

**Reply to B. E. Lapointe and P. J. Barile (2004). Comment on J. C. Zieman, J. W. Fourqurean, and T. A. Frankovich. Seagrass Die-off in Florida Bay: Long-term Trends in Abundance and Growth of Turtle Grass, *Thalassia testudinum*. 1999. *Estuaries* 22: 460–470.**

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The Lapointe and Barile (2004) note claims to be a comment on our recent paper in *Estuaries* (Zieman et al. 1999), but it is really both a comment and a statement of a hypothesis. As a comment on our paper, it demonstrates a skewed reading and direct contradiction of the stated conclusions of our paper. As a statement of a new hypothesis, it relies on a very selective re-analysis of previously published work while ignoring completely the published results of the original authors. “Getting the science correct” is indeed important, owing to the large commitment of Federal and state funds to address problems of the entire south Florida ecosystem that have been caused by a century of human activities. Lapointe and Barile unfortunately have contributed no new information on the state of Florida Bay and in their comment rely on facile reinterpretation of fragments of a very robust data set that many scientists have collected over the past two decades. In this reply, we will address issues raised in roughly the same order that they appear in their comment.

Beginning in 1987, dense meadows of *Thalassia testudinum* in Florida Bay began a rapid and as yet poorly understood die-off (Robblee et al. 1991). The first contention of Lapointe and Barile is that Zieman et al. (1999, p. 467) “overstated the role

of hypersalinity” in the Florida Bay seagrass die-off. We find this curious, since in our conclusions in that paper (p. 468) we state “(w)e have presented evidence that salinity does have a negative impact on seagrass productivity, but that salinity alone is not a sufficient explanation of the die-off.” Our data show a clear and significant negative relationship between growth rate of *T. testudinum* and salinity of the overlying water column (Zieman et al. 1999, Fig. 6). Our recognition that the original seagrass die-off episodes could not be fully explained by this relationship led to our outlining a conceptual model of causes and consequences of the die-off of seagrasses in Florida Bay.

It is in this conceptual model that we dismiss the importance of cultural eutrophication of the water column as the cause of the seagrass die-off in 1987. We made the statement (p. 440) that “general cultural eutrophication of the water column, so often the cause of seagrass mortality around the world . . . has not been a contributing factor to the recent die-off in Florida Bay”. At this point after several years of additional study we stand behind that statement and we believe that the published literature continues to support that conclusion. We also continue to believe that hypersaline conditions are stressful for *T. testudinum*, and that sulfide toxicity and excessively high biomass with resultant high oxygen demands were also factors in the initial seagrass die-off.

Lapointe and Barile also have selectively and incompletely taken isolated fragments of the water column data generated by others and published in the refereed literature (Fourqurean et al. 1993; Boyer et al. 1997, 1999; Boyer and Jones 2002) to support their contention of anthropogenic N increase in Florida Bay while ignoring the basic finding of these papers: the benthos and water column of Florida Bay are generally P-limited, which means that excess N accumulates in the water column. Epiphyte loads on seagrasses from Florida Bay are low across most of the bay, and again are strongly linked to P availability in the water column (Frankovich and Fourqurean 1997). A claim repeated (but not supported with any data) throughout the Lapointe and Barile note is that Florida Bay showed eutrophic algal growth prior to the seagrass die-off in 1987 and that this eutrophication, driven by cultural eutrophication entering through the Everglades, was the cause of the die-off. They support this claim with statements such as “the observations in 1983–1984 by Zieman and Fourqurean (1985) and by Zieman et al. (1989) that ‘turbid conditions were common’ and seagrass leaves were ‘highly epiphytized’ in the Mainland fringe of Florida Bay were clear ecological indicators of incipient nutrient enrichment.” (p. 299–301) The

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Mainland fringe is a narrow habitat band adjacent to the mainland and mangrove fringe; this mangrove fringe is a site of increased primary and secondary production in the south Florida wetland-mangrove-seagrass environment. The mangrove zone lies at the ecotone between the oligotrophic Everglades freshwater marshes and oligotrophic Florida Bay; water column nutrients are much higher in this ecotone than in the Everglades (Rudnick et al. 1999) or Florida Bay (Fourqurean et al. 1993; Boyer et al. 1997, 1999).

The oligotrophic Everglades marshes effectively remove most, if not all, of the phosphorus and much of the nitrogen that enters from human activities in the watershed; but loadings to Florida Bay and the Gulf of Mexico are proportional to rainfall (Rudnick et al. 1999). In wet years, there is increased P and N loading to the nearshore coastal system, but this loading is minor compared to other inputs. By far the greatest source of N and P for Florida Bay is water brought in via tidal exchange with the Gulf of Mexico (Fourqurean et al. 1992a, 1993; Rudnick et al. 1999). The claim made by Lapointe and Barile that the Rudnick et al. (1999) paper showed increased nutrient loadings into Florida Bay is a misinterpretation of Figs. 3 and 4 in Rudnick et al. (1999), which show loading (natural plus anthropogenic) into the headwaters of the oligotrophic Everglades, not loading into Florida Bay. There is no evidence of "increased nutrient loads to the shallow, nitrogen limited western and central regions of the bay" during 1982–1985, as claimed by Lapointe and Barile, and this statement illustrates a repeated lack of understanding of the geography and hydrology of the southern Everglades and Florida Bay on their part. We also take issue with Lapointe and Barile's selective interpretation of the literature when it comes to the relative importance of nitrogen and phosphorus in Florida Bay.

Lapointe and Barile claim that we ignore our own data on algal biomass from Florida Bay, especially data on macroalgal biomass in the bay during 1983–1984 (Zieman et al. 1989). We do not find any evidence of especially high biomass of algae in Florida Bay in 1983–1984; instead, we find that Lapointe and Barile grossly misinterpret our data. They quote our data on a "localized biomass" of *Laurencia* sp. of  $664 \text{ gm}^{-2}$ . We did report that number, but it was a localized sampling; *Laurencia* was found at only 37% of 108 survey sites, at a mean biomass of  $24.1 \text{ gm}^{-2}$  where it was present, compared to a mean of  $67 \text{ gm}^{-2}$  of green leaves of *Thalassia testudinum* (Zieman et al. 1989). Considering that *T. testudinum* has only about 10% of its biomass in green leaves (Fourqurean and Zieman 1991), this means that average *T. testudinum* bio-

mass was over  $25\times$  greater than that of *Laurencia* at sites where *Laurencia* was recorded. The biomass comparison grows when the fact that *Laurencia* was found at only 37% of our survey sites is taken into account. *Laurencia* biomass had a bay-wide average of only  $8.9 \text{ gm}^{-2}$  in 1983–1984; this is clearly and unambiguously stated in Zieman and Fourqurean (1985) and in Zieman et al. (1989). High *Laurencia* biomass occurred at a station in the southern part of Twin Key Basin, which is 15 km from the mainland Everglades coastline and in the Atlantic community, which is flushed primarily from the Atlantic and Gulf Stream, and was not due to any "predictable response to the elevated Everglades discharges" but was due to its behavior as a drift algae that is moved by the winds and currents and is blown up against lee banks or drifts in depression (Zieman et al. 1989).

The die-off of seagrasses within Florida Bay, as defined by the western boundary of Everglades National Park, was indeed first reported by fishing guides in 1987. It was at that time that we first revisited these areas for the purpose of investigating the die-off. There is anecdotal evidence of a benthic macroalgal bloom well to the north and west of Florida Bay; we suspect that this is the event referred to by Lapointe and Barile as occurring in 1985. A retrospective analysis of AVHRR images of the entire area over the period 1985–1997 did not detect seagrass loss until 1988 (Stumpf et al. 1999). One of the most striking features about the die-off of seagrasses that we (and many others) visited in 1987 and 1988 was that the plants were dying in place under a very clear water column with very low epiphyte loads. Approximately 15% of the variation of *T. testudinum* epiphyte loading in Florida Bay can be attributed to nutrient availability, particularly phosphorus (Frankovich and Fourqurean 1997). The majority of the variation is due to other factors. In seagrass ecosystems undergoing eutrophication, negative correlations of seagrass health (productivity and biomass) with epiphyte loading may be expected (Duarte 1995). As Fig. 1 illustrates, no such correlations can be made with regard to Florida Bay *T. testudinum*; the two areas of highest leaf productivity (Sprigger Bank and Tavernier Key) are coincident with the highest epiphyte loads. The epiphyte community at these sites is characterized by the encrusting coralline red algae *Hydrolithon farinosum*, which is abundant throughout most times of the year. Predominance of this epiphyte might be an indicator of oligotrophic conditions. A combination of high seagrass productivity and high epiphyte productivity may indicate positive overall seagrass ecosystem health. In the healthy subtidal *Zostera marina* meadows in Friday Harbor, Washington, simultaneous high eel-

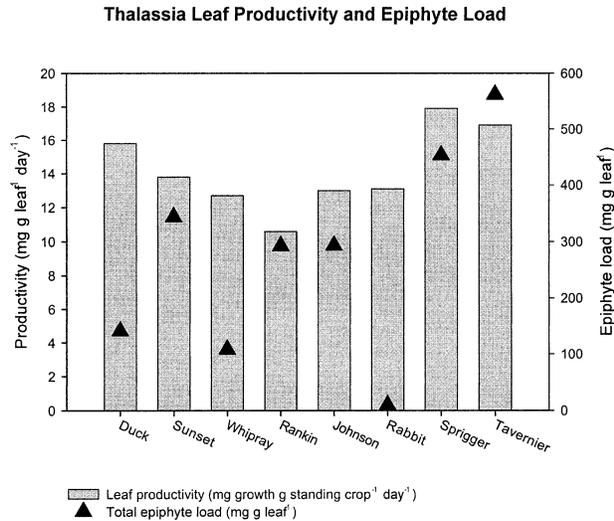


Fig. 1. Seagrass growth rates with epiphyte loads from 8 long-term monitoring sites in Florida Bay (1991–1992). Note that the highest seagrass growth rates were at the sites with the highest epiphyte loads.

grass productivity and epiphyte productivity was also observed (Nelson and Waaland 1997). The spatial and temporal distributions of Florida Bay epiphyte loads are disjunct from that of seagrass die-off. Florida Bay epiphyte loads are highest during winter and early spring and are greatest at sites experiencing greater marine influence (Frankovich and Zieman 1994; Frankovich 1996). In contrast, primary seagrass die-off is most prominent during the fall and has occurred at western interior sites. Under the present low nutrient regime in Florida Bay, seagrass biomass and productivity are not negatively correlated with epiphyte loading. These were not and are not the symptoms of seagrass loss caused by eutrophication of the water column.

We agree that pollution can lead “to quite aberrant developments as the original vegetation becomes degraded and replaced by a vegetation consisting of species which are not normally involved in the succession series” (Den Hartog 1977, p. 100); however, that did not happen in Florida Bay and certainly not, as implied, in 1983–1984. All of the abundant macroalgal species listed in Zieman et al. (1989) are normal members of the greater seagrass community of south Florida, and none are in eutrophic abundance. We did not make a linkage between eutrophication and the loss of *T. testudinum* in Florida Bay as there is none.

While there is a place for generalities, they can also be used to deflect a point even when specific information is available. In the marine environment, dissolved inorganic nitrogen (DIN) concentrations are the most frequently “limiting” nutri-

ent (Ryther and Dunstan 1971; Nixon 1995). The assumption of N-limitation of Florida Bay ignores the documentation of the widespread P-limitation of the Florida Bay benthos and water column. Numerous works have shown many seagrass meadows in south Florida and the Caribbean to be specifically phosphorus limited (Short et al. 1985, 1990; Williams 1987, 1990; Powell et al. 1989, 1991; Fourqurean et al. 1992a,b, 1993; Frankovich and Fourqurean 1997). We submit that such specific research references are more pertinent than broad-scope review papers.

Lapointe and Barile state Florida Bay is obviously eutrophic based solely on water column nitrogen numbers. They then cite our work (Fourqurean et al. 1993) to indicate “that Florida Bay was highly nutrient enriched when the first Bay-wide data were collected in 1989–1990.” (Lapointe and Barile 2004, p. 158). We completely reject this overly simplistic statement that continues to ignore the phosphorus limitation within most of Florida Bay. While it is true that some phytoplankton bioassay experiments have shown that N is a limiting factor for phytoplankton biomass at some times in western Florida Bay (Lavrentyev et al. 1998; Tomas et al. 1999; Cotner et al. 2000), stoichiometric evidence suggests that, in the benthos, there is an abundance of N with respect to P. N:P ratios in the water column and in *T. testudinum* leaves are indeed about 20:1 on the extreme western margin of Florida Bay, but in many of the areas of initial seagrass die-off, both water column and seagrass N:P ratios are in excess of 80:1—surely this is not consistent with N limitation of the entire ecosystem, as proposed by Lapointe and Barile. Relying on water column nutrient ratios to make these arguments, as Lapointe and Barile do, is tenuous at best. Wear et al. (1999), in a study of epiphyte enrichment on seagrasses in northern Florida noted on p. 210 that “water column nutrients, however, can be a poor indicator of the extent of eutrophication in aquatic systems because soluble nutrients are rapidly removed”, citing Suttle and Harrison (1988), Suttle et al. (1990), and Tomasko and Lapointe (1991). Similar conclusions were reached by Smith et al. (1981), Borum (1985), and Valiela et al. (1990).

It is also curious that Lapointe and Barile have extracted data from a funding agency data base (their Table 1, Florida Bay numbers attributed to SFWMD) instead of citing the refereed, published analyses of these data (Fourqurean et al. 1993; Boyer et al. 1997, 1999; Boyer and Jones 2002). Were they to consult the papers, they would see clearly that chlorophyll *a* (chl *a*) concentrations in the water column of Florida Bay have not behaved in a manner completely consistent with their model.

Chlorophyll concentrations have significantly increased in western Florida Bay, but in central Florida Bay, a sharp rise over the period 1989–1994 was followed by just as sharp a fall during the period 1994–1998, while eastern Florida Bay, the region closest to land-derived nutrients sources, there has been a significant decline in water column chlorophyll over the period 1989–1997 (Boyer et al. 1999). Lapointe and Barile have resorted to casting doubt on published chl *a* data to try to strengthen their case by citing an unsupported and factually incorrect pronouncement made by Brand (2002). It is not correct that there are systematic methodological errors in the chl *a* data (Boyer personal communication). Caution must also be taken when making facile comparisons of time series, as Lapointe and Barile make when they claim that a decrease in salinity in Florida Bay correlates with freshwater discharges in Shark Slough and Taylor Slough. Such correlations prove little. Freshwater runoff and rainfall are highly correlated in south Florida, and at this time runoff contributes very little to the freshwater budget of Florida Bay (Nuttle et al. 2000). The major contributor to interannual salinity variability is the balance between precipitation and evaporation directly over Florida Bay. During years with relatively high rainfall, salinity is lowered in Florida Bay and freshwater discharge increases—both of these are a direct response to rain, but the freshening of the bay currently has little to do with stream discharge (Nuttle et al. 2000).

We agree with Lapointe and Barile that ammonium concentrations in Florida Bay are indeed high—and we and others have reported on this fact many times (e.g., Fourqurean et al. 1993; Boyer et al. 1997, 1999). Our interpretation of the causes are different than Lapointe and Barile's. The high ammonium concentrations in Florida Bay are coincident with the most strongly P-limited regions of the bay. We have hypothesized that this ammonium is the result of lack of utilization of this N by severely P-limited primary producers; and anaerobic decomposition of organic matter and some interference in the nitrification and denitrification of that DIN.

What should be made of the rating of Florida Bay as highly eutrophic in the NOAA Eutrophication Assessment (Bricker et al. 1999)? The answer is complex. This assessment was based on a survey of a few scientists' opinions, and was not based on an analysis of data. Why would some scientists report that Florida Bay was, in their opinion, eutrophic? The answer lies in the change in water clarity that followed the seagrass die-off. As can be clearly seen in the time series data on water quality of Florida Bay presented in Boyer et al. (1999), tur-

bidity increased markedly beginning in late 1991–early 1992, a full 4 yr after the major episodes of seagrass die-off in 1987–1988. The switch from a clear water column to a very turbid one was obvious to all observers of Florida Bay. The most likely causes of this turbidity increase is an increase in suspended sediment and phytoplankton that occurred as a consequence of the loss of seagrasses in 1987–1988, not as a cause. It appears that internal loading of nutrients as a consequence of decomposition and sediment resuspension, led to increases in phytoplankton biomass. The loss of seagrass during the die-off not only caused an increase in the internal nutrient loadings, but, simultaneously, a very important nutrient sink was lost (i.e., the *T. testudinum* plants themselves). Using estimates of *T. testudinum* TP and TN nutrient uptake rates of 2.25 mg P<sup>-2</sup> day<sup>-1</sup> and 16.28 mg N<sup>-2</sup> day<sup>-1</sup> (Madden et al. 2003), the loss of 4,000 hectares of *T. testudinum* resulted in an estimated annual addition of 240 metric tons of TN and 33 metric tons of TP, which then became available for uptake by phytoplankton and macroalgae. These nutrient amounts are approximately 97 times larger than the annual TP loading and 8.9 times larger than the annual TN loading into Florida Bay through Taylor Creek (0.34 and 26.8 metric tons, respectively; Rudnick et al. 1999).

Increased turbidity and phytoplankton biomass did indeed cause light availability problems for Florida Bay seagrasses. The response to decreased light was a thinning of the *T. testudinum* biomass and an initial sharp decrease in the biomass of *Halodule wrightii* and *Syringodium filiforme* (Hall et al. 1999). It is interesting that the distribution of *T. testudinum* was largely unaffected by these events (Hall et al. 1999). *Halophila* species have recently begun to show up in Florida Bay (Durako et al. 2002). This species has a very low light requirement for a seagrass, and is often found in deep or turbid waters. Epiphyte accumulation rates are 1–2 orders of magnitude lower than those observed in the Patuxent River estuary of Chesapeake Bay using identical techniques (Table 1).

Of all the points raised by Lapointe and Barile, one we wish we had stated more clearly is on the general salinity response of *T. testudinum* to salinity. A more precise statement than “*T. testudinum* is a stenohaline marine plant” (on p. 467) would be that it is capable of surviving in a broad range of salinities, but that it thrives in a fairly narrow salinity range. The data presented in Zieman et al. (1999) clearly demonstrate reduced growth rates in hypersaline conditions. There is also literature support of this finding. Lapointe and Barile noted our citation of McMillan and Moseley (1967) and we recognize that the overall design of this pio-

TABLE 1. Mean Epiphyte Accumulation Rates. The Florida Bay rates are from T. Frankovich, March–April 2001, 7–11 d accumulation. The Patuxent River rates are from Stankelis et al. (1999; seasonal means estimated from graph, pages 102–103), 6–8 d accumulation.

	Total Epiphyte ( $\mu\text{g cm}^{-2} \text{ day}^{-1}$ )	Epiphyte Chlorophyll <i>a</i> ( $\text{ng cm}^{-2} \text{ day}^{-1}$ )
Florida Bay		
Duck Key	19	4
Bob Allen	13	15
Sprigger	52	18
Patuxent River estuary	60–520	100–500

neering work is not perfect. However, they overlooked our citation of Zieman (1975), where a field study of nearly 200 productivity measurements over a two-year period showed highest productivities near 30 psu. Zieman (1975) stated on p. 108 that “*Thalassia* showed a salinity optimum in these studies of 30 ppt, with decreased productivity above and below this.” *T. testudinum* can tolerate salinities as low as 3.5–5 ppt (Sculthorpe 1967) or as high as 60 ppt (McMillan and Moseley 1967) for short periods of time, but usually undergoes defoliation.

Lapointe and Barile misrepresent the citations of Tabb et al. (1962) that we used. Tabb et al. (1962, p. 42) do indeed state that “with marked reduction in salinity . . . the *Thalassia* underwent decline in size and abundance” and we also believe that to be true. Tabb et al. (1962, p. 43) state that it appears “that long periods of near or *slightly above normal salinities* (our emphasis) are a requirement for maximum growth of *Thalassia*.” That statement is in agreement with our work but gives no basis for the misleading statement of Lapointe and Barile (2004, p. xx) that “Tabb et al. (1962) concluded that *T. testudinum* thrives (our emphasis) under hypersaline conditions.” Tabb et al. (1962) did not conclude that hyper salinity caused *T. testudinum* to “thrive” as stated by Lapointe and Barile (2004, p. 160). This occurred at Salinities at or just above “normal salinities” (Tabb et al. 1962; p. 43). Tabb et al. (p. 74–75) later stated that “under hypersaline conditions (above 40–50‰) the turtle grass *Thalassia testudinum* is adversely affected. The blades of the “grass” die back and expose the bottom muds. This was actually the first description of a small-scale seagrass die off in Florida Bay.

Lapointe and Barile misrepresent the conceptual model presented in Zieman et al. (1999) time and again. It is not true that the conceptual model concludes that hypersalinity caused the seagrass die-off. We state that hypersalinity is but one stress on seagrasses in Florida Bay. Just as important in our conceptual model is the observation that sea-

grass die-off in 1987–1988 was confined to only the very densest seagrass beds in Florida Bay. Surely, some result of the dense seagrass community caused a stress on seagrasses that led to their demise. In our conceptual model, we stated on p. 468 that “these dense beds became overcrowded and unstable,” but we nowhere state that “meadows with biomass higher than 50 to 100 g dry wt<sup>-2</sup> are overcrowded.” (2003, p. 468) Our model hypothesizes that as Florida Bay became more marine, *T. testudinum* both expanded its coverage, often at the expense of the more euryhaline *H. wrightii*, and increased greatly in biomass. This is supported by the changes in seagrass distribution between the map of Schmidt (1979) and our map in 1983–1984 (Zieman et al. 1989), by Fig. 7 in Zieman et al. (1999), and by the observations of numerous observations of fishing guides as reported by Michael Collins, then president of the Islamorada Guides Association and currently a member of the governing board of the South Florida Water Management District. The seagrass beds that succumbed to the initial die-off of *T. testudinum* in 1987 were indeed unusually dense. At the beginning of our sampling of the die-off, 8 mo after it began, average standing crop at die-off stations was 200 g m<sup>-2</sup>. Lapointe and Barile claim that such densities are common, but there is no support for this in the literature. Tomasko and Lapointe (1991) report densities at 17 locations from Florida and the Caribbean, and a maximum leaf biomass of 150 g m<sup>-2</sup>, but an average of only 48 g m<sup>-2</sup>. Based on a comprehensive monitoring program in south Florida seagrass beds, a typical *T. testudinum* meadow has a leaf density of 40–50 g<sup>-2</sup>, and they rarely exceed 80 g<sup>-2</sup> (Fourqurean et al. 2001).

We find that there is no “substantial evidence” as stated by Lapointe and Barile (p. 161) linking declines in biomass, density, and productivity of *T. testudinum*, *H. wrightii*, and *S. filiforme* with decreasing salinity.” Declines before 1991 were definitely not associated with increases in nutrients, chl *a*, and turbidity, as the bay remained generally clear except at the immediate die-off basins. Figure 2 shows an aerial view of Rankin Lake in the summer of 1988, early in the die-off. The clear water column and dense seagrass with coalescing patches of bare sediment were the symptom of the die-off in this basin and are not characteristic of eutrophication events. Figure 3 shows an underwater close-up of the same area. Note the clean water, clean green leaves with few epiphytes, and brown to black lesions on the leaves caused by the slime mold *Labyrinthula*. This photo of seagrasses as they were dying is clearly not consistent with eutrophication-induced loss of seagrass.

There is no “disconnect between their data and



Fig. 2. The water column overlying seagrasses in Rankin Lake. Prior to the original episodes of seagrass die-off in 1989 remained optically clear as can be seen in this low-level oblique photograph taken on Rankin Lake in central Florida Bay (25°6.3'N, 81°47.5'W).

interpretation” in our discussion of the time series of seagrass growth rates in Zieman et al. (1999), as stated by Lapointe and Barile on p. 161. Although mass-specific productivity increased total standing crop continued to decrease because of a reduction in density of short shoots and accelerated leaf loss. We attributed “this increase in mass-specific productivity to a thinning of the seagrass canopy and the subsequent decrease in light attenuation within the plant canopy.” (p. 467) This is consistent with earlier work where Zieman et al. (1984) showed *T. testudinum* to increase its turnover rate by as much as 30% in response to canopy thinning by green sea turtles.

The restoration of historic fresh water flow to the southern Everglades and Florida Bay is a major driving force of the Everglades restoration plan. Lapointe and Barile rely on selective citation to overstate the support for their ideas about the cause of change in Florida Bay, while continuing to ignore the published interpretations of the data that they selectively use to create their “just so” story. The local, state, and Federal resource management agencies and policy makers responsible for the stewardship of Florida Bay were not at all confused by various hypotheses pertaining to the demise of Florida Bay. We believe that these policy makers have been influenced by a progression of papers and a body of knowledge that has built up over the past decade that have shown that the restoration of historic waterflows to the lower Everglades and Florida Bay is the key to the restoration of the whole ecosystem.

### Summary

While cultural eutrophication of the coastal ocean is widespread and has negatively impacted



Fig. 3. An actively dying seagrass meadow in Rankin Lake in 1989. Note the clear water and absence of notable epiphyte load or macroalgae.

many ecosystems, it was clearly not the cause of the 1987–1988 Florida Bay seagrass die-off. The published literature paints a clear picture. Lapointe and Barile (2004) have ignored much of this literature, and have instead presented a superficial re-analysis of very selective subsets of published works and gray literature. Proper environmental stewardship should be based on a careful analysis of ecological data from the system at hand. The analyses presented by Lapointe and Barile can simply not withstand scrutiny, and their direct criticisms of our paper (Zieman et al. 1999) are largely without support.

We are most concerned with the restoration of the historic Florida Bay, and this means the Florida Bay prior to the upstream water modifications. What we do not want is a return to a highly restricted system that created the conditions of the 1980s. The bay communities of the 1980s were aesthetically pleasing, but much of the bay was more like a back-reef seagrass community than an estu-

arine community. As Fourqurean and Robblee (1999, p. 355) stated as a summary to the collected works published in the special issue of Estuaries on long-term changes in Florida Bay, "... the natural state of the Florida Bay ecosystem is one of variability and change. For this reason, a clear causal link between recent changes in the ecosystem and human activities in the ecosystem eludes detection. To their credit, governments and resource managers have adopted a precautionary approach and are proceeding in recognition of the possible ecological consequences of their actions. Indeed, long-term plans for the renovation of the water management infrastructure have ecosystem restoration as a principal goal. But, restoration to what state? The insight to be drawn from this volume [1999. *Estuaries*, 22(2B)] is that the objectives for a restored Florida Bay must take account its inherently variable nature. To manage the bay as a static system would alter the nature of Florida Bay far more than may have already occurred."

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