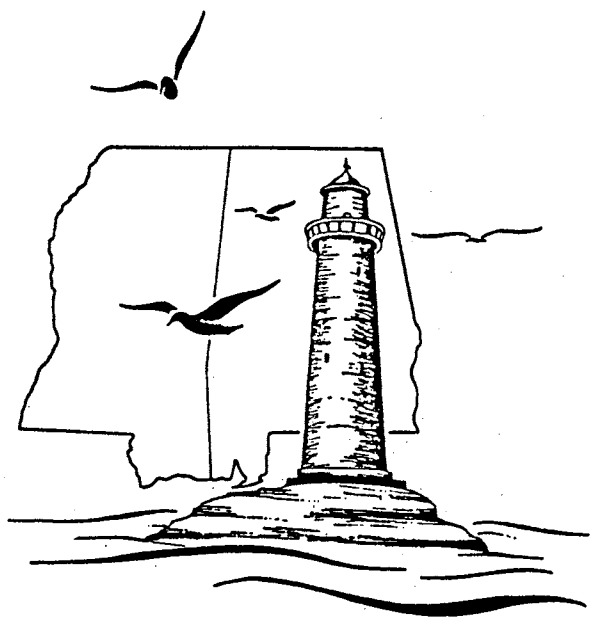
CALORIC VALUES OF MARSH BIOTA

by

Armando A. de la Cruz, Ph.D.
Department of Biological Sciences
Mississippi State University
Mississippi State, Mississippi 39762

Cooperative Funding By:
Mississippi-Alabama Sea Grant Consortium
National Science Foundation
Mississippi Marine Resources Council

JULY 1983



MISSISSIPPI-ALABAMA
SEA GRANT CONSORTIUM

Grant Nos.: 2-35362
04-7-158-44017

MASGP-83-006

This work is a result of research sponsored in part by NOAA, Office of Sea Grant, U.S. Department of Commerce under Grant Nos.: 2-35362 and 04-7-158-44017, and by the National Science Foundation under Grant Nos.: GA-25715 and OCEM 18289-A-01, by the Mississippi Marine Resources Council under Grant No.: GR 76-033, by the Mississippi-Alabama Sea Grant Consortium and the Mississippi State University. The U.S. Government is authorized to produce and distribute reprints for governmental purposes notwithstanding any copyright notation that may appear hereon.

This publication should be cited:

de la Cruz, A.A. 1983. Caloric values of marsh biota. Mississippi-Alabama Sea Grant Consortium Publ. No. MASGP-83-006. Ocean Springs, Mississippi. 32 pp.

CALORIC VALUES OF MARSH BIOTA

by

Armando A. de la Cruz
Department of Biological Sciences
Mississippi State University
P.O. Drawer GY
Mississippi State, MS 39762

Published by Mississippi-Alabama Sea Grant Consortium
Caylor Building
Gulf Coast Research Laboratory
Ocean Springs, Mississippi 39564

July 1983

Acknowledgments

Many graduate students, laboratory assistants, research technicians, and postdoctoral associates have been involved at one time or another in the collection, preparation, and analysis of samples. I thank all of them: Brenda Schumpert-Anderson, Donnie Belk, Kirit Chapatwala, Allen Dearing, Samuel Faulkner, Benjamin Gabriel, Courtney Hackney, Willie Humphrey, Sherrie James, Kuang Yang Lue, Karen McKee, Ratna Mukhopadyay, Syed Naqvi, Eui Park, Un Park, Keith Parsons, Henry Post, Battaiya Rajanna, Ana Maria Ruiz, Yvonne Sasso, Judy Stout, and Emma Wilson.

The following research grants have partially supported the acquisition of data included in this compendium: Grant Nos. 2-35362 and 04-7-158-44017 from the Mississippi-Alabama Sea Grant Consortium (now a SG College), Grant Nos. GA-35715 and OCEM 18289-A-01 from the National Science Foundation, and Grant No. GR 76-033 from the Mississippi Marine Resources Council (now Bureau of Marine Resources).

Introduction

For more than ten years, our continuing study of the trophic ecology of coastal marshes in Mississippi, has included the routine analysis of marsh organisms for caloric content and ash-free dry weight. Some of these data have been useful in converting biomass into standing crop energy. Ash-free calorific values also facilitated the analysis of energy flow at various tropic levels in the marsh ecosystem.

The compilation of this ecological information was initiated primarily to put together in one reference source a few scattered data cited in previous publications and unpublished information that has been accumulated from various research projects. This compilation could be useful to marsh investigators, particularly those who are from Mississippi and the Gulf region, who do not have access to a calorimeter, and who are in need of or who are interested in, estimating energy units from their marsh biomass data.

There are problems associated with calorimetry. Investigators have pointed out those problems associated with measurements (e.g., Cummins et al. 1971) and interpretation (e.g., Verduin 1972) of calorific equivalents. Energy values can be expressed on a per gram wet, dry, or ash-free dry weight basis. Most ecologists are presently concerned with converting biomass data to energy equivalents thus the most useful form of the caloric data is that which conforms to the most frequently employed form of the biomass data (Thayer et al. 1973). In some cases, calorific values in terms of carbon yields more accurate information (Platt and Irwin 1973). The determination of ash-free values in bomb calorimeter versus muffle furnace

has also been questioned (Reiners and Reiners 1971) and precautionary procedures have been suggested (Mook and Hoskin 1982).

The calorie itself has limited nutritional significance and thus other denominators of nutrition, as for example nitrogen or protein, have been suggested (Verduin 1972). Reaction product of nitrogen compounds in the bomb calorimeter is different from the biological reaction product. Since organisms have different nitrogen contents, nitrogen correction for caloric values is also important (Kersting 1972).

Cummins et al. (1971) have noted the differences in calorific equivalents of organisms with regard to sex, season, reproductive condition, life history stage, and nutritional history. Differences also occur in the caloric contents of various body parts of plants (Golley 1961) as well as in the same body parts at different phenological stages (de la Cruz 1975).

To partially accomodate some of the problems associated with calorimetry and calorimetric interpretation, available informations on ash-free dry weight, carbon and nitrogen are included in this compilation. Although there is no intent to show seasonal trends and phenological differences, available data on the major vegetation components of the Mississippi Marsh are presented on the basis of plant parts, life stages, and month of collection.

Methods

All samples were collected from the marsh areas located on the western side of St. Louis Bay in Hancock County, Mississippi. Most of the marsh is in the form of islands separated from the mainland and from each other by bayous and small creeks. Jourdan River, a major river system in the western end of the Mississippi Gulf Coast, empties into the St. Louis Bay after

partially flowing through these marsh islands. The marsh can be characterized as a low salinity, irregularly flooded marsh with a mixed vegetation dominated by the black needlerush Juncus roemerianus Scheele and the giant cordgrass Spartina cynosuroides (L.) Roth.

The general protocol followed in the collection and processing of samples is as follows: Aboveground plant materials were randomly collected from the field by clipping at ground level. In the laboratory the plants were sorted into species; young or mature; live, dying or dead; and/or into plant parts. The samples were routinely dried at 103 C to constant weight except subsamples used for elemental analysis (e.g., carbon and nitrogen) which were dried at 50 C. Belowground plant parts were collected by means of a coring device which was 40 cm long and 10 cm in diameter. Only the upper 20 cm of the core was used for collecting live rhizome and root tissues for analysis. Total belowground materials (live and dead) were also obtained from 0-10 cm and 11-20 cm sections of the core. The cores were washed carefully but thoroughly in running tap water over a sieve (1 mm pore). The washed materials were sorted into rhizome and roots, dead or live tissues, and/or upper or lower 10 cm section. Drying was accomplished similar to the aboveground materials. Decayed plant materials were recovered from decomposition litterbags that had been exposed in situ for 6 months while detritus samples were obtained from plant fragments $\leq$ 2.5 mm that escaped the nylon litter bags and had been allowed to decompose 6-12 months in situ.

Animal samples were collected primarily during the summer months. Except for mullet which were collected with a cast net, all fishes were caught by seine in bayous and tidal creeks. Crab and shrimp specimens were collected also in the seine and by dip net.

Benthic invertebrates were sampled manually from the marsh floor. The flesh of snails and clams were removed from the shell. Whole body of fish and invertebrates were dried at 85 C to constant weight. Subsamples used for carbon and nitrogen analyses were dried at 50 C.

Each of the dried plant and animal samples was mixed well before the samples or a subsample was ground through a Micro Wiley Mill provided with a No. 60 screen. The ground sample was thoroughly mixed again before aliquot samples were taken for the various analysis. Samples for caloric and ash determinations were pressed into 0.75 to 1.00 g pellets. Caloric content was determined by combustion in an automatic Parr Adiabatic Bomb Calorimeter Model 1241 according to the standard procedure described in the Parr Manual (1969).

Percent ash-free dry weight (AFDW) was determined by ignition in a muffle furnace at 550 C for 3-6 hr for plant samples and for 2-4 hr for animal samples. Carbon was analyzed by means of a Coleman C-H Analyzer Model 33 and nitrogen by means of a Coleman N Analyzer Model 29-021. The Coleman analyzers employ essentially high temperature combustion and determines the amount of gaseous element liberated.

In general, caloric, ash-free dry weight, carbon, and nitrogen analyses were done in triplicates. Unless indicated otherwise, values reported in the results are the mean of three determinations. Accuracy was such that the variation among the triplicates was within 2% of the mean. When more than three samples were determined, the number of replicates are indicated and the values are reported as mean $\pm$ 1 standard deviation in the tabulated results. Missing data do not mean zero or omitted values; they simply indicate that no samples were determined.

Results

Caloric content in Kcal g^{-1} and percentages of ash-free dry weight, carbon, and nitrogen for the two dominant marsh plants J. roemerianus and S. cynosuroides are presented on Tables 1-4 and 5-8 respectively.

Monthly and phenological data of aboveground materials of the leafy sedge Scirpus robustus Pursh. are summarized in Tables 9 and 10.

There are four other grasses that are commonly found and which form pure stands in certain areas of the Mississippi Gulf Coast marshes, namely: Spartina alterniflora Loisel, Spartina patens L., Distichlis spicata (L.) Greene, and Phragmites australis. Monthly data for aboveground and belowground materials of these grasses are shown in Tables 11-19.

Previous investigators have listed 34-40 species of plants found in St. Louis Bay marshes (Gabriel and de la Cruz 1974; Hackney and de la Cruz 1982). Some of these plants have also been analyzed for caloric content and AFDW, C, and N values (Table 20).

Tables 21 and 22 summarize the data on fish and selected marsh invertebrates.

References

Cummins, K.W. and J.C. Wuycheck. 1971. Caloric equivalents for investigations in ecological energetics. Mitt. Internat. Verein. Limnol. No. 18. 158 pp.

de la Cruz, A.A. 1975. Proximate nutritive value changes during decomposition of salt marsh plants. Hydrobiologia, 47:475-480.

Gabriel, B.C. and A.A. de la Cruz. 1975. Species composition, standing stock, and net primary production of a salt marsh community in Mississippi. Ches. Sci., 15:72-77.

Golley, F.B. 1961. Energy values of ecological materials. Ecology, 42: 581-584.

Hackney, C.T. and A.A. de la Cruz. 1982. The structure and function of brackish marshes in the North Central Gulf of Mexico: A Ten Year Case STudy. In Wetlands: Ecology and Management, (Gopal, B., R.E. Turner, R.G. Wetzel, and D.F. Whigham, eds.). Intl. Sci. Publ. Jaipur, India. pp. 89-107.

Kersting, K. 1972. A nitrogen correction for caloric values. Limnol. Oceanogr., 17:643-644.

Mook, D.H. and C.M. Hoskin. 1982. Organic determinations by ignition: Caution advised. Estuar. Coastl. Shelf Sci., 15:697-699.

Parr Instrument Company. 1969. Instructions for 1241 and 1242 Adiabatic Calorimeters. Manual No. 142. Moline, IL. pp.

Platt, T. and B. Irwin. 1973. Caloric content of Phytoplankton. Limnol. Oceanogr.; 18:306-310.

Reiners, W.A. and N.M. Reiners. 1972. Comparison of oxygem-bomb combustion with standard ignition techniques for determining total ash. Ecology, 53:132-136.

Thayer, G.W., W.E. Schaaf, J.W. Angelovic, and M.W. LaCroix. 1973. Caloric measurements of some estuarine organisms. Fishery Bull., 71:289-296.

Verduin, J. 1972. Caloric content and available energy in plant matter. Ecology, 53:1.

Table 1. Monthly data on aboveground tissues of *Juncus roemerianus* Scheele.

Month	Caloric Content Kcal gm^{-1}	AFDW* %	Carbon %	Nitrogen %
January	4.35	95.61	46.61	0.74
February	4.63	96.09	46.10	0.72
March	4.50	96.06	44.11	0.59
April	4.41	92.04	44.81	0.70
May	4.44	95.38	45.38	0.67
June	4.48	95.17	44.51	0.63
July	4.41	94.68	44.72	0.70
August	4.42	93.04	45.83	0.81
September	4.59	95.01	44.25	0.86
October	4.38	95.05	45.14	0.99
November	4.60	96.18	45.14	0.96
December	4.48	95.67	45.20	0.98

*Ash-free dry weight

Table 2. Phenological data on J. roemerianus.

Phenological Stage	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Young Leaves	(8)4.10±.09	(8)88.40± .13	-	-
Mature Leaves	(5)4.50±.09	(5)95.62± .32	(11)44.97± .84	0.98
Dying Leaves	(5)4.37±.06	(5)94.19± .24	44.78	-
Dead Leaves	(6)4.36±.08	(11)94.14± .24	42.49	0.67
Partly Decayed	(6)4.35±.10	(8)89.21±3.3	(5)42.20±1.77	(5)0.52±.09
Detritus	(8)3.33±.21	(8)77.77±6.6	(6)36.87±3.01	(6)0.81±.19

*Values in parenthesis are numbers of replicates.

Table 3. Monthly data on belowground live materials of J. roemerianus.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Nitrogen* %
Rhizomes			
January	3.78	86.74	0.88
February	4.04	92.87	0.92
March	4.03	94.01	0.84
April	3.65	92.55	0.88
May	3.93	91.81	0.84
June	3.87	89.73	0.92
July	4.02	92.24	1.05
August	4.18	90.90	1.21
September	4.16	91.91	1.09
October	4.20	92.67	0.84
November	3.92	89.84	1.05
December	-	-	-
Roots			
January	3.52	81.75	0.59
February	3.88	83.03	0.50
March	4.18	88.56	0.55
April	3.43	87.08	0.50
May	3.60	86.62	0.55
June	4.03	87.57	0.59
July	3.85	86.62	0.59
August	4.13	-	0.46
September	-	87.10	0.54
October	4.30	86.04	0.63
November	5.17	89.70	-
December	-	-	-

*Analyzed by micro-Kjeldalh technique.

Table 4. Monthly data on total (live and dead) belowground materials of *J. roemerianus*.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
0-10 cm depth				
January	-	-	-	-
February	4.24	88.02	43.96	0.70
March	4.59	88.58	-	0.55
April	4.26	88.98	42.05	0.55
May	4.45	94.46	43.16	0.55
June	4.21	87.00	40.83	0.51
July	3.96	81.37	40.57	0.50
August	4.06	80.02	41.73	0.50
September	4.13	80.60	39.54	0.52
October	-	-	-	-
November	4.24	85.08	41.99	0.40
December	-	-	-	-
11-20 cm depth				
January	-	-	-	-
February	3.37	87.60	42.63	0.51
March	-	-	-	-
April	4.07	86.05	44.59	0.42
May	4.13	85.12	39.87	0.49
June	4.31	84.00	42.47	0.35
July	4.19	83.16	38.21	0.53
August	4.43	83.93	41.96	0.64
September	4.56	86.88	43.54	0.66
October	-	-	-	-
November	4.37	82.00	41.24	0.66
December	-	-	-	-

Table 5. Monthly data on aboveground tissue of *Spartina cynosuroides* (L.) Roth.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	4.23	92.60	-	-
February	-	-	-	-
March	4.08	-	-	-
April	3.94	86.17	39.79	0.80
May	4.20	91.04	42.35	0.93
June	(8)4.37±0.04	(8)93.81±.07	41.63	0.65
July	(8)4.23± .11	(8)91.95_.21	41.08	0.60
August	(8)4.21± .18	(8)93.78±.22	42.06	0.64
September	4.39	93.78	42.64	0.60
October	4.16	89.85	42.56	0.81
November	4.21	92.66	43.08	0.70
December	4.11	90.00	42.23	0.61

Table 6. Phenological data on S. cynosuroides.

Phenological Stage	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Young Shoots	(6)4.11±.03	(11)88.18±0.32	40.46	-
Mature Shoots	(6)4.31±.09	(11)92.77±1.31	(9)42.03± .93	0.51
Dying Shoots	(11)4.39±.16	-	-	-
Dead Shoots	(10)4.29±.07	(11)92.61± .55	(9)43.48±1.19	0.08
Partly Decayed	(11)3.94±.06	(11)87.35±1.7	41.97	0.27
Detritus	(11)3.27±.17	(11)71.94±1.4	34.70	0.31

Table 7. Monthly data on belowground live materials of S. cynosuroides.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Nitrogen* %
Rhizomes			
January	3.87	87.33	0.67
February	3.83	92.13	0.75
March	4.00	93.62	0.75
April	3.96	89.74	0.75
May	3.49	85.14	0.71
June	-	90.16	0.75
July	4.06	92.50	0.46
August	3.79	86.76	0.50
September	3.75	91.24	0.54
October	3.63	91.69	0.75
November	3.84	89.70	0.67
December	-	-	-
Roots			
January	4.15	87.98	0.67
February	3.91	86.07	0.79
March	4.17	91.52	0.79
April	4.52	91.27	-
May	4.29	88.97	0.67
June	4.19	88.32	0.71
July	3.98	88.24	0.71
August	3.96	88.24	0.71
September	4.07	91.92	0.79
October	-	-	-
November	3.77	84.14	0.58
December	-	-	-

*Analyzed by micro-Kjeldalh technique.

Table 8. Monthly data on total (live and dead) belowground materials of *S. cynosuroides*.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
0-10 cm depth				
January	-	-	-	-
February	3.99	85.27	43.24	0.53
March	-	-	-	-
April	3.92	84.23	40.27	0.73
May	4.00	82.42	39.84	0.48
June	4.08	81.03	34.07	0.41
July	3.66	82.00	37.48	0.49
August	3.76	79.64	33.66	0.43
September	3.26	66.86	37.08	0.50
October	-	-	-	-
November	3.80	81.10	37.98	0.66
December	-	-	-	-
11-20 cm depth				
January	-	-	-	-
February	4.16	88.52	39.31	0.38
March	-	-	-	-
April	4.29	86.00	39.69	0.45
May	3.99	87.05	34.63	0.51
June	4.31	85.58	32.88	0.41
July	3.92	82.52	39.89	0.63
August	3.67	74.35	36.14	0.41
September	4.22	84.49	37.11	0.59
October	-	-	-	-
November	4.26	87.08	38.62	0.57
December	-	-	-	-

Table 9. Monthly data on aboveground tissues of Scirpus robustus Pursh.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	4.13	90.30	-	-
February	-	-	-	-
March	4.05	89.25	-	-
April	3.92	90.68	38.98	1.16
May	4.01	90.33	40.01	0.98
June	3.99	90.32	43.20	1.10
July	4.13	90.61	39.07	0.69
August	4.16	91.29	39.31	0.84
September	4.13	-	41.90	1.15
October	3.74	90.80	-	-
November	4.17	91.58	42.31	0.91
December	-	-	-	-

Table 10. Phenological data on S. robustus Pursh.

Phenological Stage	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Young Shoots	(7)3.93±.05	(7)87.56± .16	37.81	-
Mature Shoots	(7)4.23±.10	(7)91.54±1.15	40.53	1.12
Dead Shoots	(6)3.92±.06	(6)88.09± .32	40.83	0.57
Partly Decayed	(6)4.27±.04	(6)92.31± .21	41.55	0.22
Detritus	(6)3.24±.07	(6)69.44±1.23	35.22	0.62
Roots	3.87	87.85	-	-
Stems	4.05	91.66	-	-
Leaves	4.14	91.17	-	-

Table 11. Monthly data on aboveground tissues of Spartina alterniflora Loisel.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	-	-	-	-
February	3.93	86.05	41.62	0.77
March	3.50	-	-	-
April	-	86.62	39.97	0.55
May	3.99	85.95	38.96	0.59
June	4.49	91.35	39.23	0.55
July	4.22	90.93	39.90	0.53
August	4.39	94.04	40.45	0.60
September	3.91	91.35	40.62	0.53
October	4.24	91.88	42.34	0.66
November	4.12	91.99	40.23	0.56
December	4.25	-	-	-

Table 12. Monthly data on total (live and dead) belowground materials of *S. alterniflora*.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
0-10 cm depth				
January	-	-	-	-
February	4.31	87.60	-	-
March	-	-	-	-
April	3.68	71.56	38.42	0.61
May	4.06	82.98	38.68	0.68
June	4.21	80.00	40.33	0.80
July	3.94	76.30	39.71	0.78
August	-	-	-	-
September	3.95	81.11	38.80	0.67
October	-	-	-	-
November	3.96	76.92	38.26	0.70
December	-	-	-	-
11-20 cm depth				
January	-	-	-	-
February	3.36	60.91	-	-
March	-	-	-	-
April	3.59	62.29	37.98	0.69
May	3.48	60.80	31.35	0.70
June	4.11	77.76	35.69	0.67
July	4.24	75.00	43.42	0.61
August	-	-	-	-
September	4.28	75.41	40.20	0.70
October	-	-	-	-
November	4.31	63.86	39.00	0.68
December	-	-	-	-

Table 13. Monthly data on aboveground tissues of Spartina patens L.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	4.42	94.36	45.66	0.59
February	4.50	95.24	45.93	0.51
March	4.61	95.23	44.09	0.36
April	4.48	95.67	45.12	0.33
May	4.56	96.25	45.21	0.57
June	4.44	96.08	46.21	0.24
July	-	-	4.18	0.50
August	4.47	94.96	44.59	0.58
September	4.56	95.75	44.47	0.57
October	4.57	96.80	45.51	0.50
November	4.52	95.79	45.03	0.56
December	4.44	96.48	45.37	0.59

Table 14. Monthly data on total (live and dead) belowground materials of *S. patens*.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
0-10 cm depth				
January	-	-	-	-
February	4.40	94.59	-	-
March	-	-	-	-
April	3.95	80.42	41.78	0.52
May	4.12	89.50	42.22	0.58
June	4.09	87.31	40.55	0.46
July	3.84	81.61	41.22	0.53
August	3.70	80.69	44.55	0.47
September	3.85	80.00	40.38	0.56
October	-	-	-	-
November	3.79	80.59	41.78	0.52
December	-	-	-	-
11-20 cm depth				
January	-	-	-	-
February	4.19	85.56	-	-
March	-	-	-	-
April	4.16	88.75	44.64	0.31
May	4.42	91.12	41.99	0.36
June	4.40	92.30	44.81	0.43
July	4.19	85.99	43.77	0.55
August	4.08	84.65	45.42	0.52
September	4.15	85.45	40.89	0.48
October	-	-	-	-
November	4.20	86.00	43.53	0.41
December	-	-	-	-

Table 15. Monthly data on aboveground tissues of Distichlis spicata (L.) Greene.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	-	-	-	-
February	4.39	92.22	45.61	0.94
March	-	-	-	-
April	4.37	92.30	42.60	0.54
May	4.20	92.57	41.90	0.65
June	4.19	95.03	43.06	0.56
July	4.31	92.78	42.63	0.58
August	4.48	94.68	43.60	0.63
September	4.34	91.80	41.90	0.53
October	-	-	-	-
November	4.39	92.23	42.17	0.57
December	4.26	-	-	-

Table 16. Phenological data on D. spicata (L.) Greene.

Phenological Stage	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Young Shoots	(9)4.06±.19	(9)86.66± .19	43.40	-
Mature Shoots	(6)4.64±.17	(6)95.01±1.64	42.50	0.78
Dying Shoots	(4)4.49±.11	-	-	-
Dead Shoots	(6)4.23±.06	(6)93.25± .25	42.51	0.51
Partly Decayed	(6)4.24±.06	(6)89.91± .88	42.60	0.55
Detritus	(5)3.03±.02	(5)63.21±2.13	32.40	0.55

Table 17. Monthly data on total (live and dead) belowground materials of *D. spicata*.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
0-10 cm depth				
January	-	-	-	-
February	2.91	60.00	39.05	0.47
March	-	-	-	-
April	2.90	58.96	37.05	0.51
May	3.20	65.00	35.60	0.50
June	3.51	75.55	31.52	0.36
July	3.47	74.09	35.61	0.49
August	3.48	71.48	-	-
September	3.36	86.13	41.73	0.85
October	3.80	80.68	37.70	0.86
November	3.58	76.21	35.39	0.46
December	-	-	-	-
11-20 cm depth				
January	-	-	-	-
February	-	77.30	-	-
March	-	-	-	-
April	-	-	-	-
May	2.85	60.00	-	-
June	2.40	50.77	18.61	0.46
July	2.42	54.96	26.06	0.40
August	1.85	43.40	-	-
September	2.21	67.15	35.38	-
October	-	-	-	-
November	2.61	44.53	35.67	-
December	-	-	-	-

Table 18. Monthly data on aboveground tissues of Phragmites australis.

Month	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
January	-	-	-	-
February	-	-	-	-
March	-	-	-	-
April	3.93	86.87	41.29	1.73
May	4.37	92.50	41.20	1.03
June	4.37	91.69	42.45	1.12
July	4.20	90.92	-	1.21
August	4.40	94.14	43.26	1.02
September	4.27	90.89	42.07	1.35
October	4.36	94.29	43.59	0.74
November	4.30	91.18	41.75	0.88
December	-	-	-	-

Table 19. Phenological data on Phragmites australis.

Phenological Stage	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Young Shoots	3.77	91.77	37.79	1.32
Mature Shoots	4.32	(7)91.66±1.30	(7)42.23± .93	(7)1.19±.28
Dead Shoots	4.54	(9)94.96±2.07	(7)43.47±1.08	(7)0.44±.12
Partly Decayed	4.13	87.12	39.79	0.70
Detritus	3.88	80.10	37.67	1.22
Belowground	3.82	(8)80.25±4.00	(9)37.20±1.65	(8)0.60±.10

Table 20. Summary of data on other marsh plants.

Family Names Plant Parts	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Asteraceae:				
Boltonia sp.				
Saltmarsh Boltonia				
Leaves	4.06	85.19	40.31	2.85
Stems	3.66	85.41	36.97	0.71
Roots	3.49	78.55	34.82	1.10
Baccharis halimifolia				
Sea Myrtle				
Leaves	5.18	90.97	46.28	1.03
Stems	4.67	94.06	44.93	0.64
Roots	4.48	93.11	42.25	0.19
Iva frutescens L.				
March Elder				
Leaves	4.04	82.35	36.50	1.89
Stems	4.21	92.20	40.79	0.96
Amaryllidaceae:				
Crinum americanum L.				
Southern Swamp Lily				
Shoots	3.20	76.49	30.33	2.00
Roots	3.28	70.19	33.63	1.61
Iridaceae:				
Iris virginica L.				
Southern Blue Flat or Louisiana Iris				
Shoots	3.91	90.67	38.54	0.91
Roots	3.14	69.89	32.00	0.87
Apiaceae:				
Lilaeopsis chinensis (L.) (Kuntze)				
Long-stemmed Mud Lily				
Whole Plant	2.62	57.24	27.01	1.47
Lythraceae:				
Lythrum lineare L.				
Loosestrife				
Leaves	4.09	91.95	42.32	2.10
Stems	4.12	95.36	41.36	0.60
Roots	3.41	77.98	34.27	0.85
Pontederiaceae:				
Pontederia cordata				
Pickerelweed				
Leaves	4.33	89.17	43.14	2.88
Stems	3.43	82.37	38.10	1.72
Roots	2.41	60.46	28.28	0.81

Polygonaceae:				
Polygonum punctatum				
Knotweed or Smartweed				
Leaves	4.48	92.53	43.39	2.53
Stems	3.89	93.01	40.69	1.03
Roots	2.34	59.48	28.08	0.46
Malvaceae:				
Hibiscus moscheutos				
Marsh Mallow				
Leaves	4.69	91.05	44.03	1.44
Stems	4.09	91.51	41.04	0.69
Roots	3.76	89.31	36.47	0.98
Flowers	4.14	93.73	41.75	0.71
Aeschynomone virginica				
Leaves	4.74	93.55	44.17	5.35
Stems	4.06	42.59	41.14	2.09
Roots	2.70	61.34	27.23	1.07
Alismataceae:				
Sagittaria graminea				
Duck Potato				
Shoots	3.63	83.42	36.12	1.77
Roots	3.43	74.35	34.43	1.10
Sagittaria lancifolia				
Arrowhead				
Shoots	(8)3.95±.22	(8)87.38±3.95	35.58	2.02
Roots	3.48	78.68	36.33	1.40
Cyperaceae:				
Scirpus validus Vahl.				
Moses or Giant Bulrush				
Whole Plant	3.85	87.95	-	-
Eleocharis olivacea				
Spike Rush				
Whole Plant	3.60	66.76	32.71	1.28
Cladium jamaicense				
Cut Grass or Saw Grass				
Shoots	(8)4.15±.05	(8)95.44±0.37	43.55	0.82
Roots	3.70	77.69	33.31	0.76
Scirpus americanus Persoon				
Bulrush				
Whole Plant	(5)4.20±.09	(5)91.24±1.09	41.48±1	-
Scirpus olneyi Gray				
Three-square Sedge				
Whole Plant	4.18	90.53	40.96	-
Belowground	(4)4..71±.09	(4)91.44± .37		

Poaceae:				
Echinochloa crusgalli Wild Millet or Barnyard Grass				
Leaves	3.71	85.80	37.78	1.13
Stems	3.65	83.01	42.65	0.70
Roots	3.73	84.74	36.43	0.44
Flowers	4.37	93.04	35.26	1.59
Panicum virgatum L. Switch Grass				
Leaves	(6)4.40±.05	(6)93.11±1.9	42.73	2.05
Stems	4.19	95.41	41.84	0.43
Roots	3.77	86.70	38.33	0.47
Phragmites australis Roseau Cane or Common Reed				
Leaves	(8)4.16±.11	(8)91.35±1.25	41.97	2.03
Stems	4.15	92.14	41.77	1.37
Roots	3.45	81.06	34.86	1.00
Spartina alterniflora Loisel				
Tall form, whole plant	(5)4.12±.07	(5)88.18±.39	-	-
Short form, whole plant	(5)3.70±.01	(5)82.01±.56	-	-
Medium form				
Leaves	4.04	89.19	40.41	1.19
Stems	4.19	91.10	39.65	0.90
Roots	3.60	79.71	35.27	0.62
Spartina patens (Aiton) Muhl. Saltmeadow Cordgrass				
Shoots	(8)4.35±.08	(8)93.88±1.72	43.31	0.47
Rhizomes	4.40	91.44	-	0.69
Roots	3.81	81.98	36.73	0.62

Table 21. Summary of data on common estuarine-marsh fishes.

Classification; Scientific Name	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Gulf menhaden				
Brevoortia patronus (Goode)	4.64	67.40	32.47	9.44
Gulf killifish				
Fundulus grandis Baird and Girard	4.04	74.74	33.61	10.78
Saltmarsh topminnow				
Fundulus jenkinsi (Evermann)	4.29	77.35	38.85	9.50
Largemouth bass				
Micropterus salmoides (Lacépède)				
Young	4.69	84.00	-	-
Adult	4.49	78.47	-	-
Spotted seatrout				
Cynoscion nebulosus (Cuvier)				
Young	4.37	79.57	36.28	11.54
Adult	4.51	89.79	37.15	7.00
Striped mullet				
Mugil cephalus Linneaus				
Juvenile	4.12	76.13	36.83	9.38
Young	4.12	76.69	36.87	10.75
Adult	3.79	66.01	-	-
Atlantic croaker				
Micropogon undulatus (Linneaus)	4.45	80.03	-	-
Redear Sunfish				
Lepomis microlophus (Gunther)	4.84	81.71	-	-
Spot				
Leiostomus xanthurus	4.62	82.40	-	-
Warmouth				
Lepomis gulosus (Cuvier)	4.79	82.85	42.45	9.53
Silverperch				
Bairdiella chrysura (Lacépède)	4.04	72.88	35.04	10.75

Table 22. Summary of data on common marsh invertebrates.

Classification; Scientific Names	Caloric Content Kcal gm^{-1}	AFDW %	Carbon %	Nitrogen %
Marsh periwinkle *Littorina irrorata* (Say)	4.14	78.23	40.41	8.99
Eastern melampus *Melampus bidentatus* (Say)	4.35	71.20	-	-
Ribbed mussel *Geukensia demissa* (Dillwyn)	5.41	89.12	-	-
Carolina marsh clam *Polymesoda caroliniana* (Bosch)	4.84	-	-	-
Marsh grass shrimp *Palaemonetes pugio* (Holthuis)	4.40	82.01	39.60	7.29
Commercial brown shrimp *Penaeus setiferus*	4.67	60.70	-	-
Harris's mud crab *Rhithropanopes harrissii* (Gould)	2.41*	49.85	-	-
Gulf mud fiddler *Uca longisignalis* Salmon	2.74*	56.85	25.15	4.35
Blue crab *Callinectes sapidus* Rathbun				
(Young)	2.59*	54.74	26.17	4.35
(Adult)	3.20	63.41	32.42	5.92

*Low caloric value was due to inclusion of chitinous exoskeleton in whole body analysis.