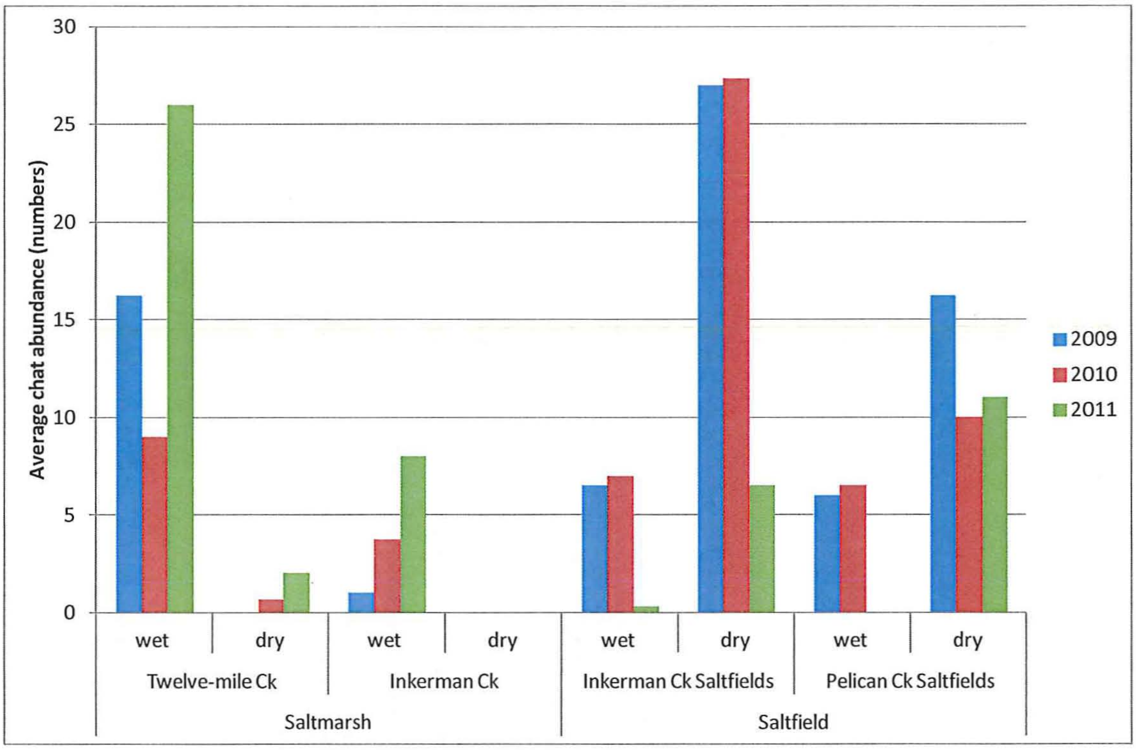


Figure 23: A comparison of the average chat abundance of the 4 wettest months (December to March) with the average chat abundance of the 4 driest months (June, July, August, September) between 2009 and 2011 at the two saltmarsh and two saltfield sites in the Southern Fitzroy delta

However, there is an alternative explanation: saltfields may not be as important as dry season habitat in these relatively wet years (the 2010-11 wet season was more than twice the average). An example of this may be the relatively high contribution to the 2011 census count of the Nankin Ck Oxbow site, much higher than previous census counts (Fig. 19). Second, chats were present at Raglan Ck Oxbow (Christiansen's) in September 2011 (and were reported from there in August 2011) suggesting a possible exploitation of additional areas during wetter phases. Chats were also found at this site between March and August 2004 and in May 2010. Such a pattern is consistent with occupancy of this site during non-drought periods (the period of absence coincided with a sequence of below average years – 2005, 2006 and 2007). Furthermore, it is also possible that chats may have persisted at Twelve Mile Ck through the dry season in 2011. There was only one survey, July 2011, in which chats were not found at this site. Salinity remained low at Twelve Mile Ck in 2011. In typical years, chats leave the site as the minimum salinity in the supratidal pools exceeds 20 ‰ (the drought year of 2006-07 was an exception) and the site dries completely (Houston 2010). In 2011, pools remained relatively full and below 20 ‰ throughout the drier months (Fig. 24). This possibly reflected the relatively low evaporation rates but also the influence of several wet years reducing the overall salt loads within the system.

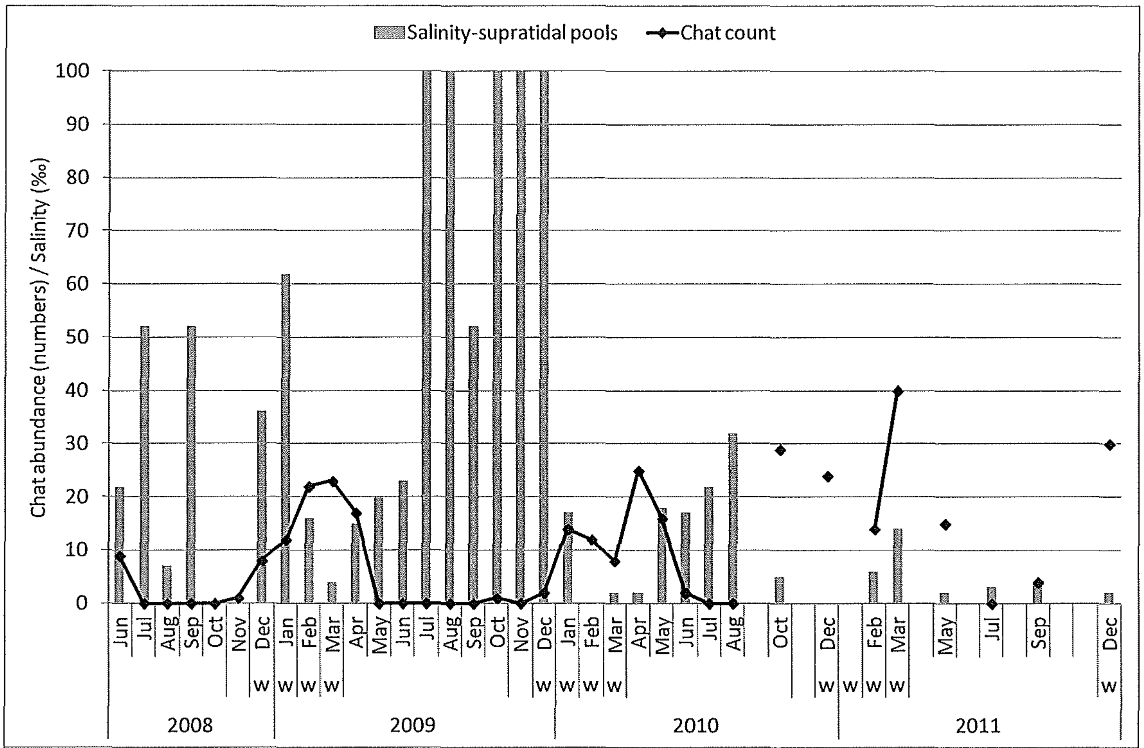


Figure 24: A long-term dataset of chat abundance in relation to the minimum salinity within the supratidal pools bordering Capricorn Yellow Chat breeding habitat (note that when no surface water was present a measure of 200 ‰ was substituted) (w=wet season months)

Other sites, yet to be discovered, may also be providing habitat during wetter climatic phases and thus reducing the dependency of chats on saltfields as dry season habitat. Conversely, this accentuates the importance of the saltfield sites during drought years where they may act as dry season refugia.

Conclusion

Chats have continued to show a seasonal pattern of habitat use, using saltmarshes to breed and other sites, particularly saltfields as non-breeding dry season habitat. However, during the current wetter climatic phase, chats appear to use additional sites such as Raglan Ck Oxbow in the dry season. It is also possible that some chats remain at the breeding sites, particularly Twelve Mile Ck as it remained inundated and with relatively low salinities (i.e. less than 20 ‰) even during the drier months.

3.4 *Influences on seasonal habitat use of the saltfields*

This component of the research was aimed at understanding why the chats move to the saltfields in the dry season and evaluated food and water (in the form of dew) availability at saltfield sites used by Capricorn Yellow Chats.

3.4.1 Background

3.4.1 Food availability in the post-breeding period (April to July)

Foliage-associated invertebrates

The food availability within fringing vegetation at the saltfields (three samples, March, May and July) was compared with similar samples taken at Twelve Mile Ck between October 2007 and June 2010 (Fig. 25). The relative abundance of invertebrates at Inkerman Ck Saltfields was at least as much as the wet season peaks observed at Twelve Mile Ck. Of greatest interest, however, was the abundance of invertebrates during the period when chats move from Twelve Mile Ck to the saltfields. In typical years this transition period corresponds to March-April but was relatively later in 2011 with chats first appearing at the two saltfield sites in May. Thus, to evaluate if food availability differed between the wet season breeding site and the dry season sites, the data from the months of April or May and June or July from 2008 and 2009 at Twelve Mile Ck were statistically compared with equivalent data from Inkerman Ck Saltfield (May and July, 2011).

In both years, food availability based on invertebrate abundance was much greater at Inkerman Ck Saltfield in the transition months than at Twelve Mile Ck (this applied to both the supratidal and the tidal subsites; Fig. 26). Thus, for comparison of dominant Orders, years for Twelve Mile Ck were treated as replicates.

The saltfields had significantly greater abundance of spiders and numbers of this taxon were evenly spread across the months of transition (Fig. 27). Saltfields also had significantly greater abundance of flies but with an uneven spread across the two sample periods (Fig. 28). Furthermore, there were almost no flies sampled at Twelve Mile Ck during this period. Bugs were in relatively low abundance at the saltfields and this pattern was stable over the transition period (Fig. 29). Tidal edge samples at Twelve Mile Ck had significantly greater abundance of bugs than other site types. Beetles were similar in abundance at the saltfields to the edge samples irrespective of whether they were from tidal or supratidal zones; samples of the flats at Twelve Mile Ck being significantly lower than some of the edge site types (Fig. 30).

Conclusion

During the critical period when chats move from the breeding grounds to the dry season sites, there is much more spider and fly food available in the fringing vegetation of the saltfields than at Twelve Mile Ck. These taxa are known to be important components of the diet of chats. In contrast, beetles showed no difference in abundance between the saltfields and core breeding habitat (the supratidal subsite at Twelve Mile Ck) while bugs were more numerous at the Twelve Mile Ck tidal subsite.

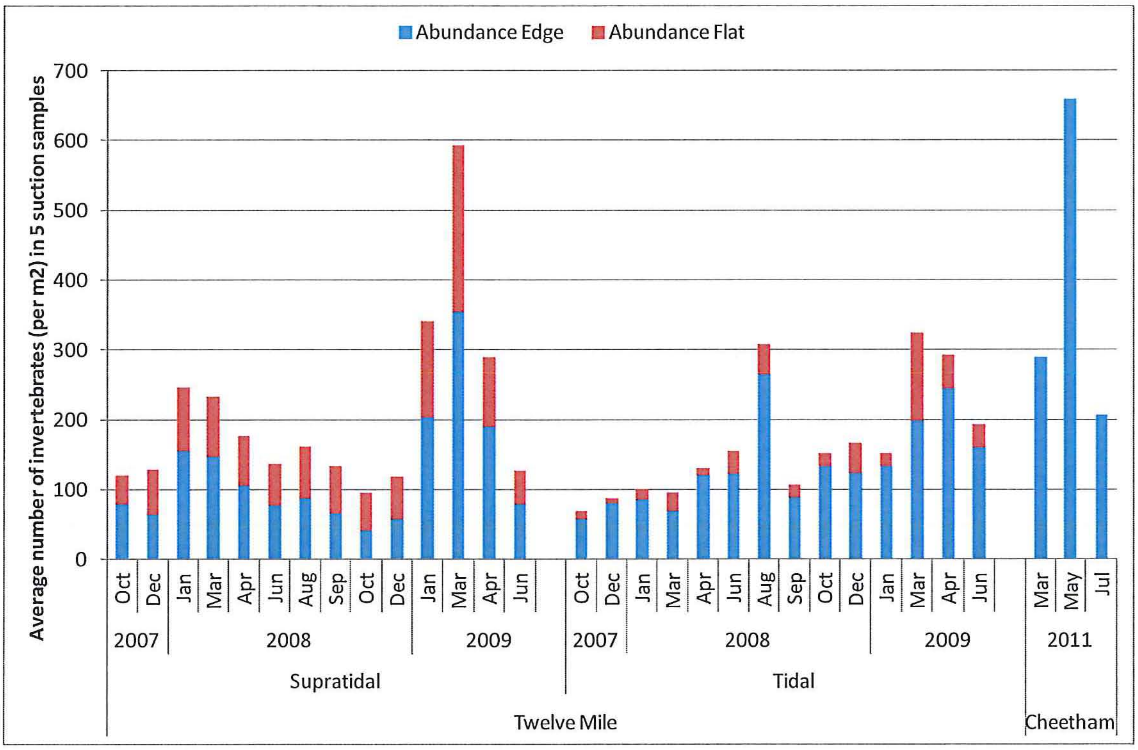


Figure 25: A comparison of the monthly abundance of foliage-associated invertebrates of the two subsites at Twelve Mile Ck with those at Inkerman Ck Saltfield (Cheetham)

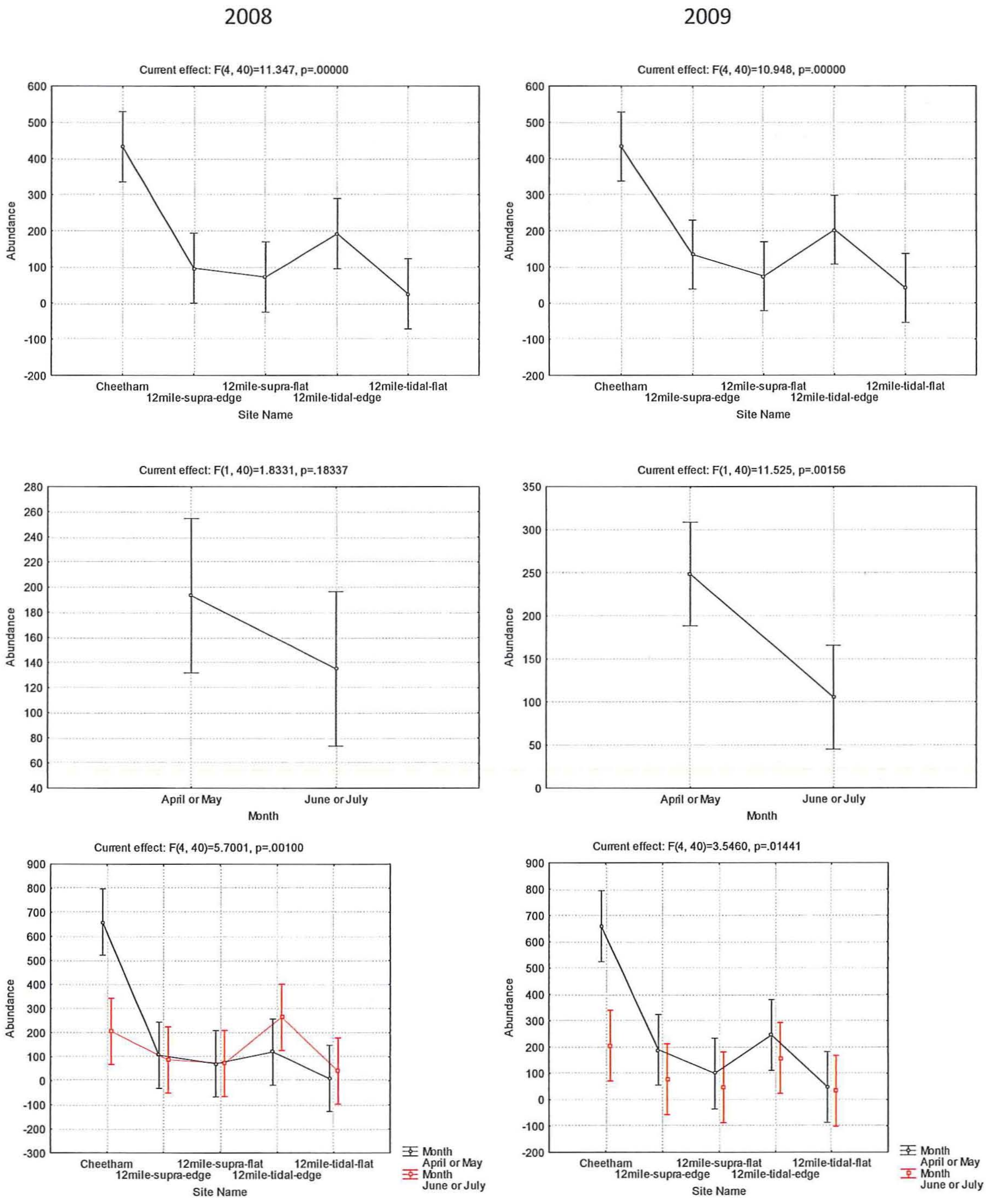
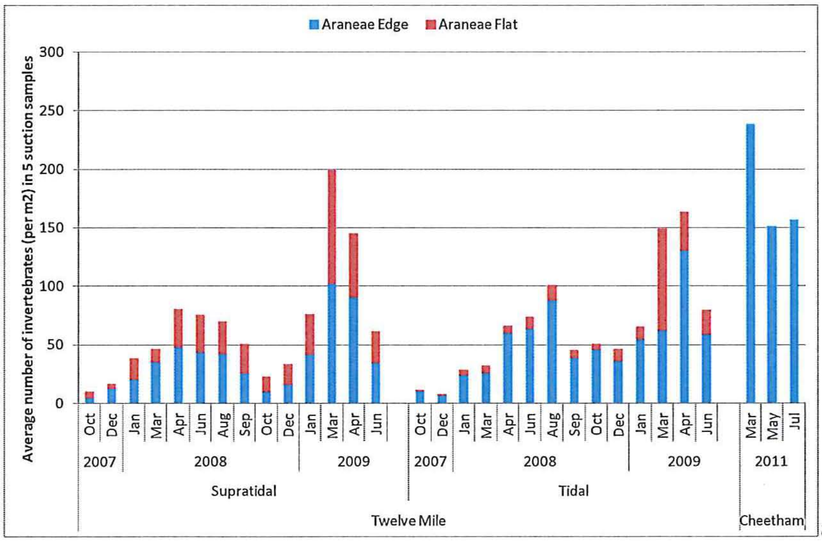


Figure 26: Graphical results of the 2-way ANOVA (Habitat Type × Month) comparing the invertebrate abundance (i.e. numbers m^{-2}) of the fringing vegetation for the transition months (April or May, June or July) at Twelve Mile Ck subsites with the Inkerman Ck Saltfield (Cheetham) 2011 data. Each year of sampling at Twelve Mile (2008 or 2009) was compared separately. Main and interaction (Habitat Type by Month) effects are shown. Vertical bars denote 0.95 confidence intervals



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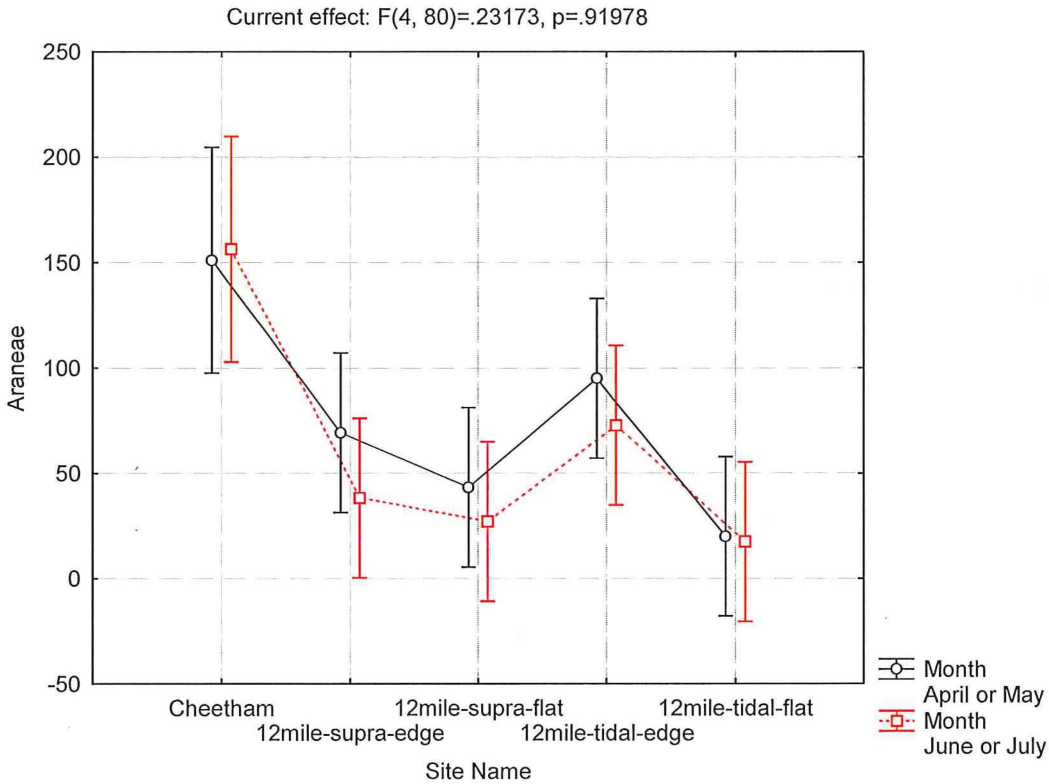

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Figure 27: (a) A comparison of the monthly abundance of vegetation-associated spiders of the two subsites at Twelve Mile Ck with those at Inkerman Ck Saltfield (Cheetham) (b) Graphical results of the 2-way ANOVA (Habitat Type × Month) comparing the spider abundance (i.e. numbers m^{-2}) of the fringing vegetation for the transition months (April or May, June or July) at Twelve Mile Ck subsites with the Inkerman Ck Saltfield (Cheetham) 2011 data. Only interaction (Habitat Type by Month) effects are shown (Habitat Type: $F_{4,80}$= 10.114, P<0.001; Month: $F_{1,80}$=1.006, P=0.319; Habitat Type by Month: $F_{4,80}$=0.232, P=0.920). Vertical bars denote 0.95 confidence intervals.

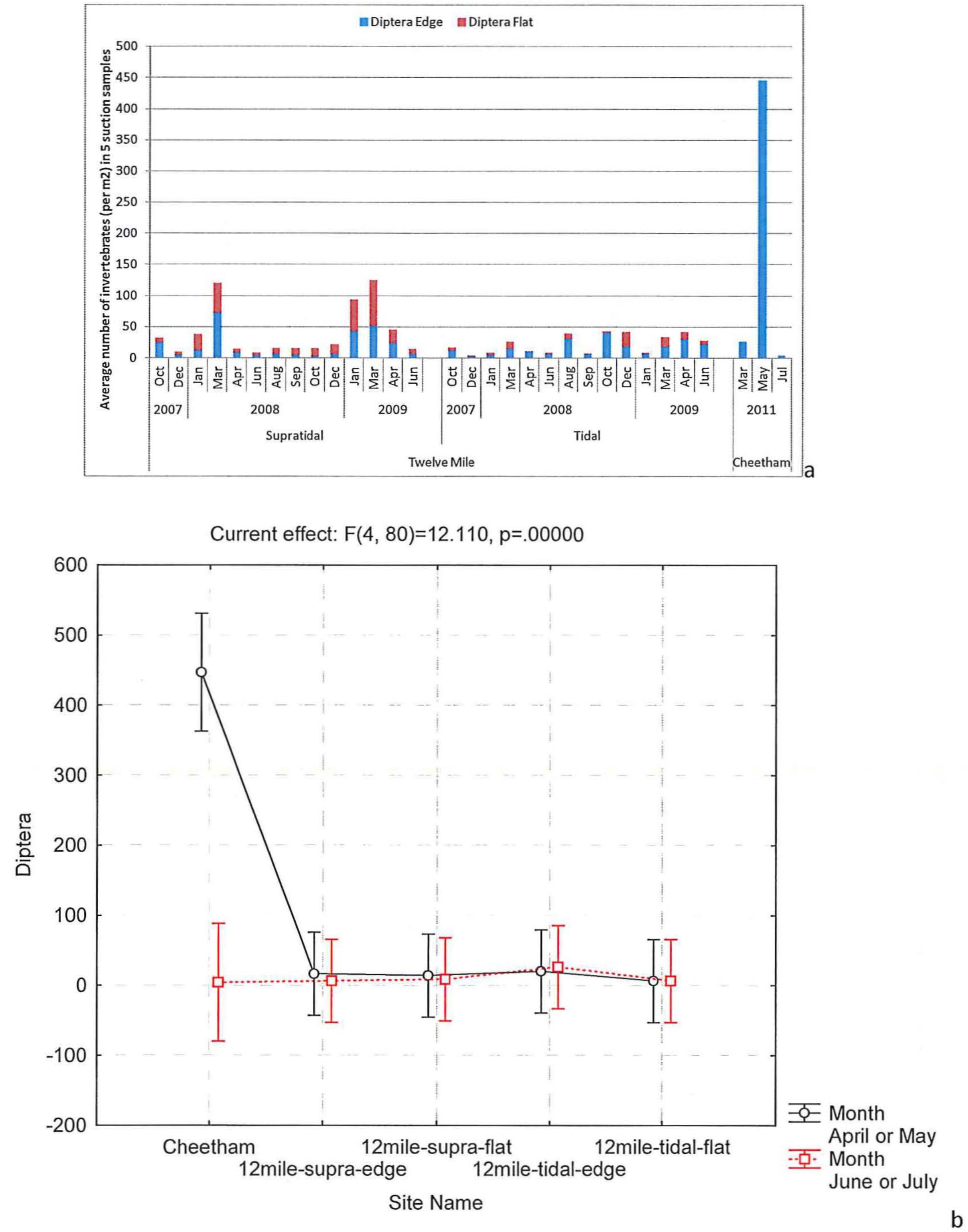
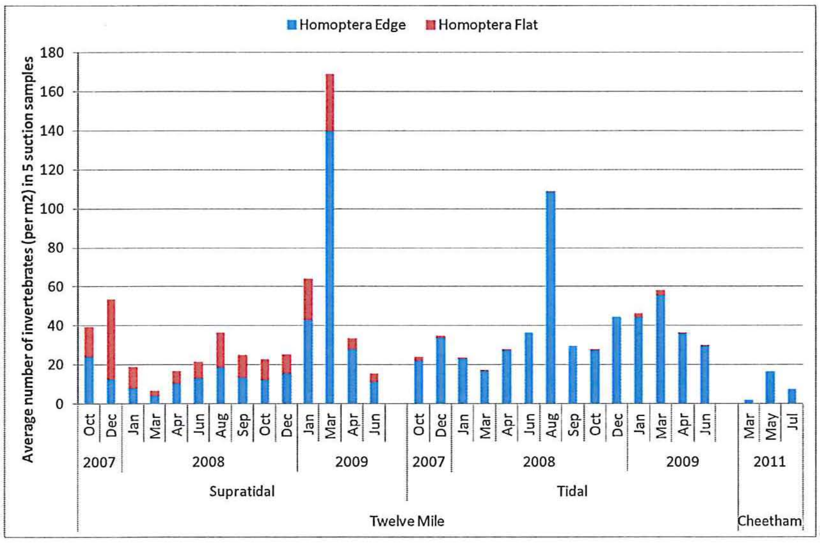


Figure 28: (a) A comparison of the monthly abundance of vegetation-associated flies of the two subsites at Twelve Mile Ck with those at Inkerman Ck Saltfield (Cheetham) (b) Graphical results of the 2-way ANOVA (Habitat Type × Month) comparing the fly abundance (i.e. numbers m^{-2}) of the fringing vegetation for the transition months (April or May, June or July) at Twelve Mile Ck subsites with the Inkerman Ck Saltfield (Cheetham) 2011 data. Only interaction (Habitat Type by Month) effects are shown (Habitat Type: $F_{4,80}$= 11.341, P<0.001; Month: $F_{1,80}$=18.936, P<0.001; Habitat Type by Month: $F_{4,80}$=12.110, P<0.001). Vertical bars denote 0.95 confidence intervals.



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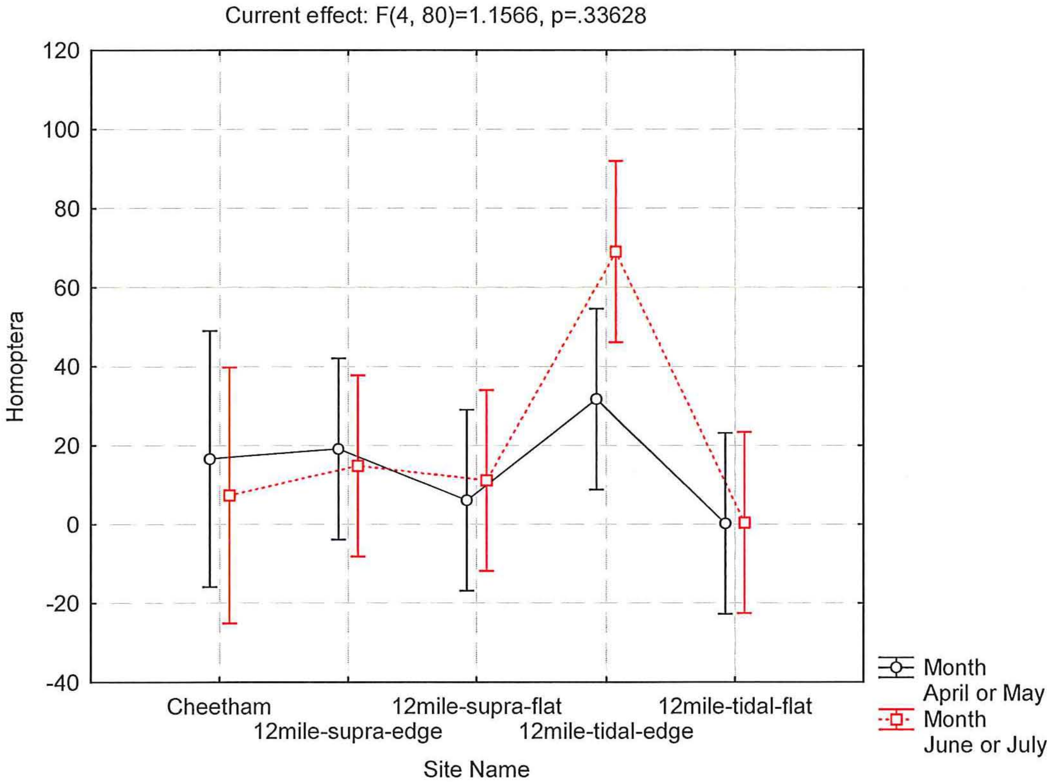

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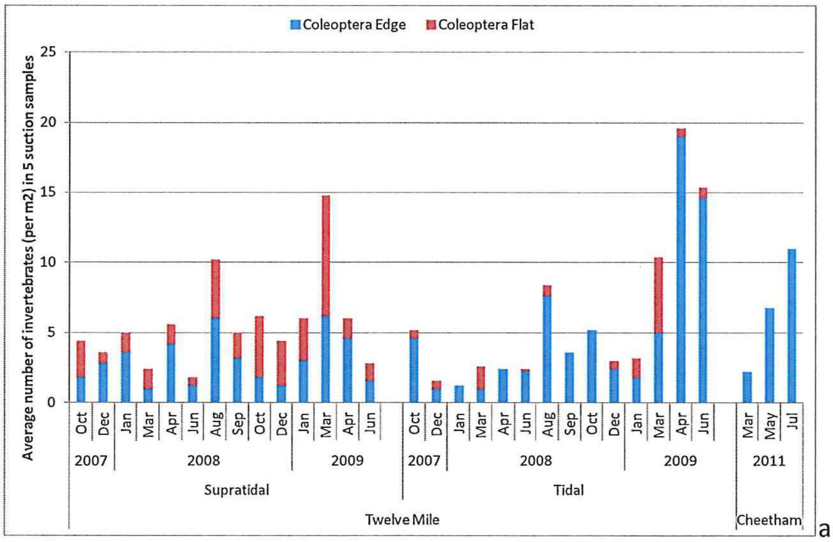
Figure 29: (a) A comparison of the monthly abundance of vegetation-associated bugs of the two subsites at Twelve Mile Ck with those at Inkerman Ck Saltfield (Cheetham) (b) Graphical results of the 2-way ANOVA (Habitat Type × Month) comparing the bug abundance (i.e. numbers m^{-2}) of the fringing vegetation for the transition months (April or May, June or July) at Twelve Mile Ck subsites with the Inkerman Ck Saltfield (Cheetham) 2011 data. Only interaction (Habitat Type by Month) effects are shown (Habitat Type: $F_{4,80}$= 5.528, P<0.001; Month: $F_{1,80}$=0.543, P=0.463; Habitat Type by Month: $F_{4,80}$=1.157, P=0.336). Vertical bars denote 0.95 confidence intervals.



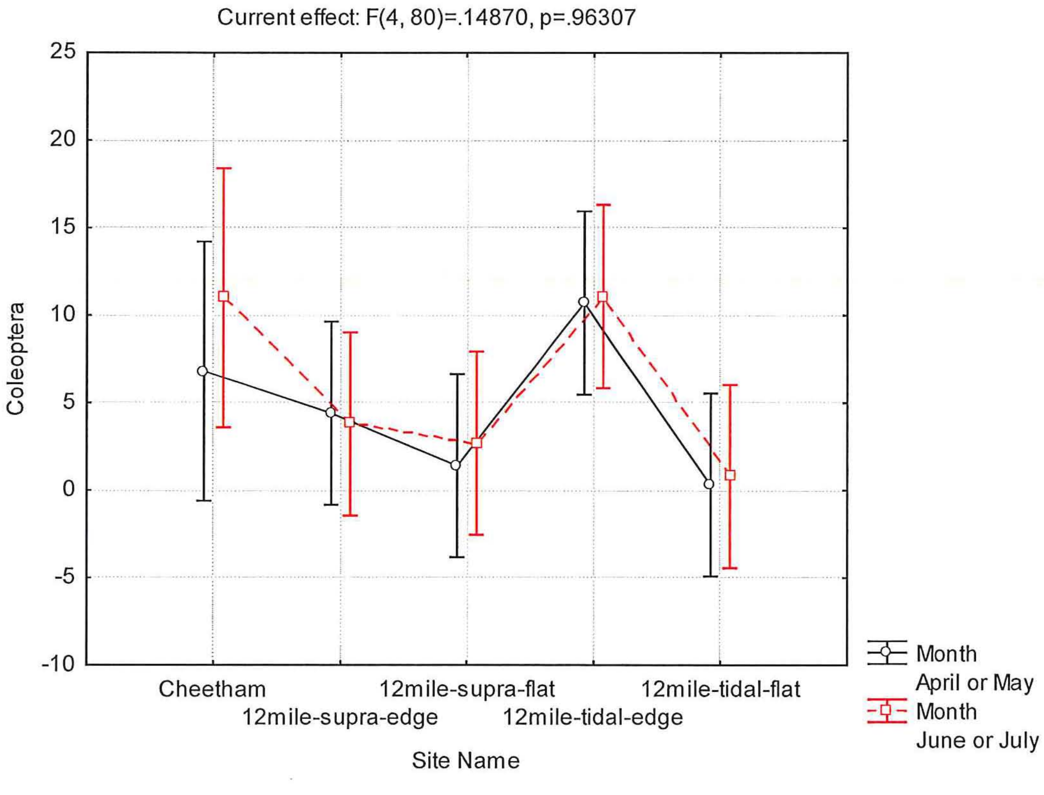


Figure 30: (a) A comparison of the monthly abundance of vegetation-associated beetles of the two subsites at Twelve Mile Ck with those at Inkerman Ck Saltfield (Cheetham) (b) Graphical results of the 2-way ANOVA (Habitat Type × Month) comparing the beetle abundance (i.e. numbers m^{-2}) of the fringing vegetation for the transition months (April or May, June or July) at Twelve Mile Ck subsites with the Inkerman Ck Saltfield (Cheetham) 2011 data. Only interaction (Habitat Type by Month) effects are shown (Habitat Type: $F_{4,80}$= 5.176, P<0.001; Month: $F_{1,80}$=0.405, P=0.526; Habitat Type by Month: $F_{4,80}$=0.149, P=0.963). Vertical bars denote 0.95 confidence intervals.

Food availability of semiaquatic macrobenthic invertebrates

The food availability of the muddy and rocky margins of the saltfields ponds was also evaluated at Inkerman Ck Saltfield. No comparison was needed with Twelve Mile Ck becasue in most years this site dries out completely in the post-wet period, and thus invertebrate food resources would be relatively low.

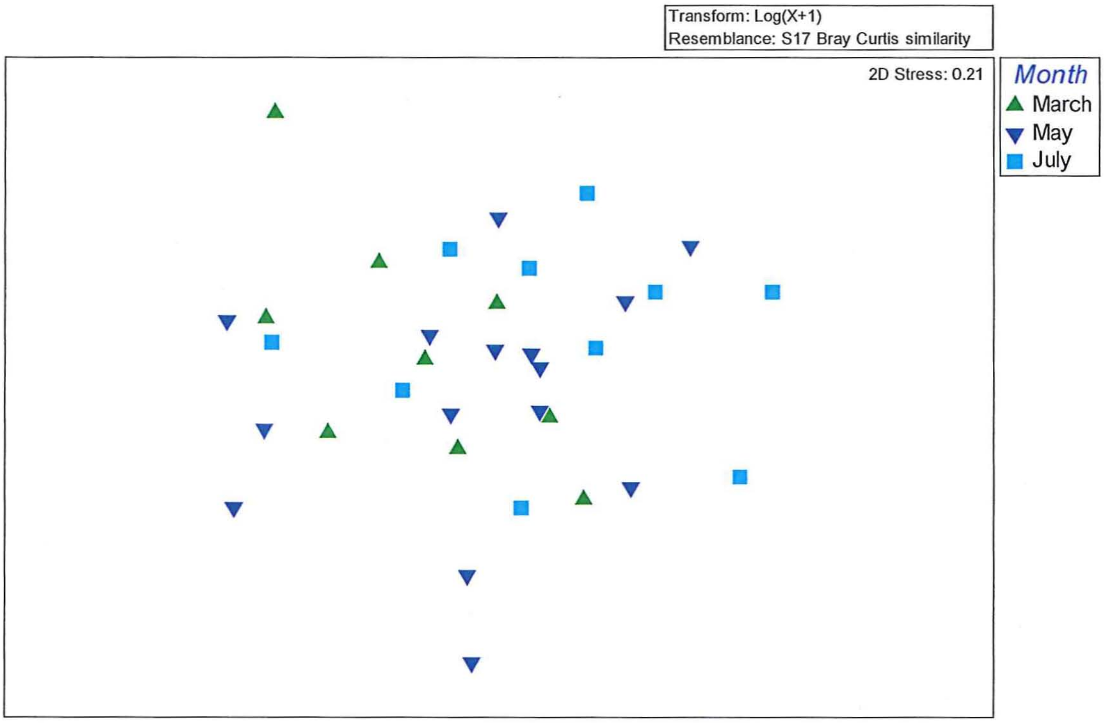
Month of sampling and pond (average salinities of A=41,B= 47, C=54, D=67, P=110 g l^{-1}) differed in invertebrate composition (ANOSIM: Month: R=0.328, P<0.01, number of iterations=999; Pond: R= 0.484, P<0.01, number of iterations =999; Fig. 31). Post-hoc tests showed that the March and July samples differed significantly while May overlapped both. The hypersaline pond (P) was the most variable in composition while pond C was the most distinctive and differed significantly from all other ponds in semiaquatic macrobenthic invertebrate composition.

Densities of benthic invertebrates (peaks of 30,000 amphipod/isopods m^{-2}, Fig. 32) were comparable to published data for salt ponds elsewhere - approximately 40,000 bivalves m^{-2} in ponds in North America and 26,000 gastropods m^{-2} in European ponds (Britton and Johnson 1987; Takekawa *et al.* 2009). In general, food resources within the muddy/rocky saltfield pool edges were extremely abundant, although abundance of insect groups was much lower than marine evolved taxa such as crustaceans and molluscs.

Comparison of insect density between vegetated margins and mud

Comparing food availability (density data) of the terrestrial and semiaquatic ecotones, there is more potential food associated within the moist substrates of the pool edges than the bordering vegetation (Fig. 33). Mud samples were dominated by larval insects such as flies and beetles (up to 800 m^{-2}) while, spiders and flies were the most important groups in the vegetation (approximately 200 m^{-2}). Chats forage over both substrate types and their combined food resources at the saltfields were much greater than the peaks recorded at Twelve Mile Ck saltmarsh. This relatively high abundance of food at the saltfields compared with the breeding site at Twelve Mile Ck suggest that this may be one of the reasons for chats using it as dry season refuge. In most years at Twelve Mile Ck, the pools dry out completely and abundance of food in the fringing vegetation declines greatly.

However, natural sites such as Twelve Mile Ck provide other resources for breeding birds that are not available at the saltfields (e.g. nesting microhabitat – samphire bushes and Marine Couch, greater protection from predators when nesting, relatively predictable pulses in food abundance during the wet season following inundation). These other resources are also essential for breeding success.



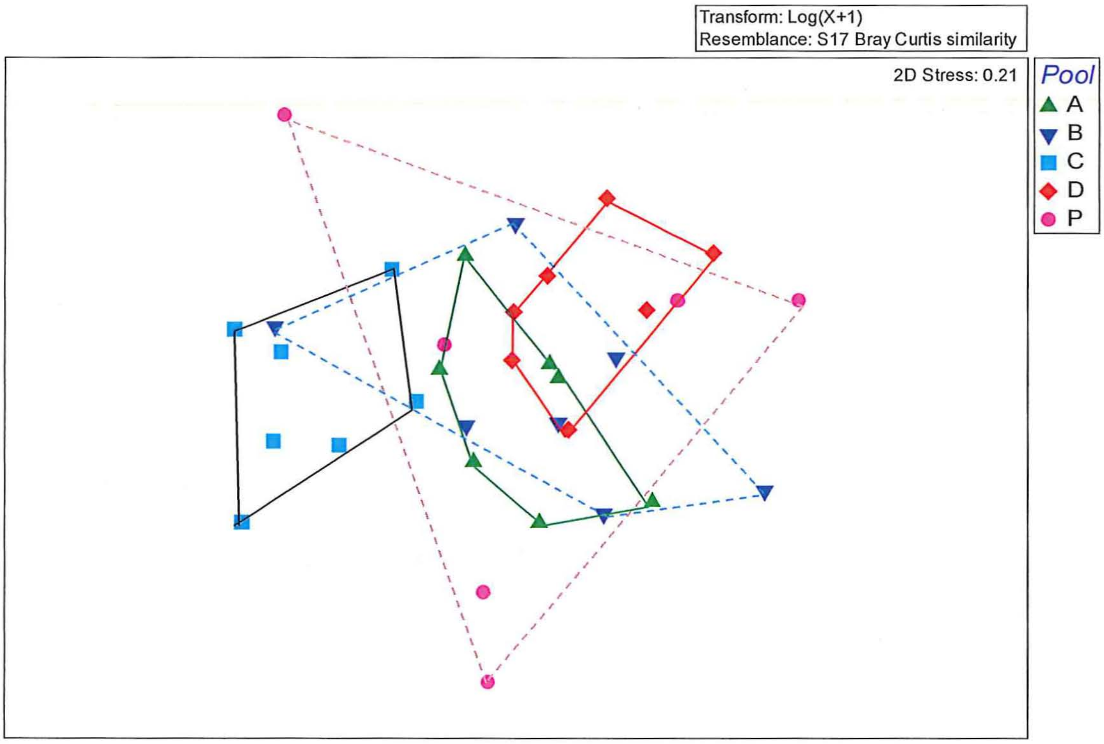
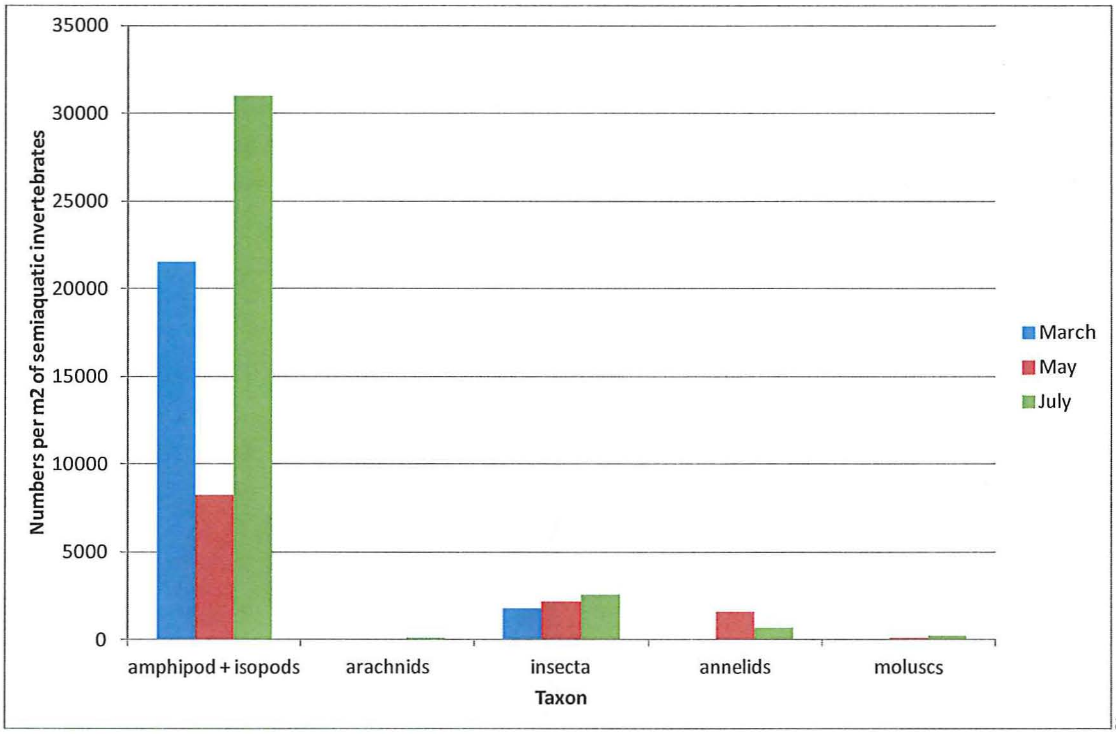


Figure 31: NMDS ordination of invertebrate samples from Twelve-mile Ck to show effect of Month and Pond on invertebrate composition (a) supratidal (b) tidal (the distance between sites represents their dissimilarity and sites closer together are more similar than sites further apart)



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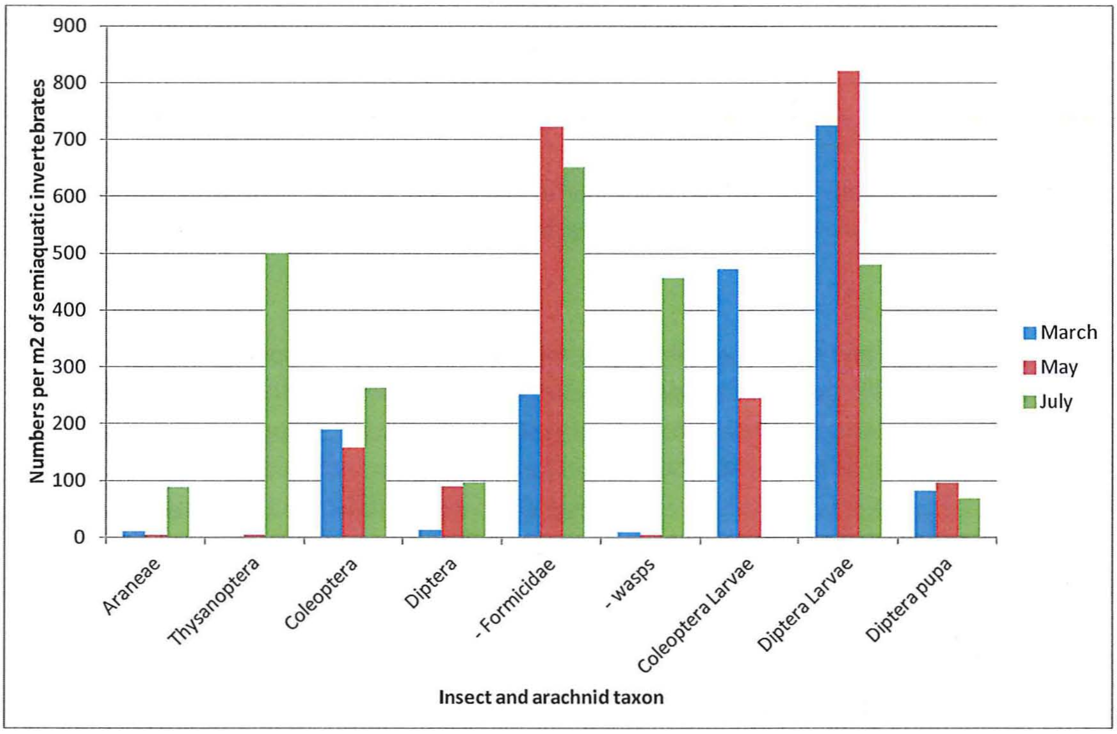

b

Figure 32: (a) summary of the inveretbrate composition of the mud samples at Inkerman Ck Saltfields and (b) only the insect and arachnid component

While the density of invertebrates associated with fringing vegetation at Inkerman Ck Saltfield may have been comparable to the peak at Twelve Mile Ck (Fig. 33), the actual availability of food must also include an area component. At Twelve Mile Ck, the extensive flats (up to 100 m wide in places) have the capacity to support a much greater absolute abundance of saltmarsh associated food resources than at the saltfields where the food is concentrated in the narrow margins bordering the pools (mostly less than two metres wide).

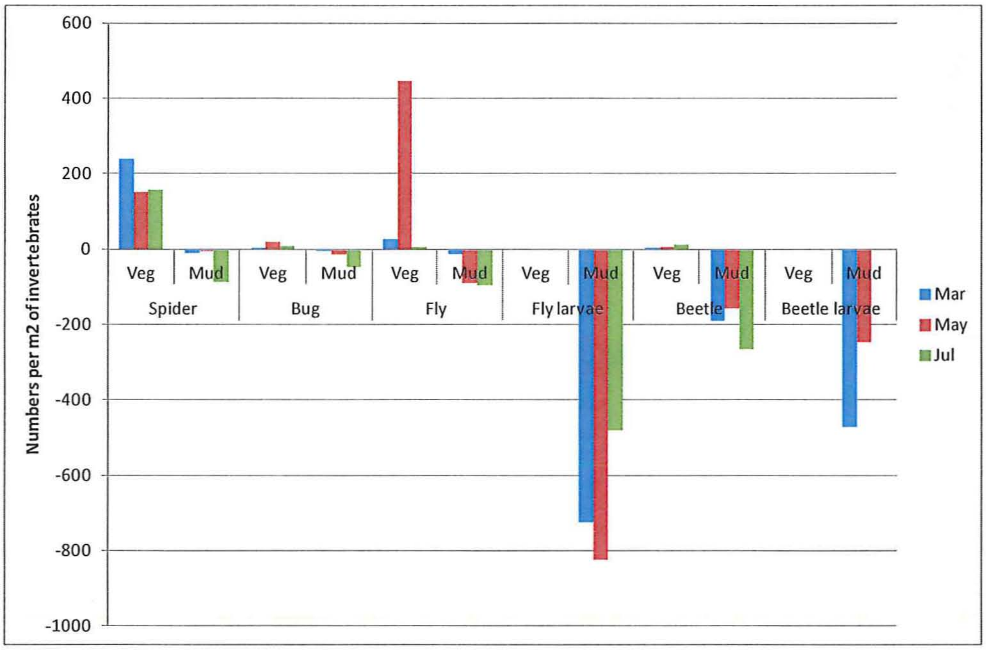

Figure 33: A comparison of the arachnid and insect food availability (no's m^{-2}) at Inkerman Ck Saltfield in the fringing vegetation (above the X axis) and the pool edge substrate (below the X axis)

Conclusion

Both foliage-associated and semiaquatic macrobenthic invertebrate food resources were abundant at Inkerman Ck Saltfield in the transition period (April to July); with levels of the former in excess of those found at the breeding site during the same months. These resources appear to be relatively constant; whereas those at Twelve Mile Ck declined rapidly as it dried. While chats choose natural wetlands for breeding due to the presence of a range of resources (food, shelter, protection from predation), food availability in the drier months may be of some importance in determining dry season habitat use.

3.4.3 Water availability in the post-breeding period (April to July)

All three sites (the one breeding and two dry season saltfields) showed a similar pattern in the difference between air temperature and dewpoint temperature (troughs and peaks coinciding) but peaks were greatest at Inkerman Ck Saltfield. This probably reflected a more open canopy at this site (data loggers were concealed beneath bushes). In general, dew was not available at any of the sites except in March at the Inkerman Ck Saltfield site, when the temperature differential approached zero. However, there were only 3 or 4 nights when this occurred and this was confined to the late wet period rather than to the drier months when freshwater may have been less readily available. In the previous study, the Pelican Ck Saltfield site had slightly greater dew forming potential and the Inkerman Ck Saltfield site less, but again only during the late wet season period (February and March). Thus, this confirms the previous findings that dew formation is not a factor in the movement of chats to the saltfields (Houston 2010). In general, dew availability is low during the dry season at all habitat types and that water availability, in the form of dew-fall, is unlikely to be a factor in determining dry season habitat use by chats.

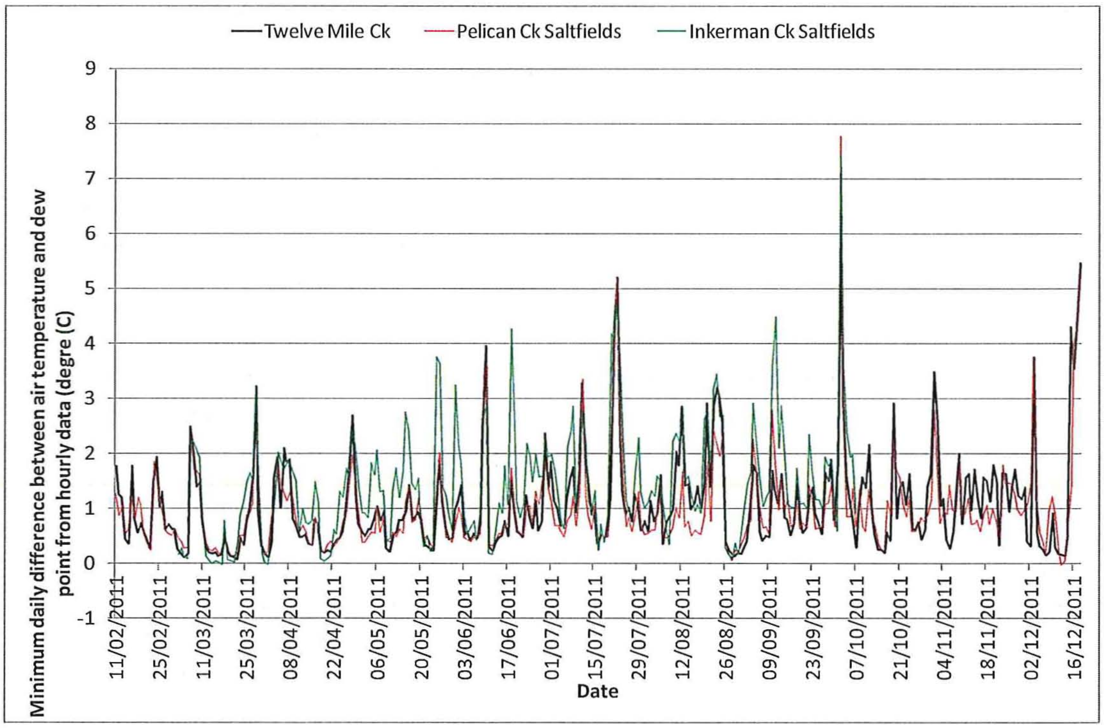

Figure 34: A comparison of dewpoint between the breeding site at Twelve Mile Ck and two dry season habitat sites (the saltfields, Pelican Ck Saltfield (Port Alma) and Inkerman Ck Saltfield (Cheetham)

3.5. Potential Habitat

A protocol for mapping potential habitat was developed based on the RE mapping (Table 3). However, this protocol will miss many areas of saltmarsh vegetation in the Fitzroy River delta as much of this vegetation is mapped as saltflat (RE 11.1.2a) rather than saltmarsh (RE 11.1.2b). Thus, the addition of NDVI (Normalized Difference Vegetation Index) classified satellite imagery is required. An example of this is shown in Figure 35 where the Regional Ecosystem mapping for Twelve Mile Ck is compared with that derived from NDVI mapping. All the areas of saltmarsh shown by the yellow/orange patches in the NDVI image are mapped as saltflat by the RE mapping. Such areas of

NDVI mapped vegetation, where they overlap land zone 1, need to be included as they indicate the presence of saltmarsh vegetation.

Once the polygons of interest have been mapped using the two approaches, they should be expanded to include a buffer zone (up to 500 m) as chats may forage away from core habitat into surrounding vegetation (could be bare or alluvial terrace or even mangrove margins).

There will be some 'fine-tuning' required. For example, where the saltmarsh is dominantly RE 11.1.1 (i.e. marine Couch grasslands) the vegetation generally lacks complexity with little samphire or sedge, and less mud for foraging.

Table 3: Protocol for using Regional ecosystem mapping to identify potential Capricorn Yellow Chat habitat

Step	Layers	Comments
1	**Select the pre-European land zone 1 (central coast and SE Qld layers) is the target but don't exclude adjoining areas on land zone 3**	**Almost all known chat sites overlay pre-European land zone 1 with a few outliers on land zone 3 where it abuts suitable land zone 1 habitat (also in some cases land zone 1 is incorrectly mapped as land zone 3 due to scale issues)**
	Include land zone 3 that is embedded in land zone 1	Reflects the likelihood that in this situation that land zone 3 has had some salty influence
2	**Overlay the target RE types (use the 2006 mapping)**	
	Include any vegetated land zone 1 non-mangrove areas – 11.1.1, 11.1.2b, 11.1.3	This targets vegetated saltflats and excludes definitely unvegetated saltflats (11.1.2a) / the general saltflat-saltmarsh category, 11.1.2, is also excluded as the vast majority is unvegetated
	Exclude saltmarsh (11.1.1 or 11.1.2b) that is embedded (i.e. surrounded) by mangroves (11.1.4) but don't exclude 11.1.3 (this is unlikely to be embedded in any case	This excludes saltmarsh that is fully tidal (target is supratidal)
	Include 11.3.27x1a, x1b or x1c (may be able to use 11.3.27 which overlays land zone 1)	These generally correspond to salt tolerant sedge vegetation & typically overlay old marine plains

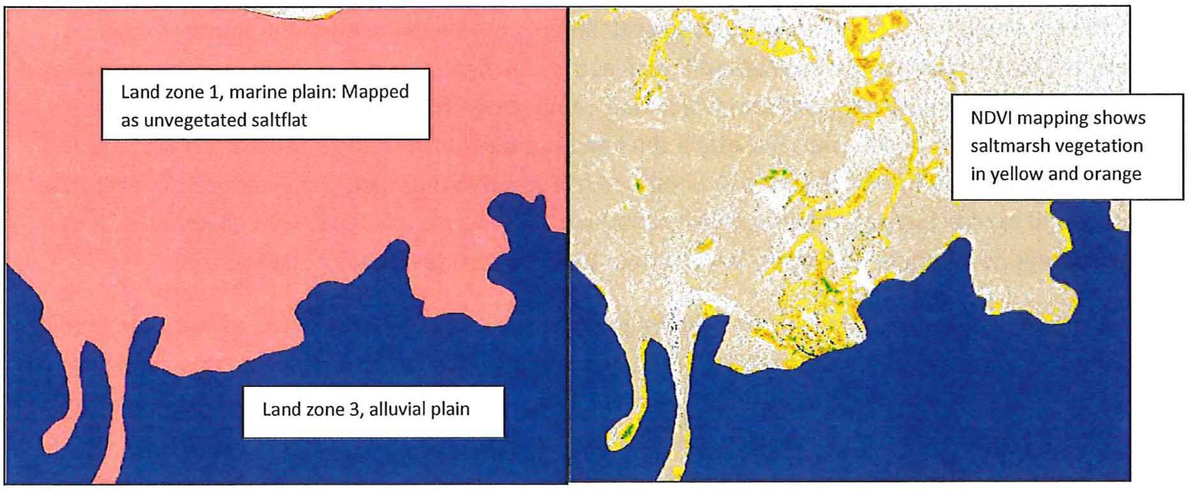

Figure 35: Twelve Mile Ck showing current RE mapping (purple indicates land zone 3*, pink indicates land zone 1 mapped as saltflat, i.e. RE 11.1.2a). On the right is the same image with the NDVI classified vegetation showing the presence of saltmarsh (yellow and orange) corresponding to RE 11.1.2b
*the land zone 1 – 3 boundary needs adjustment (some of the area shown as land zone 3 is land zone 1)

4. Management issues relevant to the pipeline corridor

- Preserve the hydrological regime of the core breeding areas (Twelve Mile Ck, Inkerman Ck saltmarshes, plus others such as Raglan Ck Oxbow etc)
- Prevent soil erosion and in-filling of downstream habitat
- Minimise soil disturbance during construction
- Minimise the width of the development corridors
- Maintain weed prevention protocols
- Maintain a 500 m buffer zone to chat habitat
- Suspend construction during the wet season or following substantial rain events
- Ensure the maintenance of the hydrological integrity of Twelve Mile Creek (i.e. the stream-associated aquifers that maintain water in the pools immediately upstream of the Twelve Mile Creek core chat breeding habitat; a pipeline over the creek rather than under it may carry less risk)
- Refer to the preliminary recommendations in Houston (2006).

5. Conclusion

Capricorn Yellow Chats use habitats that may be regarded as ephemeral or seasonal wetlands, and breed most successfully when these habitats are inundated. A relationship between Capricorn Yellow Chat breeding success and rainfall has been demonstrated, confirming the need to protect current levels of surface flows into chat breeding habitats. It is likely that a loss or reduction of surface flows would lead to a decline in abundance of this Critically Endangered subspecies. All sites where chats occur are fed by relatively small creeks, most of which are unrestrained by dams or other water storage devices (except the Bajool Weir on a tributary of Inkerman Creek). Given their relatively small size, it is not likely that such catchments will be dammed in the future. However, they are still vulnerable to developments such as stream diversions due to industrial development, weirs or off-stream ponded pastures which may remove significant portions of the water flow. Reductions in flow events may also affect the habitat upon which chats depend. Both primary and secondary production was found to depend on wet season inundation. The presence of vegetative cover and muddy foraging areas typified habitat where chats occurred. Changes in composition or percentage cover could potentially have serious ramifications for chat occupancy.

The relatively low population size and the fragmented nature of Capricorn Yellow Chat sites (and of suitable habitat) indicate a subspecies that is vulnerable to extinction. In this situation, while the largest population (Torilla Central) is the most important, all populations and the habitat at sites where they occur are of conservation significance. The rapid changes in relative abundance observed at the Torilla Plain sites also indicate that monitoring is essential in order to provide early warning of any downward trends in population size.

6. References

Arnold D., Bell I. & Porter G. (1993) Incidence of Yellow Chats on the Marine Plain, Curtis Island. In: *Curtis Case Study: Environmental Planning for the Future* pp. 1-7. Queensland Parks and Wildlife Service, Gladstone.

Birds Australia. (2005-07) *Birdata*. http://www.birdata.com.au/homecontent.do. Birds Australia, Melbourne.

BOM. (2010) Rainfall Variability Map of Australia, December to February http://reg.bom.gov.au/jsp/ncc/climate_averages/rainfall-variability/index.jsp?period=dec, 24 August 2010. Bureau of Meteorology.

Bostock H., Ryan D., Brooke B., Packett B., Hancock G., Pietsch T., Revill A., Leeming R., Moss P. & Harle K. (2006) *Sediment Accumulation and Holocene Evolution of the Fitzroy River Lower Floodplain, Central Queensland, Australia*. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Technical Report 48, Brisbane.

Britton R. H. & Johnson A. R. (1987) An ecological account of a Mediterranean salina: The Salin de Giraud, Camargue (S. France). *Biological Conservation* **42**, 185-230.

Brooke B., Bostock H., Smith J. & Ryan D. (2006) *Geomorphology and Sediments of the Fitzroy River Coastal Sedimentary System – Summary and Overview*. Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management, Technical Report 47, Brisbane.

Burgis W. A. (1975) *Cainozoic history of the Torilla Peninsula, Broad Sound, Queensland*. Bureau of Mineral Resources Report 172. Australian Government Publishing Service, Canberra.

Castelnau F. D. & Ramsay E. P. (1877) Notes of a collection of birds from the Norman River, Gulf of Carpentaria, with descriptions of some new species. *Proceedings of the Linnaean Society of New South Wales* **1**, 379-86.

Christidis L. & Bowles W. E. (2008) *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing, Melbourne.

Christidis L., Schodde R. & Robinson N. A. (1993) Affinities of the aberrant Australo-papuan honeyeaters, *Toxorhamphus*, *Oedistoma*, *Timeliopsis* and *Epthianura*: Protein evidence. *Australian Journal of Zoology* **41**, 423-32.

Clarke R. H., Oliver D. L., Boulton R. L., Cassey P. & Clarke M. F. (2003) Assessing programs for monitoring threatened species: A tale of three honeyeaters (Meliphagidae). *Wildlife Research* **30**, 427-35.

DEHWA. (2009) Australian Wetlands Database. http://www.environment.gov.au/water/topics/wetlands/database/index.html, updated October 2009. Australian Government, Department of the Environment, Water, Heritage and the Arts. Canberra.

DERM. (2010) *Wildlife Online.* http://www.derm.qld.gov.au/wildlife-ecosystems/wildlife/wildlife_online/index.html. The State of Queensland, Department of Environment and Resource Management, Brisbane.

Dorfman E. J., Lamont A. & Dickman C. R. (2001) Foraging behaviour and success of Black-necked Storks (*Ephippiorhynchus asiaticus*) in Australia: implications for management. *Emu* **101**, 145-9.

Driskell A. C. & Christidis L. (2004) Phylogeny and evolution of the Australo-Papuan honeyeaters (Passeriformes, Meliphagidae). *Molecular Phylogenetics and Evolution* **31**, 943-60.

Garnett S. T. & Crowley G. M. (2000) *The Action Plan for Australian Birds 2000*. Environment Australia, Canberra.

Higgins P. J., Peter J. M. & Steele W. K. (2001) *Epthianura crocea* Yellow Chat. In: *Handbook of Australian, New Zealand and Antarctic Birds. Volume 5: Tyrant-flycatchers to Chats* (eds P. J. Higgins, J. M. Peter and W. K. Steele) pp. 1229-38. Oxford University Press, Melbourne.

Hill D., Fasham M., Tucker G., Shewry M. & Shaw P. (2005) *Handbook of Biodiversity Methods: Survey, Evaluation and Monitoring*. Cambridge University Press, New York.

Houston W. (2006) *Advice on the proposed pipeline from Marlborough to Gladstone with respect to protecting habitat of the Capricorn Yellow Chat. Consultancy Report to RLMS*. Centre for Environmental Management, Central Queensland University, Rockhampton.

Houston W., Elder R., Black R. & McCabe J. (2006) Conservation significance of coastal wetland habitats for birds at Twelve Mile Creek, Fitzroy River, Central Queensland. *Sunbird* **36**, 20-36.

Houston W., Jaensch R., Black R., Elder R. & Black L. (2009) Further discoveries extend the range of Capricorn Yellow Chat in coastal central Queensland *Sunbird* **39**, 29-38.

Houston W. & Melzer A. (2008) *Yellow Chat (Capricorn subspecies) Epthianura crocea macgregori Recovery Plan*. Report to Department of the Environment, Water, Heritage and the Arts, Canberra. Queensland Environmental Protection Agency, Brisbane.

Houston W., Porter G., Elder R., Black R. & Sheaves M. (2004) Rediscovery of Yellow Chats (Capricorn subspecies) on the Fitzroy River delta, Central Queensland. *Sunbird* **34**, 36-42.

Houston W. A. (2010) Distribution, breeding ecology, population and habitat use of the critically endangered Capricorn Yellow Chat *Epthianura crocea macgregori* Keast (Aves: Meliphagidae). Master of Applied Science (by Research), Faculty of Sciences, Engineering & Health, Central Queensland University, Rockhampton.

Hutchinson M. F., McIntyre S., Hobbs R. J., Stein J. L., Garnett S. & Kinloch J. (2005) Integrating a global agro-climatic classification with bioregional boundaries in Australia. *Global Ecology and Biogeography* **14**, 197-212.

Jaensch R., Houston W., Black R., Campbell L., Elder R. & McCabe J. (2004) Rediscovery of the Capricorn subspecies of Yellow Chat *Epthianura crocea macgregori* at Torilla Plain, on the mainland coast of central Queensland. *Sunbird* **34**, 24-35.

Jardine F. (1923) The physiography of the lower Fitzroy Basin. *Queensland Geographical Journal* **38**, 1-43.

Keast A. (1958) The relationship between seasonal movements and the development of geographic variation in Australian chats (*Epthianura* Gould and *Ashbyia* North; Passeres: Muscicapidae, Malurinae). *Australian Journal of Zoology* **6**, 53-68.

Kikkawa J. & Wilson J. M. (1983) Breeding and dominance among the Heron Island silvereyes *Zosterops lateralis chlorocephala*. *Emu* **83**, 181-98.

Matthew J. (2007) Family Epthianuridae (Australian Chats). In: *Handbook of the Birds of the World. Volume 12: Picathartes to Tits And Chickadees* (eds J. del Hoyo, A. Elliott and D. A. Christie) pp. 612-26. Lynx Edicions, Barcelona.

Naumann I. D. (1991) *Insects of Australia, 2nd Edn.* Melbourne University Press, Melbourne.

Nix H. A. (1982) Origin, adaptation and evolution of birds in arid Australia. In: *Evolution of the Flora and Fauna of Arid Australia* (eds W. R. Barker and P. J. M. Greenslade) pp. 47-66. Peacock, Frewville.

Parker S. A. (1973) The tongues of *Epthianura* and *Ashbyia*. *Emu* **73**, 19-20.

Queensland Herbarium. (2009) Regional Ecosystem Description Database (REDD). Version 6.0b. http://www.derm.qld.gov.au/wildlife-ecosystems/biodiversity/regional_ecosystems/, November 2009. The State of Queensland, Department of Environment and Resource Management, Brisbane.

Sattler P. & Williams R. (1999) *The Conservation Status of Queensland's Bioregional Ecosystems.* Queensland Environmental Protection Agency, Brisbane.

Schodde R. (1982) Origin, adaptation and evolution of birds in arid Australia. In: *Evolution of the Flora and Fauna of Arid Australia* (eds W. R. Barker and P. J. M. Greenslade) pp. 191-224. Peacock, Frewville.

Schodde R. & Mason I. J. (1999) *The Directory of Australian Birds: Passerines.* CSIRO Publishing, Melbourne.

Sheaves M. & Johnston R. (2008) Influence of marine and freshwater connectivity on the dynamics of subtropical estuarine wetland fish metapopulations. *Marine Ecology Progress Series* **357**, 225-43.

Sibley C. G. & Ahlquist J. E. (1990) *Phylogeny and Classification of Birds. A Study in Molecular Evolution.* Yale University Press, New Haven.

Takekawa J. Y., Miles A. K., Tsao-Melcer D. C., Schoellhamer D. H., Fregien S. & Athearn N. D. (2009) Dietary flexibility in three representative waterbirds across salinity and depth gradients in salt ponds of San Francisco Bay. *Hydrobiologia* **626**, 155-68.