RESEARCH PUBLICATION No. 53

The Effect of the Daintree River Flood Plume on Snapper Island Coral Reefs

A M Ayling and A L Ayling
Sea Research

A REPORT TO THE GREAT BARRIER REEF MARINE PARK AUTHORITY

ISSN 1037-1508
ISBN 0 642 23049 8

Published April 1998
by the Great Barrier Reef Marine Park Authority

National Library of Australia Cataloguing-in-Publication data:

Ayling, Tony, 1947- .
The effect of the Daintree River flood plume on Snapper Island coral reefs.

ISBN 0 642 23049 8.

1. Reef ecology - Queensland - Snapper Island. 2. Sediment transport - Queensland - Snapper Island. I. Ayling, A. L. (Avril L.), 1953- . II. Great Barrier Reef Marine Park Authority (Australia). III. Title. (Series : Research publication (Great Barrier Reef Marine Park Authority (Australia)) ; no. 53)

577.7894099436

GREAT BARRIER REEF
MARINE PARK AUTHORITY

PO Box 1379
Townsville Qld 4810
Telephone (07) 4750 0700

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INTRODUCTION

We made surveys of fringing reefs in the Cairns region in early 1995 (Ayling and Ayling 1995). The reef slope of these reefs supported rich coral communities with mean coral cover of around 80%. The reefs around Snapper Island (ID no. 16-006) were particularly rich at this time with 88% cover recorded on the north face of the Island and 88.3% on the south. This small, narrow island is only about two kilometres long from west tip to east tip and lies about 75 kilometres north of Cairns and only five kilometres east of the Daintree River mouth (figure 1).

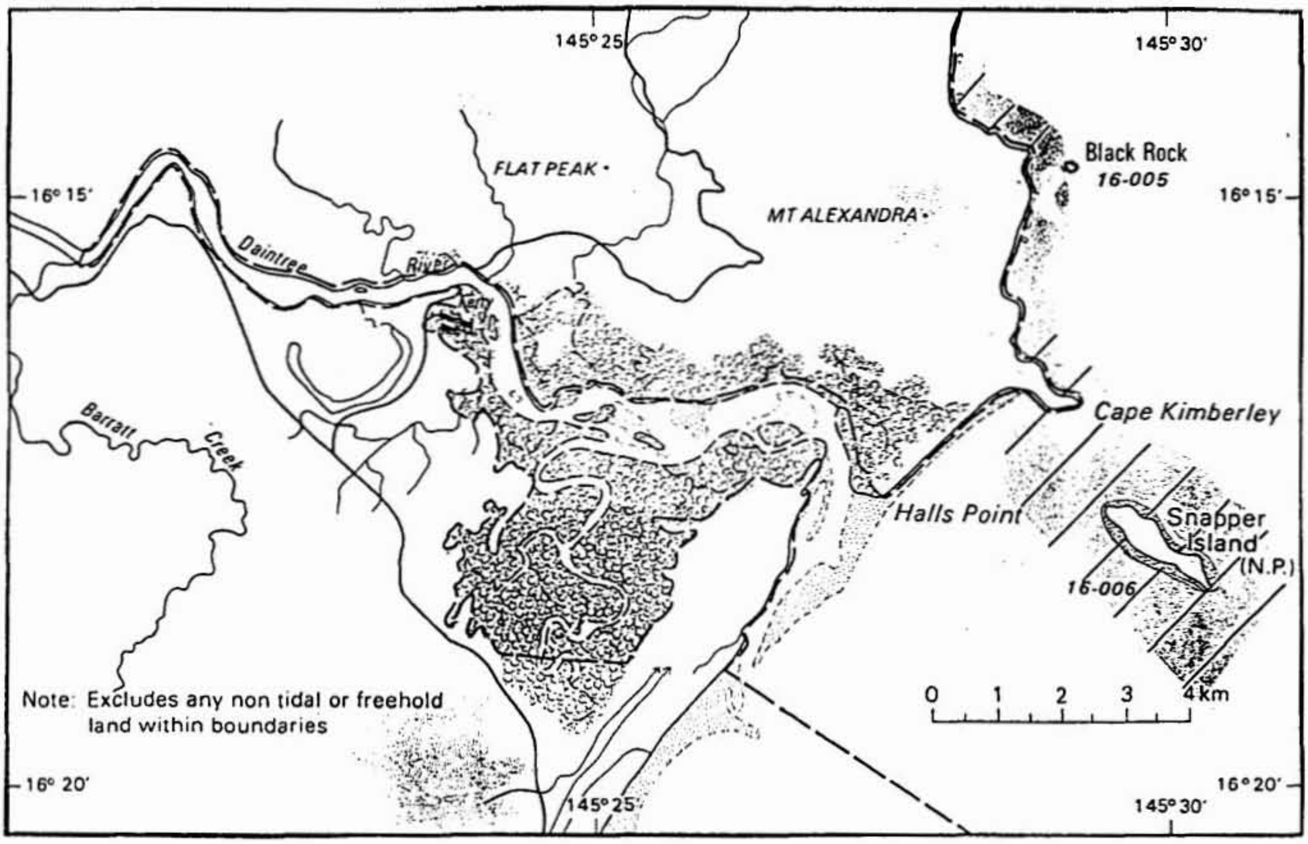

Figure 1. Map showing the position of the study sites

In early March 1996 the Daintree region received several days of extremely heavy rain (over 1300 millimetres in a five-day period), resulting in flooding of the Daintree River at least as severe as any other incident in the past century. The river was about six to eight metres above high spring tide level 15 kilometres upstream from the mouth. Surveillance by the Department of Environment, Cairns showed that the resulting flood plume was driven northward along the coast by the prevailing south-east winds. Continuing rain resulted in the river flowing for about five days. This plume inundated Snapper Island and continued northward for some kilometres. Photographs showed that although the brown sediment laden plume surrounded Snapper Island, there was a patch of relatively clean water on the north side of the island (figure 2).

A visit to the south side of Snapper Island late in 1996 showed that corals on the reef flat and upper slope were almost all dead. This was reported to the Great Barrier Reef Marine Park Authority as being probably due to freshwater inundation during the March flood event. The Great Barrier Reef Marine Park Authority expressed interest in documenting the effect of the flood on the fringing reefs around Snapper Island. Given that there appeared to have been a difference in the water mass on the north face of the island compared with the south, reef managers were especially interested in seeing if there were any differences in the impact on the reefs on the two faces. We were asked to survey the reefs around Snapper Island, and also those around Black Rocks, about five kilometres to the north, to see if the plume influence had reached that far. Black Rocks reefs (ID no. 16-005) had also been surveyed in early 1995. This report presents the results from the recent survey and makes comparisons with the 1995 survey.

Figure 2. Aerials of Snapper Island area showing the flood plume from the Daintree River, 8 March 1996. Note the lens of clear water on the north-facing lee side of the island (Photos courtesy of the Great Barrier Reef Marine Park Authority)

METHODS

Field work for this survey was carried out on 23–24 January 1997 about 10 months after the 1996 flood episode. Although the 1997 wet season had been underway since late December 1996 the Daintree catchment had not received any 24-hour totals of more than 100 millimetres in that time and the river had not experienced even minor flooding (A.M. Ayling personal observations and unpublished data).

The same survey methods used in 1995 were employed for this survey. Surveys were confined to the shallow reef slope in depths between about two to three metres below low tide level. A length of this stratum of about 60 metres comprised each site and five 20-metre line intersect transects were run approximately parallel to the reef edge within this area. Length of intersect in centimetres was recorded for all encrusting organisms beneath each transect line. Four sites were selected approximately equally spaced along the north face of Snapper Island, and four more, similarly spaced, were surveyed on the south face. Two of the sites on each face were in a similar location to those surveyed in 1995. On Black Rocks the same two sites used in 1995 were resurveyed.

At one of the south Snapper Island sites five additional transects were surveyed in a depth strata five to six metres below low tide level to see if there was any depth effect in the flood plume impact.

All transect data were summarised in spreadsheet form, and ANOVA techniques were used to make comparisons. Three comparisons were made:

1. A comparison of the south face and the north face of Snapper Island with four sites on each face. Location was regarded as fixed and site as random.

2. A comparison of coral cover at two sites in each location (south Snapper Island, north Snapper Island, Black Rocks) between 1995 and 1997. For this analysis location was regarded as fixed, and site and time as random.

3. A depth comparison for shallow and deep strata on the south face of Snapper Island. Depth was a fixed factor.

RESULTS

There had been a marked reduction in hard coral cover on the upper reef slope of the entire south face of Snapper Island between early 1995 and early 1997. Total hard coral decreased by about 85% from 88% cover to less than 15% cover (table 1, figure 3). Acroporids were the most severely affected with almost 100% mortality. Other coral groups were not as badly affected as the acroporids, with moralities of between 70–80% of the area covered (figure 3).

Table 1. Abundance of encrusting organisms in the survey sites. Figures are means from groups of five 20-metre line intersect transects with standard deviations in italics beneath.

Location/site		Hard coral	Acroporids	Poritids	Faviids	Turf algae	Soft coral
Snapper Is. Sth:	1	19.1	0.1	15.7	2.5	17.6	3.7
		5.1	*0.1*	*3.6*	*1.2*	*8.6*	*2.0*
	2	7.2	0.2	5.8	0.7	42.3	1.4
		6.2	*0.4*	*6.4*	*0.4*	*13.1*	*3.1*
	3	6.9	0.2	5.0	1.7	36.8	4.0
		3.1	*0.5*	*2.1*	*1.3*	*10.1*	*5.3*
	4	14.5	5.0	7.8	1.3	50.9	0.3
		10.3	*5.9*	*3.9*	*1.0*	*20.6*	*0.6*
Snapper Is. Nth:	1	68.8	68.0	0.2	0.2	19.3	7.6
		17.0	*17.2*	*0.3*	*0.3*	*12.8*	*5.9*
	2	68.4	66.0	0.0	0.0	16.3	3.3
		16.8	*17.0*	*0.0*	*0.0*	*13.9*	*3.7*
	3	68.8	67.1	0.0	0.1	7.5	19.9
		4.7	*4.2*	*0.0*	*0.2*	*6.5*	*4.7*
	4	76.1	73.8	0.0	0.8	15.4	1.7
		13.9	*14.5*	*0.0*	*1.2*	*13.9*	*1.7*
Black Rocks:	1	82.3	76.3	0.0	0.0	15.8	0.8
		9.8	*8.8*	*0.0*	*0.0*	*8.4*	*0.9*
	2	69.8	66.7	0.0	0.0	17.7	4.7
		11.7	*12.4*	*0.0*	*0.0*	*4.8*	*4.6*

On the north side of Snapper Island there were some patches of dead acroporids, mainly staghorn growth form, but coral cover had only decreased by about 20%. There was a nominal reduction of about 10% in total coral cover on Black Rocks.

The marked reduction in the cover of all hard coral groups on the south face of Snapper Island gave a strongly significant location effect in the north/south four site comparison (table 2), and a significant time x location interaction in the three location 1995–1997 comparison.

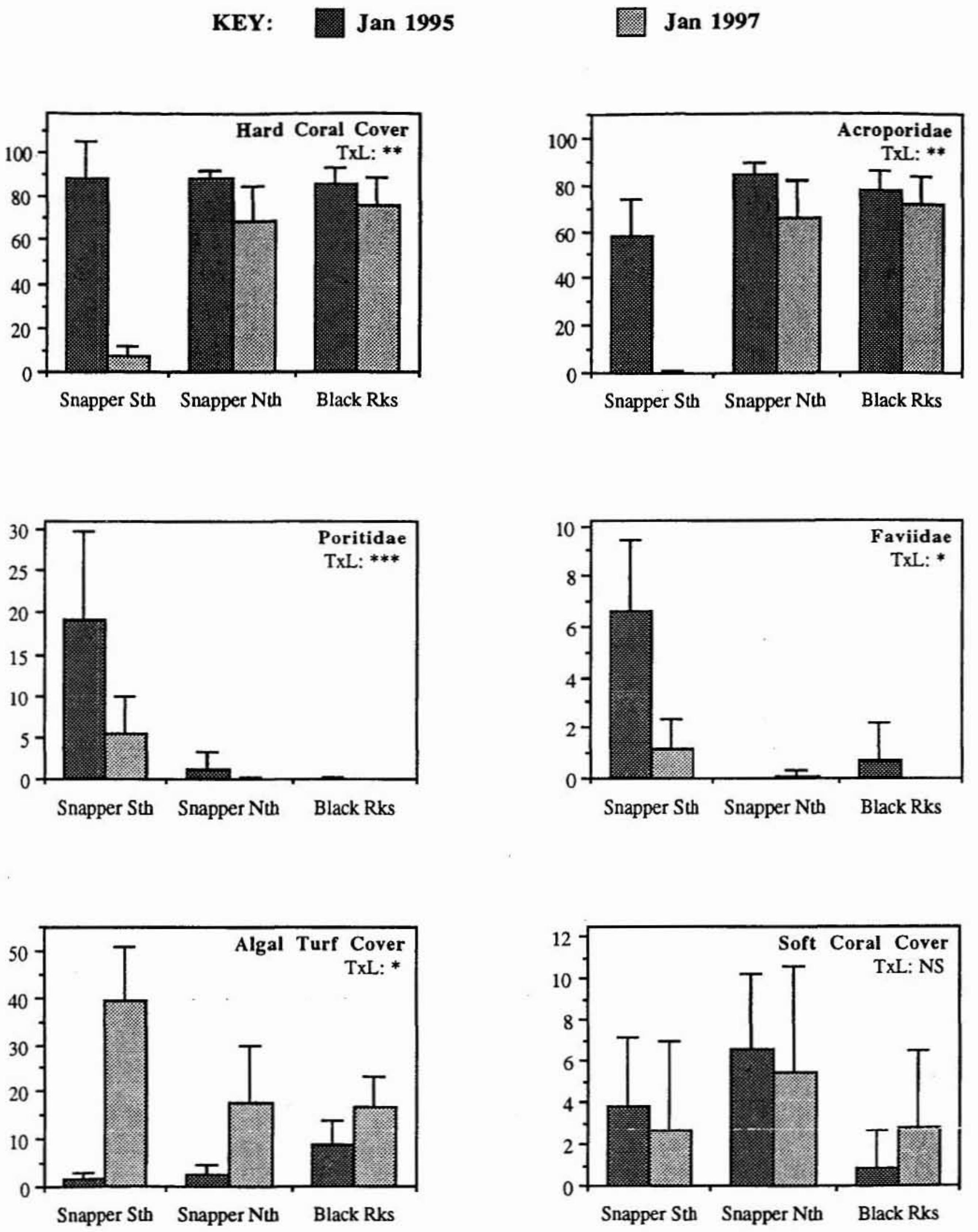

Figure 3. Changes in the cover of encrusting organisms: 1995–1997. Graphs show percentage cover from ten 20-metre line intersect transects at each location. Error bars are standard deviations. Significance of tests for the interaction between time and location (TxL) are shown.

Turf algae increased on the south side of Snapper Island, covering some of the dead coral, and giving a significant location and time x location interaction for this encrusting life form as well. Soft coral cover was low in all three locations and did not change significantly between 1995 and 1997 (figure 3).

The major death of hard cords on the south side of Snapper Island was limited to depths shallower than about 3.4 metres below low tide level, although there was some mortality of acroporids evident to depths of almost four metres. Cover of all coral groups was significantly higher in the deep strata group of transects than in the shallow transects at the same site (tables 2 and 3).

The mortality affected the entire range of coral colony sizes present on the south side of the island, from small newly established individuals to massive poritids over two metres in diameter.

Table 2. Summary of ANOVA results for the survey data. Significance of difference for the factors in the three series of analyses are shown. Note: NS = not significant; * = 0.01<p<0.05; ** = 0.001<p<0.01; *** p<0.001

Comparison: - factors	**Hard coral**	**Acroporids**	**Poritids**	**Faviids**	**Turf algae**	**Soft coral**
Snapper Is. Nth/Sth 4 sites:						
- Location	***	***	*	*	*	NS
- Site (location)	NS	NS	***	NS	*	***
Three locations 1995–1997:						
- Time	***	**	***	**	**	NS
- Location	**	***	***	*	*	NS
- Site (location)	NS	NS	NS	NS	NS	NS
- T x L	**	**	***	*	*	NS
- T x S(L)	NS	NS	NS	NS	NS	NS
Snapper Sth Depth:						
- Depth	***	***	*	**	***	***

Table 3. Depth patterns in the abundance of encrusting organisms on the south face of Snapper Island. Figures are means from groups of five 20-metre line intersect transects with standard deviations in italics beneath.

Depth strata	**Hard coral**	**Acroporids**	**Poritids**	**Faviids**	**Turf algae**	**Soft coral**
Shallow (2-3 m)	7.2	0.2	5.8	0.7	42.3	1.4
	6.2	*0.4*	*6.4*	*0.4*	*13.1*	*3.1*
Deep (4-6 m)	50.7	18.3	26.1	2.0	5.5	15.2
	11.3	*12.0*	*13.2*	*0.7*	*4.7*	*11.5*

DISCUSSION

The Daintree River flood event of March 1996 was probably the cause of the almost total coral mortality first noticed on the shallow reef slope of the entire south face of Snapper Island in October 1996. The strongly depth limited mortality, with an abrupt lower limit at just over three metres depth, is typical of flood plume affects on reef corals (van Woesik et al. 1996). The coral had been dead for some time with much of it covered in algal turf suggesting that the March 1996 estimate of time of death is reasonable.

Although the 1996–97 wet season had been underway for about a month at the time the quantitative survey was made in January 1997 there had been no flood events recorded in the Daintree River during that period (A.M. Ayling personal observations). There were also no flood events between the time of the first surveys in January1995 and the March 1996 deluge. On several casual visits during late 1995 and early 1996 the reef appeared healthy around both sides of Snapper Island. The evidence strongly suggests that the coral mortality recorded between January 1995 and January 1997 was all due to the severe flood that occurred in March 1996.

The freshwater of the flood plume had killed all corals on the outer reef flat, all the acroporids down to over three metres depth, and at least 70% of other coral groups down to this depth. There had been some acroporid death down to almost four metres depth but few colonies of other groups had been affected below three metres. As has been found previously (van Woesik et al. 1996) it seemed that acroporids were the species of corals most susceptible to extended freshwater inundation. Poritids, and some faviids such as *Goniastrea* were the most resistant of the corals in this location. Small patches of some of the massive poritid colonies had survived even in shallow water, and a few colonies were largely unaffected. Soft coral cover at all locations was similar during both surveys. Although the presence of bare calcareous bases indicated that some large *Sinularia* colonies had been killed in shallow water on the reef edge, soft corals were apparently much more resistant to the freshwater than the hard corals.

Although the flood plume completely surrounded Snapper Island, coral mortality on the north face was only minor, with only some staghorn acroporid colonies in shallow water affected. The pool of relatively clear water on the northern lee side of the island, evident in the aerial photos of the plume, apparently protected the corals on this face from the effects of the flood. The work of Wolanski et al. (1996) suggests that when a current flows past a reef or island there will be an upwelling of deeper water on the lee side. In this case it seems that there was an upwelling of almost normal salinity seawater from beneath the freshwater plume on the lee side of Snapper Island. This was sufficient, over the several days that the flood lasted to maintain the health of the majority of corals on the north face of the island.

The extent of influence of the flood plume is not known, but there was no coral mortality on the reef around Black Rocks five kilometres north of Snapper Island. This is the closest reef formation to Snapper Island and suggests that the freshwater influence from this flood event only affected Snapper Island.

Many large coral colonies were present at all the sites visited around Snapper Island during the 1995 survey (Ayling and Ayling 1995). The south face in particular was a very attractive reef and supported a variety of large coral colonies, including *Porites* massive up to three metres in diameter, *Acropora* staghorn, bottlebrush, corymbose plate and tabulate species, *Goniopora, Pachyseris rugosa,* many faviids, merulinids and pectiniids. Particularly noteworthy were a colony of *Acropora nobilis* about 30 x 20 metres, many tabulate *Acropora* over three metres in diameter, and a *Goniopora* colony 15 x 10 metres. This suggests that it has been 50–100 years since the last flood event of similar severity affected this reef. It is possible that flood plumes of similar magnitude have occurred over that period but have flowed to the south and not affected Snapper Island. However, the normal wind direction during heavy rain episodes is south-east, as lots of moisture off the sea is necessary to fuel the rainfall, and in such conditions the plume would flow to the north as was observed in this case.

The shallow reef slope on the south side of Snapper Island has been completely destroyed by this flood episode. This was the most diverse, and one of the most attractive, of the 17 fringing reefs we surveyed in 1995 (Ayling and Ayling 1995). Rather than being entirely acroporid dominated other, more slow-growing groups such as poritids, were important on this reef. Full recovery of the reef to the pre-flood condition will probably take the best part of a century, although it can be expected that fast-growing acroporids will reach high cover values within 15–20 years. Given the widespread belief that fringing reefs close to disturbed catchments are stressed and less able to cope with disturbance, it will be instructive to follow the recovery of this reef.

ACKNOWLEDGMENTS

We would like to thank Ray Berkelmans of the Great Barrier Reef Marine Park Authority for suggesting this project and for pointing out the applicable hydrodynamic work of Wolanski from the Australian Institute of Marine Science. Thanks to Andrew Elliott of the Great Barrier Reef Marine Park Authority who supplied the aerials of the flood plume.

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