United States v. Melvin A. Fisher et al.

Case No. 92-10027-CIVIL-DAVIS

Report Submitted by:

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I. Statement of opinions.

The Role of the Seagrasses in South Florida

The seagrass meadows of south Florida constitute one of the most important natural resources in the state. They have high rates of primary productivity which result in large leaf canopies and an abundance of fixed carbon for food for higher trophic levels. The extensive leaf canopies provide food, substrate, and protection from predators. This results in seagrasses providing food and critical habitat for large numbers of important commercial and recreational fish and shellfish. The presence of seagrasses with their associated leaf canopy and dense root and rhizome mats stabilize sediments and promote sedimentation of material. This current baffling effect and enhanced sedimentation in turn aids maintaining a clearer water column than would exist without the seagrasses. This is true of all seagrasses but especially true of turtle grass, *Thalassia testudinum*. The well developed sediment layer leads to vigorous recycling of nutrients in seagrass sediments. Thus while all seagrasses are important to the local environment, in south Florida waters *Thalassia testudinum* can be considered a keystone species.

To survive, seagrasses, as rooted benthic plants, require adequate sediments for rooting and adequate sunlight reaching the bottom to achieve photosynthesis and growth. Any reduction in water column quality, be it resuspension of sediments, increased epiphytes, or increased phytoplankton in the water column, will have a detrimental impact on the seagrasses. While moderate water currents and wave action can be beneficial in breaking down physical and chemical gradients in the leaf canopy, extreme currents and wave energy are detrimental to seagrasses.

The Environment near Coffin's Patch

Many sea bottoms in the Florida Keys have a localized environment which is a diverse mix of natural habitats. Among others, the Coffins Patch area is a mix of seagrasses, sand,

and hardbottom communities. This mixture is typical and common in the area. The relative mix of these habitats is determined by local conditions. Especially important is the degree of exposure to high wave and current energy, and the nature of the underlying substrate. For the seagrasses to develop there must be pockets in the bedrock where sediments can accumulate for rooting of the seagrasses and sufficient dampening of the wave energy so that the seagrasses and sediments are not removed.

The region of Coffins Patch is a relatively high energy region for the middle keys seagrass communities. This is because there is a reduced offshore barrier here, which allows higher energy waves to penetrate further inshore than can occur where there is a well developed, just subtidal, barrier reef front, such as occurs off of most of the upper keys. There are some areas where patch reefs and emergent rocky features locally buffer the waves that allow small continuous seagrass beds to occur. In this region these areas are found further inshore, but the area of Coffins Patch where the damage occurred is a discontinuous seagrass bed with sandy blowouts. The seagrass is predominantly *Thalassia testudinum*, turtle grass, with some local beds of *Syringodium filiforme,* manatee grass. Naturally occurring features called migrating blowouts are common features in seagrass beds in this type of an environment in south Florida and throughout the Caribbean. The blowouts are typically crescentic or irregularly shaped features that are slowly eroding at one end while recolonizing at the other end. These are quite different in nature from the vertical craters found at Coffins Patch in 1992. The seagrasses were of moderate to somewhat high density, which is typical of this high energy environment, and were very securely anchored in the calcareous substrate. The substrate is a dense carbonate sand and mud, with significant amounts of larger pieces of broken shells, coral skeletons, and other consolidated carbonate chunks. The combination of the seagrass rhizome and root mat and the local energy regime yielded a very dense, packed substrate which was difficult to disturb. The hardbottom features were of sparse density and low relief. The predominant organisms were sponges and soft corals.

The seagrass beds just to the north of the damage area and the remnant beds between the blowout craters appeared to be healthy *Thalassia* beds. The density, leaf morphology, and general appearance were those of typical *Thalassia* beds from similar environmental conditions. Quantitative measurements of the seagrasses in the damage area were made, including seagrass density and productivity. Standard methods of seagrass ecology were used, such as the leaf-marking method for productivity (Zieman, 1974).

Table 1. Density and Productivity of *Thalassia testudinum* from western end of Coffins Patch damage site. Results are the average of six replicate samples. Collection date: 13 August 1992.

Standing Crop	77.9	gm^{-2}
Density	675	shoots m^{2}
Turnover Rate	2	% d^{-1}
Leaf Length	15.3	cm
Leaf Width	9	mm

These measurements show that the Coffins Patch seagrasses were typical of the region and were productive contributors to the local environment, with densities and growth rates typical of healthy south Florida seagrasses from their type of habitat.

The Damage to the Seagrass Beds near Coffin's Patch

The damage to the seagrass beds at Coffins Patch was severe and extensive. The forces creating the large holes were severe and directed vertically downward, as the craters that were formed were circular in shape with relatively steep sides. Both on-site inspection and aerial photography showed that the craters were nearly circular and not elongate in shape. Where the blast cut directly through seagrass beds with their thick root mats, the initial slopes were often vertical for as much as a meter in depth. Sometimes whole chunks of the seagrass bed of a square meter or more in size were torn free and either thrown from the crater or landed further down the crater. The diameter of the craters varied from about 6 to about 17 meters in size, with a mean of about 11 meters. Initially the craters were several meters in depth. This was the depth from the height of the original seagrass beds to the bottom of the crater. The steepness of the side slopes of the craters, the steepness of the berms of ejecta thrown from the craters, and the relatively fresh condition of the seagrass that had been buried by ejecta all showed that when first observed the craters were very new.

As the seagrass beds were ripped out of the bottom and the sediment redistributed, much fell immediately adjacent to the craters, forming berms that covered and smothered the surrounding beds. In addition to the sediment and rubble that settled immediately adjacent to the craters forming the berms, the finer sediment from the initial blasting of the craters created plumes of turbidity that drifted with the prevailing currents and would have damaged or killed thousands of organisms downstream of the blowholes. This damage destroyed significant seagrass resources and the benefits of those natural systems. The very bottoms of the deep holes soon filled with a variety of debris, primarily dead seagrass leaves, but also with sponges, drift algae, sort corals, and other marine organisms. This litter layer was up to 50-75 cm in depth, and would have created localized oxygen depletion.

The severity of the damage and the shape of the craters indicated that seagrass beds were severely damaged by non-natural causes and that large areas of seagrass were totally destroyed. There is no type of natural disturbance or stress that causes holes of the size and shape originally found in this area. In my experience, the only features that I have ever seen in seagrass beds that were at all similar to these craters were craters made by 1,000 and 2,000 pound bombs dropped from naval aircraft that inadvertently landed in seagrass beds.

The creation of these blowholes has disturbed the original community mix in the area, largely substituting unstable sand and rubble communities at the expense of the seagrass communities. While each of these communities has habitat values, they are different from seagrasses and not a substitute.

Quantitative Damage Assessment

The identified damage to the seagrass beds is grouped in two areas. One is the western region of damage and is a linear feature with its axis running from just north of west to just south of east. This has been referred to as site 'A' by Macintosh Marine Inc (MMI). The other site is further eastward and is more of a loose cluster of holes rather than a linear string. This has been referred to as site 'B'.

The area of seagrass beds damaged in the central core area (which includes areas A and B) was *approximately* ±2 acres. This determination was made by numerous visits to the site, detailed analysis of aerial photographs, and comparisons with other estimates from other workers and sources. The size of the area of seagrasses lost that was provided to NOAA was 1.63 acres. This is actually the acreage lost estimated by MMI for the defendants (Proffer of New Evidence, 24 June 1992).

The various analyses that were used are summarized in Table 2. Assessment 1 was performed by MMI in June 1992. Two different methods of assessing the damaged areas were performed on aerial photography from June 1992. The first method consisted of counting the number of craters in each of the two damage areas (A and B). This number of 102 holes was multiplied by 50.3 m^2, the size of an 8 m or 26.2' diameter hole. This yielded an area of 1.25 acres of direct identifiable damage. The second method used by MMI was to block off two similar, adjacent plots in the east and west areas. The percentages of seagrass and sand were then estimated by a random dot count method to show the differing percentages of seagrass/sand in the damaged areas. This method yielded a loss of seagrass of 1.63 acres.

I performed Assessment 2 on photography from June 1992. The areal photographs were formed into a continuous-strip mosaic. A mylar overlay was placed over the mosaic and the areas of damage were marked off with colored pens. A NOAA boat that is in the photograph was measured for absolute scale. The area of the holes and the overburden caused by them was calculated. This analysis found 102 holes and estimated the area damaged at 1.98 acres.

Assessment 3 was made using a series of drawings made by Mr. Harold Hudson and co-workers underwater. Using SCUBA and underwater surveying gear, they delineated the size and shape of 41 craters. Analysis of these craters yielded 1.03 acres of damage in craters and 0.3 acres of damage from adjacent overburden.

Assessment 4 was an analysis done by Mr. Harold Hudson and Dr. Robert Dill. It is very similar to one of the analyses performed by MMI. The damaged areas were divided into two sites, an east and a west site. Each of these sites were then enclosed in a rectangular polygon that surrounded the damage. Adjacent polygons were selected of the same size and shape. The relative areas of sand, seagrass, and the craters were delineated by computerized planimetry and the relative areas were determined. These calculated areas were then used to determine the difference and loss of seagrass in the damaged area. This analysis estimated the damaged area at 2.31 acres.

Assessment 5 was performed by MMI for David P. Horan on 26 May 1992. This analysis used the number of blowholes created by the Fisher vessels as supplied by Mel Fisher (597 holes) and the size of holes (30' to 40' diameter) also as supplied by Fisher. The area estimated was 69,697 m^2, or approximately 16 acres. This number is representative of one aspect of the total disturbance created, but overestimates seagrass damage as all of the blowholes were not in seagrass.

In summary, several different methods were used to obtain estimates of the damaged area. Analysis (1) and (2) in Table 2 were made using the same photography and are quite similar. As analysis (1) was performed by a consultant for Fisher et al, and is compatible with our own analysis, the value of 1.63 acres was accepted as a conservative, reasonable estimate of the area of seagrass damage.

Table 2. Determination of area of damage in the Coffin's Patch area.

	ANALYSIS	AREA
1)	Macintosh Marine Analysis for Fisher (22 June 1992) 92/6 Photography. 102 craters identified in 2 areas, 1.25 acres total crater damage, area of seagrass loss estimated from adjacent control areas to north and east. Final estimate = 1.63 ac.	1.63 ac
2)	Zieman photographic analysis 92/6 Photography. 102 craters identified, 1.98 acres of damage	1.98 ac
3)	Hudson Crater Measurements direct underwater mapping and measurement of craters 41 craters = 1.03 acres, overburden .3 acres	1.33 ac
4)	Dill/Hudson Analysis area estimated by grass/sand ratios in damaged areas and adjacent control sites (analysis similar to (1) above using photography from May 1992).	2.31 ac
5)	Original Macintosh Analysis for Fisher (26 May 1992) 597 holes total, average hole = 40' diam = 116.75 m^2 Total area = 69,697 m^2, or approximately	16 ac

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The above information shows the sources used to determine the extent of the gross loss of seagrass but underestimates the total damage to the ecosystem. When the blowholes were made, the large sediment plumes drifted down current from the blowholes. This sediment had the capacity to smother and weaken or kill numerous types of organisms, either by smothering them or by interfering with filtering capacity for both feeding and respiration.

Creating the blowholes has disturbed the natural mix of communities in the area, largely by substituting unstable sand and rubble communities at the expense of the seagrass communities. These other habitats are a part of the natural community mix of the area, but their habitat values are different from seagrasses, especially from the habitat values of a well developed *Thalassia* community. These other communities are different from seagrasses and do not substitute for a well developed *Thalassia* community. When considering not just the relatively few species of seagrasses, but the accompanying micro and macroalgae, infauna, epifauna, and associated fish fauna, the seagrass communities have very high total biodiversity.

Recovery and Restoration

The damaged seagrass areas will be a very long time in recovering. The primary seagrass destroyed was *Thalassia testudinum*, or turtle grass. While this seagrass has the highest total of habitat values for the local seagrasses, it is also the slowest to recover. *Thalassia* has already begun to send out runners into portions of the damaged area where sediment level has been reestablished, but this does not constitute restoration. While this is the earliest stage of recolonization, it is a process that will take decades. In a high energy environment such as Coffins Patch, initial steps at regrowth will be begun and destroyed many times before true recolonization becomes established. It is anticipated that this site will need a lag time of 10 to 20+ years before significant recovery begins and that full recovery may take 50 to 100 years.

During this recovery period, the habitat values and the services of the seagrass beds will be lost or severely diminished. Some of the services include primary productivity, substrate for epiphytes, trophic base material, sediment stabilization, feeding ground and nursery ground. These will be fully restored only when seagrass communities, primarily turtle grass, are restored to their original density.

After examining the site and comparing it with other natural and anthropogenic damage to seagrass meadows, it is my opinion that on-site restoration of the damaged area is not feasible. The area is swept with very high energy waves that keep the bare sand areas in motion. This will inhibit or prevent recolonization. Natural recolonization in the natural sand patches or blowouts is very slow, and is typically matched by erosion on the opposite side so that the total area of seagrass/sand tends to remain relatively constant. Because of the high energy in this area, these craters will tend to behave more like migrating blowouts than if the cratering had been in a more benign environment. There have not been successful transplants in areas with wave energy approaching those on Coffins Patch. While it is certainly possible to plant propagules in the area and have them survive for some period of time, this does not constitute restoration. The likelihood of patches of transplanted plants surviving major storms in this area is very low to zero.

II. Data or other Information Considered. In forming my opinions, I have considered the following information or data:

- Aerial Photography: 55/3/26, 75/3/6, 82/2/19, 92/2/14, 92/5/14, 92/6/11, 94/10/25, 96/7/24

- Various underwater still photography of blowholes and seagrass damage as provided by NOAA, C. Kruer, and defendants
- Videotapes of blowholes and seagrass damage as provided by NOAA
- Report of Harold Hudson and Dr. Robert Dill
- Macintosh Marine, Inc.
    Proffer of new evidence
    Report of damage to seagrass
- Harold Hudson Crater descriptions and diagrams

I have also used my experience and knowledge as a biologist and ecologist who works in the area and has lived in the area in forming my opinions, as well as a variety of literature on the area.

III. Exhibits. The following exhibits are expected to be needed:

- Aerial Photography: 55/3/26, 75/3/6, 82/2/19, 92/2/14, 92/5/14, 92/6/11, 94/10/25, 96/7/24
- Various underwater still photography of blowholes and seagrass damage as provided by NOAA, C. Kruer, and defendants
- Videotapes of blowholes and seagrass damage as provided by NOAA
- Report of Harold Hudson and Dr. Robert Dill
- Macintosh Marine, Inc.
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- Mylar overlays, illustrating how the craters were delineated
- Charts and tables showing the resultant mapped areas
- Illustration of how scale is determined initially
- Regular and oversized NOAA Charts of Coffins Patch
- Publications on seagrass in resume.

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