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HYDRODYNAMIC AND ECOLOGICAL ASSESSMENT OF A SUB-TROPICAL STREAM IN EASTERN AUSTRALIA

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Abstract : A detailed multi-disciplinary field study was conducted in a small subtropical creek in Eastern Australia. Hydraulic and ecological measurements were conducted simultaneously in the river mouth to assess the complexity of a small estuarine system, and the interactions between hydraulic engineering, environmental issues, biology and ecology. The results provide an unique and original snapshot of a subtropical creek system and set new standards for comprehensive surveys of small estuaries in sub-tropical zone. A key feature of the results was the contrasted outcome. Fauna observations showed strong bird and fish activities. But, some aspects of the study demonstrated on-going pollution.
Keywords: Hydrodynamics, Ecology, Sub-tropical stream, Field works, Multi-disciplinary.

INTRODUCTION

Eprapah Creek is a small sub-tropical stream in Eastern Australia. Located in the Redlands shire, close to Brisbane QLD, the catchment is mostly urban in the lower reaches and semi rural/rural residential in the upper reaches (Fig. 1). The creek flows through several conservation areas hosting endangered species : e.g., koalas, swamp wallabies, sea eagles. The stream is basically 15 km long with about 3.8 km of estuarine zone. In the latter, the water depth is typically about 1 to 2 m in average in the middle of the channel.

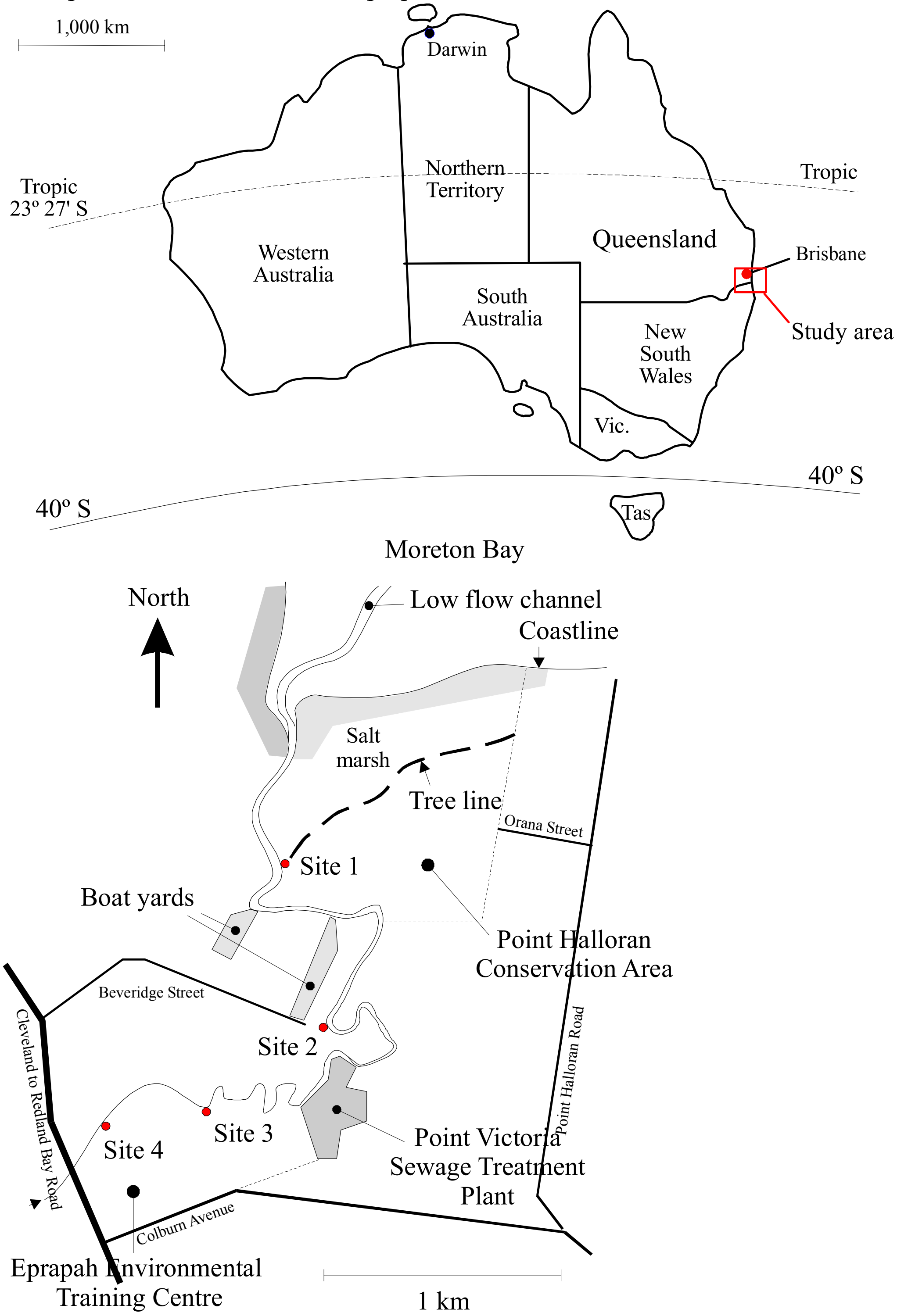
Water quality and ecology have been closely monitored at Eprapah Creek for more than 30 years. The creek was heavily polluted four to five years ago by illegal discharges of TBT and chemical residues. Although the estuarine zone includes two environmental parks, there are some marinas and boat yards, and a sewage plant impacting heavily on the natural system (JONES et al. 1999). The upstream catchment has been adversely affected by industrial poultry farms, land clearance and semi-urban development. Recent developments included the constructions of new shopping centres and residential lots.

On Friday 4th April 2003, a series of detailed hydrodynamic, environmental and ecological measurements were conducted in the estuarine zone of Eprapah Creek (Victoria Point QLD) (CHANSON 2003). The purpose of the field works was to assess the complexity of a small estuarine system, the interactions between hydraulic engineering, biology and ecology, and to provide an overall assessment of the estuarine system that was heavily polluted few years ago.

EXPERIMENTAL TECHNIQUES

Field works took place at four sites along the estuarine zone (Fig. 1) and involved more than 60 people (Fig. 2). Measurements were conducted between 6:00 am and 6:00 pm. The low tides were at 04:58 (0.53 m) and 17:06 (0.43 m), and the high tides were at 10:49 (2.02 m) and 23:17 (2.20 m). The weather was sunny with few clouds. The wind conditions were moderate (Sites 1 & 2) to nil (Sites 3 & 4). On the night before, an intense but short rainstorm took place around 6:00 pm, with possibly more showers overnight. The freshwater runoff was felt on the 4th April 2003.

Fig. 1 - Map of Eastern Australia and Eprapah Creek



At each site, a series of hydraulic, water quality and ecological measurements were conducted from the bank: e.g., water elevations, surface velocity, air and water temperatures, conductivity, pH, dissolved oxygen, turbidity. Most readings were taken every 15 minutes while fish sampling were conducted every 30 minutes and bird watching was continuous.
Vertical profiles of water quality parameters were conducted twice in the middle of the creek.

These were performed at high tide and during ebb flow using a water quality probe YSI™6920 lowered from a boat drifting with the flow. Measurements of water temperature, conductivity pH, conductivity, dissolved oxygen content and turbidity were performed every 20 cm.

For measurements from the bank, the data accuracy was about 1 cm for water level elevation, 0.2 to 0.5 ºC for water temperature, 1 to 2% for conductivity, 0.2 to 0.5 for pH measurement with pH paper, 5 cm on turbidity Secchi disk length, 10% on the surface velocity and 5 to 10% on the dissolved oxygen concentration. With the water quality probe YSI6920, the data accuracy was : ±2% of saturation concentration for D.O., ±0.5% for conductivity, ±0.15ºC for temperature, ±0.2 unit for pH, ±0.02 m for depth, ±1% of reading for salinity, and ±5% for turbidity.

Fig. 2 - Field works at Eprapah Creek on 4 April 2003
Left : Fish sampling. Right : Site 2, looking downstream

FIELD OBSERVATIONS (1) HYDRAULIC AND ENVIRONMENTAL ENGINEERING

Water level observations showed consistently maxima and minima slightly after the reference high and low tides (Brisbane bar). This is typical of an estuarine system where the information on tide reversal must travel. Surface velocity observations indicated that the flow reversal was clearly observed with greater delay than that observed with water depth data. This might be the result of possible recirculation zones next to the banks at high tide. The tidal influence was felt up to Site 3 (AMTD 3.1 km) but not at Site 4. The latter site was basically a freshwater system.

Water quality observations were conducted every 15 to 30 minutes. Samples were taken next to the free-surface from the bank. Air and water temperatures at Site 2 located 2 km upstream of the river mouth are shown in Figure 3. The data indicated an increase in water temperature near the middle of the day, as the surface waters were heated by the sun. The flood flow also brought in some warm waters from the Moreton Bay. The data showed lower air temperatures in the early morning and late afternoon. The result is consistent with the greater inertia of the water system.

Measurements indicated that the DO content was maximum around high tide and midday. Further the downstream waters were more oxygenated than waters at upstream sites (Table 1). Waters rich in oxygen were brought by the flood tide. Turbidity data are presented in Table 1 in terms of Secchi disk length and NTU. Although the Secchi disk technique is subjective, all turbidity data showed consistently a greater water clarity at high tide and at the beginning of the ebb flow. The Secchi disk data were about constant along the creek while the YSI probe data suggested a slight increase in turbidity with increasing distance from the river mouth (Table 1). Water conductivity data followed the tidal cycle with an influx of saltwater during the flood flow and a reflux during the ebb at Sites 1 to 3. The data at Site 4 suggested predominantly freshwater. The surface water data suggested clearly a decrease in conductivity with increasing distance from the river mouth (Table 1). The pH data ranged from 6.4 to 7 which corresponded to slightly acidic waters. The data suggested a slight decrease in pH with increasing distance from the river mouth (Table 1).

Vertical profiles of water quality parameters showed that the distributions of water temperature, dissolved oxygen content, turbidity and pH were reasonably uniform at high tide and in the early ebb flow. All conductivity data showed a stratification of the flow with a fresh water lens of about 0.4 to 0.6 m thickness and a saltwater wedge underneath. Depth-averaged water quality parameters are summarised in Table 2, in which column 4 gives the observed water depth. Overall similar trends were observed between depth-averaged data and surface water data. The result confirms that surface water quality parameters were reasonable indicators of the waterway health. This observation was valid on the 4 April 2003 but it should not be extrapolated without further comparative tests.

Along an estuarine zone, the depth-averaged density increases with increasing seaward distance. Basic momentum considerations show that a slope of the mean water surface must counterbalance the mean density gradient while the solution of the motion equation gives vertical residual velocity distributions (CHANSON 2002). The results yield residual surface velocities of up to 1 cm/s. The residual circulation is relatively significant, corresponding to a renewal of the estuarine waters in about one week.

Fig. 3 - Air and water temperatures at Site 2 (AMTD 2 km)- Comparison with Brisbane bar tides

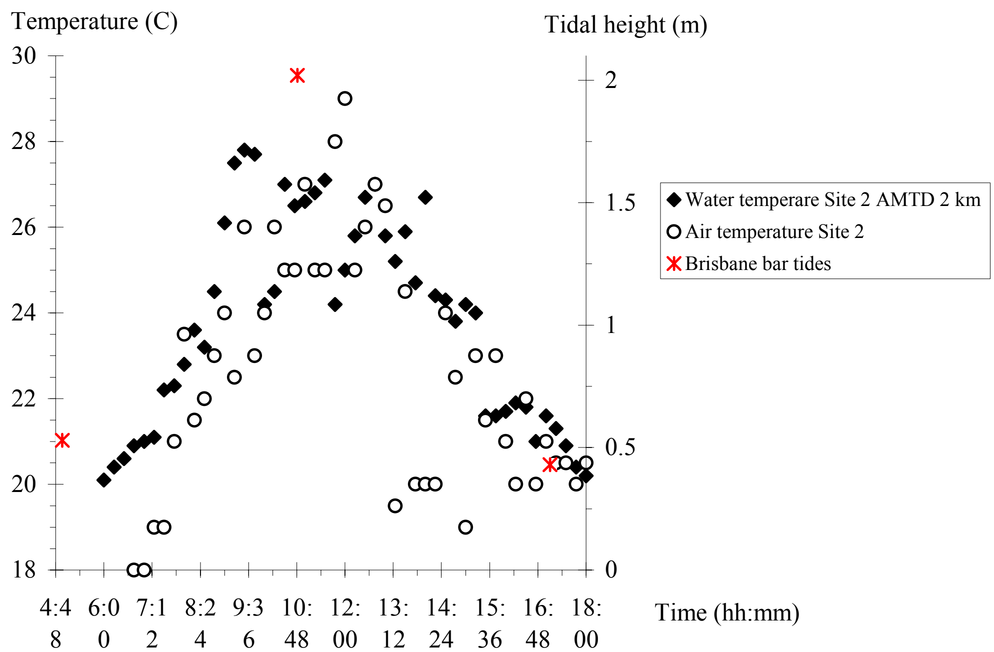


Table 1 - Summary of water quality observations (next to the free-surface) as functions of the site location - Average values and data range (in brackets) - Comparison with mid-stream data (YSI6920 probe) near the free-surface

	Location				Remarks
Site :	Site 1	Site 2	Site 3	Site 4	
AMTD (km):	0.6	2	3.1	3.8	
DO (% sat) =	60 (46-84)	85 (62-107)	45 (32-69)	48 (35-70)	Group data.
DO (% sat) =	80 / 77	61 / 56	40 / 39	--	YSI6920 probe. 2 data sets.
Turbidity (Secchi, m) =	0.7 (0.6-0.9)	0.7 (0.5-1.0)	0.8 (0.5-1.1)	0.6 (0.3-0.7)	Group data (Secchi disk).
Turbidity (Secchi, m) =	1.0 / 0.8	0.8 / 0.6	0.65 / 0.75	--	Secchi disk, mid-stream. 2 data sets.
Turbidity (NTU) =	7 / 9	11 / 10	10 / 10	--	YSI6920 probe. 2 data sets.
Conductivity (mS/cm) =	35.3 (39.6-29.5)	29.6 (18.3-45.9)	4.5 (1.75-10)	0.4 (0.38-0.44)	Group data.
Conductivity (mS/cm) =	44.1 / 40.6	39.4 / 27.8	4.9 / 5.8	--	YSI6920 probe. 2 data sets.
pH =	6.8 (6.4-7.2)	6.7 (6.4-6.8)	6.5 (6.4-6.8)	6.4 (6.4-6.4)	Group data. pH paper.
pH =	8 / 7.7	7.1 / 7.7	7.8 / 6.6	--	YSI6920 probe. 2 data sets.

Notes : AMTD = Adopted Middle Thread Distance measured upstream from the mouth; DO : percentage of solubility of oxygen in water at equilibrium.

Table 2 - Depth-averaged water quality parameters as functions of site location (YSI6920 probe data)

Time	Site	AMTD	Water depth m	Temperature Celsius	D.O. (%)	Turbidity NTU	Conductivity mS/cm	pH
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
10:20	1	0.6	2.3	24.1	0.84	6.9	48.6	8.1
10:44	2	2	2.3	23.7	0.67	9.5	44.1	7.9
9:20	2B	2.1	1.5	23.6	0.59	12.2	37.0	7.6
11:12	3	3.1	2.1	23.2	0.34	8.2	23.9	7.1
12:31	1	0.6	2.3	24.3	0.84	8.6	47.6	7.9
12:48	2	2	2.1	24.0	0.70	10.1	42.6	7.8
13:23	3	3.1	1.3	23.2	0.32	6.6	21.2	6.7

FIELD OBSERVATIONS (2) ECOLOGY

FISH SURVEY

Fish habitat and behaviour were recorded at each site using one bait trap and one dip net every 30 minutes and by rotating the sampling sites between 2 to 8 locations without re-using the same site within an hour. The traps and nets were designed to catch small fish (i.e. less than 10 cm long) that were representative of the native species.

More than 400 fish were caught corresponding to 21 species. Results are summarised in Table 3, including the list of fish species at each Site (Column 5). Marine species are underlined while exotic species are in italic. The largest numbers of fish were caught between 10:00 and 17:00. It is very likely that the combination of flood flow with higher dissolved oxygen

contents and sun light induced significant fish activities during the period 10:00 to 16:00. At Site 4 (freshwater pool), 98.6% of the catches were Mosquito fish, an exotic species tolerant to environmental extremes. This might suggest that native species had difficulties in reduced dissolved oxygen conditions, although native fish activity were present.
A large amount of macro invertebrates and crustaceans were also observed and caught: i.e., more than 8 species of macro-invertebrates and crustaceans. Further very large numbers of shrimps and prawns were sighted early morning between 6:00 and 8:00 at all sites, although these sightings were too numerous to be counted. A very small number of macro-invertebrate species was observed at Site 3 and that might be likely related to past TBT pollution. Site 3 was located immediately downstream of the TBT runoff in 1998-99.

Table 3 - Summary of fish numbers and species (bait trap & dip net)

Site (1)	AMTD (2)	Total numbers (3)	Number of species (4)	Species (number in brackets) (5)	Remarks (6)
1	0.6	19 (*)	4 (*)	<u>Toad fish</u> (10), <u>Bream</u> (1), Rainbow fish (7), <u>Mudskipper</u> (1) (*)	Right bank. No fish sampling data until 12:00 noon.
2	2	111	8	Agassiz's Glassfish (15), Perchlet (32), Pacific Blue eye (47), <u>Toad fish</u> (10), <u>Krefft Goby</u> (4), <u>Bream</u> (1), *Mosquito fish* (2), <u>Mullet</u>	Left bank.
3	3.1	87	8	Bony bream (8), Australian smelt (8), Flat headed gudgeon (1), <u>Toad fish</u>, Perchlet (20), *Swordtail* (49), <u>Mullet</u>, *Trout (?)*	Right bank.
4	3.8	220	4	*Mosquito fish* (217), Empire gudgeon (1), Firetail gudgeon (1), <u>Bullrout</u> (1)	Right bank. Freshwater pool.
Total:	0.6 to 3.8	437	21		Sites 1, 2, 3 and 4

Notes : (*) : no fish sampling data until 12:00 noon; *Italic* : exotic species; <u>Underlined</u> : marine species.

BIRDS AND WILDLIFE OBSERVATIONS

Bird and wildlife surveys were continuously conducted at each site from a main platform. Sightings were analysed using reference books, local reports and with expert-advice from the local Waterwatch group. Note that Sites 3 and 4 were located in dense bushlands. Bird sightings were possibly more difficult there than at Sites 1 and 2.
Almost 500 birds were sighted. That is, more than 72 bird species (Table 4). Results must be considered with care. Flocks of birds were seen and accounted for nearly 1/3rd of the total number of sightings. Overall bird sightings showed a strong activity at all sites between 7:00 and 10:00. That is, 60% of all sightings took place during that period. A second period of activity was seen between 15:00 and 18:00. Yet there was always a minimum of five bird species seen every hour of the day between 6:00 and 18:00 at Sites 1 to 4. This suggests a fair diversity of the bird population in the Eprapah Creek estuarine zone. COOPER (1978) indicated 120 bird species at Eprapah, while MELZER and MORIARTY (1996) listed more than 70 bird species in the Eprapah Creek catchment sections from the Cleveland to Redland Bay road to the river mouth which encompassed all Sites 1 to 4 of the present study. Present findings (at least 72 bird species) suggest that the bird population was diverse and active on 4

April 2003. However the survey is limited and it is difficult to make any definite conclusion.

Table 4 - Summary of bird numbers and species (sightings from a fixed point)

Site (1)	AMTD (2)	Total numbers (3)	Nb of species (4)	Species (number in brackets) (5)	Remarks (7)
1	0.6	261 ([a])	21	Australian Magpie (41), Australian White Ibis (48), Brahminy Kite (8), Brown Honey Eater (2), Duck (3), Great Egret (1), Grey Fantail (1), Little Black Cormorant (7), Long-billed Corellas (10), Masked lapwing (2), Osprey (2), Pelican (1), Pied Currawong (11), Rainbow Lorikeet (11), Stripped Honey Eater (1), Torresian Crow (98), Welcoming Swallows (8), Whistling Kite (1), White-faced Herrons (2), Whistling Kite (2), Willoe Wagtail (1)	Right bank. Change of group at 12:00 noon ([b]).
2	2	189	27	Australian Darter (1), Bar Shouldered Dove (3), Bria Mini (3), Brown Honey Eater (1), Collared Kingfisher (2), Torresian Crow (18), Galah (2), Great Egret (5), Grey Fan Tail (1), Grey Strike Thrush (1) , Honey Eater (3), Little Black Cormorants (63), Long Billed Corellas (9), Paled Head Rosalle (3), Pardalotes (Chippies) (5), Pied Cormorants (1), Rainbow Lorikeet (23), Rufous Whistler (1), Sacred Ibis (Australian) (19), Satin Fly Catcher (1), Spangled Drongo (1), Spur Wing Plover (10), Warbler Mangrove (1), Whip Bird (3), Whistling Kite (1), White Breasted Wood Swallow (5), White Throater Honey Eater (3)	Left bank.
3	3.1	47	10	Grey Fantail (6), Yellow Robin (17), Pidgeon (2), Galah, (5), Mistletoe bird (1), Grey Shrike - thrush (3), Honey Eater (1), Rufous Whistler (6), Silver Eye (3), Kookaburra (3)	Right bank.
4	3.8	88	37	Black-faced Cuckoo shrike (1), Brown Honeyeater (1), Brown thornbell (2), Cicadabird (1), Corella (1), Cormorant (1), Eastern Spinebill (1), Eastern Yellow robin (2), Fantailed Cuckoo (1), Figbird (1), Gerygone (1), Grey Fantail (1), Grey Shrike-thrush (2), Kookoburra (1), Lewin's Honeyeater (4), Magpie (1), Mistletoe Bird (2), Noisy Friabird (1), Rainbow Bee-eater (1), Rainbow Lorikeet (37), Red Brownfinch (4), Sacred Kingfisher [nest] (1), Silvereye (1), Spangled Drongo (1), Spotted Pardolote (1), Tree Creeper (2), Turtle-dove, (1), Variegated fary wren (1), Whip bird (4), Whistler (1), White breasted (1), White browed scrub (1), White throated Gerygone (1), White Throated Honeyeater (1), White Throated Treecreeper (1), Wood swallow (1), Wren (2)	Right bank. Freshwater pool.
Total	0.6 to 3.8	496	72		Sites 1, 2, 3 and 4

Notes : Site 1 : ([a]) there are concerns about the quality of morning observations; Site 1 : ([b]) change of group members at 12:00 noon.

More than 100 sightings of wildlife (e.g. mammals, skink, insects) were made with identification of more than 20 species. Three species of marsupials were observed : i.e., koala, ringtail possum and brushtail possum. Most wildlife activity was observed between 7:00 and 18:00. That is, after sunrise till sunset. The wildlife observations was not as diverse on 4 April 2003 as surveyed by MELZER and MORIARTY (1996). MELZER and MORIARTY listed 200 species while the present study included only 20 species. However the present field work was not specifically focused on wildlife observations, and it was limited to one day.

SUMMARY AND CONCLUSIONS

Eprapah Creek is a small sub-tropical stream in Eastern Australia. Detailed hydraulic and ecological measurements were conducted simultaneously in the river mouth.

This new series of field works was designed to assess the complexity of a small estuarine system, and the interactions between hydraulic engineering, environmental issues, biology and ecology. The results provide an unique snapshot of a subtropical creek system. The original approach of the problem sets new standards for comprehensive surveys of small estuaries in sub-tropical zone.

A key feature of the study was the contrasted outcomes. Fauna observations showed strong and diverse bird and fish activities. Hydrodynamic parameters showed also a reasonably energetic flushing process. While these findings might suggest a "healthy" estuarine zone, the study demonstrated also on-going pollution highlighted by low dissolved oxygen and pH levels at the upstream reaches. These were combined with surface slick observations and large numbers of exotic fish.

The present results demonstrated a sound approach of field work, the needs for a multi-disciplinary investigation, associated with simultaneous measurements of a wide range of parameters and broad-base expertise. Such a field study must cover hydrodynamics, water quality, and ecology. Future studies should also include sediment sampling and analysis, and measurements of nitrate and phosphate contents.

Additional informations on the field works are available in print (CHANSON 2003) and on-line {http://www.uq.edu.au/~e2hchans/eprapa.html}.

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