APPENDIX

Table of Contents

Additional Details of Energy Calculations

Crab Carapace Width - To estimate the energy content of sargassum swimming crabs captured by grackles in this study, I first had to estimate the sizes of the crabs. This was accomplished by comparing the width of the crab carapace (CWp) with the length of the grackle beak (GBp) in photographs where both crab carapace and beak were sub-parallel to the camera sensor. The width of the crab carapace (W) was then determined by multiplying the carapace width in the photo (CWp) / beak length in the photo (GBp) times the average beak length of female Great-tailed Grackles (GBavg = 22 mm; Johnson and Peer, 2022).

Crab Wet Mass - Next, I had to estimate the mass of the observed sargassum swimming crabs. Only limited paired data are available for the size and mass of sargassum swimming crabs (West and Brooks, 2018), so I supplemented the published data with unpublished measurements from a nearby study (V. Monroy Velazquez, pers. commun.). I then determined the width-mass constant (a) and exponent (b) of the power-law relationship by regression. Finally, I estimated the wet masses (m[W]) of the observed crabs using the estimated carapace width (W) and the power law relationship (m[W] = a * W^b).

Energy Content of Sargassum Swimming Crabs – The effective digestible energy of sargassum swimming crabs is unknown but can be estimated using data for a blue crab proximate. The fraction of blue crab that is tissue (Ft) depends in part on growth stage and is estimated to range from 0.15-0.5 (Fuso et al., 2025). Based on studies of passerine, poultry, and seabirds, I estimated the digestibility of tissue (DT) to range from 0.5-1.0 (Potter et al., 1962; Twedt, 1985). Analyses of the energy density of tissue (EDt) of blue crab indicate a range from 3.5-4.2 $kJ \cdot g^{-1}$ wet (USDA 2026 nutrient data, NDB 100330). The digestibility of shell (DS) is estimated to range from 0-0.5 based studies of seabirds (Jackson et al., 1992; Barrett et al., 2007). Although it is unknown whether Great-tailed Grackle can extract the energy content of the crab hard parts, I nonetheless estimated the energy content of the shell to assess its potential impact on the energy calculations. Using protein (Ps), lipid (Lw), and chitin (Cw) fractions of a blue crab proximate (Fuso et el., 2025), and Atwater factors (Afp, Afl, Afch, respectively) for each of these components (FAO Food and Nutrition Paper 77 (2003), I calculated the energy density of shell (EDs = Afp * Pw + Afl * Lw + Afch * Cw * DFch). The digestibility of chitin is adjustable in the model (DFch) but assumed to be near zero for icterids. Finally, I estimated the effective digestible energy (K) using the following: K = Ft * DT * EDt + (1-Ft) * DS * Eds.

Energy Cost per Successful Forage – The average female Great-tailed Grackles has a mass (m) ~130 g (Johnson and Peer 2022), with an estimated basal metabolic rate (BMR = 10^(-1.521 + 0.705 * LOG10(m))) of ~0.93 W (Lasiewski and Dawson 1967, McKechnie and Wolf 2004). Using data from passerine scaling studies (Bishop 1999, Ward et al. 2001), I assume an average flight multiplier (k = 13) to estimate the energetic costs of forward flight and hovering (k x BMR). Based on an average mass of 203 g (Johnson and Peer, 2022), male grackles are estimated to have a BMR of 1.39 W. I then used the observed average foraging time per success (t - 21.5 s) to estimate the energetic cost of foraging flight (Ecost = k * BMR * t).

Net Energy Cost per Successful Forage – Finally, the net energy gain of a successful forage (Net(W)) can be estimated from the mass of the sargassum swimming crab prey, the effective digestible energy density of the crab, and the energy cost of foraging flight (Net(W) = m(W) * K - Ecost). The model permits adjustment of many of parameters (e.g., crab size, tissue weight fraction, fraction of digestible tissue, fraction of digestible shell, average foraging time, flight multiplier, etc.) to evaluate their sensitivity of the model to each.

Table A.1. List of dates, start times, durations of observation sessions, and ID numbers of eBird checklists from each session. Photographs from observation sessions can be accessed from the Macaulay Library using the checklist IDs (e.g., *https://ebird.org/checklist/S115695958*).

Date	Start Time (EST)	Duration	eBird Checklist IDs
24-Jul-22	07:45	109	S115695958
30-Jul-22	12:18	47	S116029317
30-Jul-22	14:00	59	S116036332
31-Jul-22	08:43	17	S116080044
31-Jul-22	11:02	61	S116101765
31-Jul-22	12:48	30	S116101759
01-Aug-22	09:57	30	S116155204
01-Aug-22	19:04	27	S116216594
02-Aug-22	11:44	34	S116241287
02-Aug-22	19:10	13	S116242713
04-Aug-22	06:20	50	S116346192
05-Aug-22	07:40	51	S116378528
05-Aug-22	11:09	10	S116377158
05-Aug-22	18:40	40	S116399909
06-Aug-22	08:26	40	S116428155
06-Aug-22	18:33	38	S116460502
08-Aug-22	19:04	30	S116638895
10-Aug-22	08:28	60	S116669909
11-Aug-22	08:01	30	S116719661
11-Aug-22	09:28	33	S116719654
14-Aug-22	07:52	40	S116903882
14-Aug-22	10:45	46	S117036899
15-Aug-22	18:39	15	S117036909
17-Aug-22	15:04	65	S117113846
19-Aug-22	18:55	17	S117236168
21-Aug-22	08:57	74	S117332724
21-Aug-22	19:10	10	S117410208
22-Aug-22	18:48	37	S117415507

Table A.2. Parameters and equations used for energy calculations.

Symbol	Parameter	Value / Range	Units	Source
E1. Width of Crabs from Photos; this study				
W = CWp / GBp x GBavg				
CWp	Carapace width in photo	*measured*	*mm*	Measured from photographs; this study
GBp	Grackle Beak Length in photo	*measured*	*mm*	Measured from photographs; this study
GBavg	Beak Length of Female Grackle	22	mm	Johnson and Peer (2022)
W	Crab carapace width	-	mm	derived, this study
E2. Crab Mass from Width & Regression Parameters				
m(W) = a * W^b *(used first with paired P. sayi length & weight data to determine a & b; then used to solve for wet mass of P. sayi this study)*				
W	Carapace width	6-39	mm	West & Brooks (2018); V. Monroy Velazquez, pers. communication
a	Width-mass constant	0.00059	-	regression, this study
b	Width-mass exponent	2.428	-	regression, this study
m(W)	Crab wet mass	0.05-4.3	g	calculated from width estimates from photographs using regression values derived from publ. width and mass pairs
E3. Energy Density of Crab Shell				
EDs = 17 * Pw + 37 * Lw + 17 * Cw * DFch				
Pw	Protein fraction (wet)	0.0733	$g \cdot g^{-1}$	Blue crab proximate composition; Fuso et al. (2025)
Lw	Lipid fraction (wet)	0.015	$g \cdot g^{-1}$	Blue crab proximate composition; Fuso et al. (2025)
Cw	Chitin fraction (wet)	0.1075	$g \cdot g^{-1}$	Blue crab proximate composition; Fuso et al. (2025)
DFch	Digestibility of chitin	0-1	–	Adjustable; assumed near zero for icterids
Afp	Atwater factor for protein (kJg)	17	-	FAO Food & Nutrition Paper 77 (2003)
Afl	Atwater factor for lipids (kJg)	37	-	FAO Food & Nutrition Paper 77 (2003)
Afch	Atwater factor for chitin (kJg)	17	-	FAO Food & Nutrition Paper 77 (2003)
EDs	Energy Density of crab shell	-	$kJ \cdot g^{-1}$ wet	Derived from proximate analyses

E4. Energy Density of Whole Crab				
K = Ft * DT * EDt + (1-Ft) * DS * EDs				
Ft	Tissue fraction of whole crab	0.15–0.50	–	Anatomy estimates & from Blue Crab proximate; Fuso et al. (2025)
DT	Digestibility of Tissue	0.5–1.0	–	Passerine/poultry/seabird studies; Potter et al. (1962; Twedt (1985)
EDt	Energy Density of tissue	3.5-4.2	$kJ \cdot g^{-1}$ wet	USDA 2026 nutrient data, NDB 100330
DS	Digestibility of Shell	0–0.5	–	Seabird studies; Jackson et al. (1992); Barrett et al. (2007)
EDs	Energy Density of shell	~0.6–1.8	$kJ \cdot g^{-1}$ wet	As above; protein and lipid only (excl. chitin)
K	Effective digestible energy	*derived*	$J \cdot g^{-1}$	From E4
E5. Energy Cost per Successful Forage				
BMR = 10^(-1.521 + 0.705 * LOG10(m))				Lasiewski & Dawson (1967); Bennet and Harvey (1987); McKechnie & Wolf (2004)
Ecost = k * BMR * t				
m	Body mass	130-230	g	Johnson & Peer 2022; Female avg = 130 g, Male avg = 230 g
BMR	Basal metabolic rate	*derived*	W	From E5; Female = 0.93, Male = 1.39
k	Flight multiplier	~13	–	11-16x from Ward et al. (2001) and Bishop (1999)
t	Foraging time per success	21.5	s	This study; total foraging time / no. successful forages
Ecost	Flight energy cost	*derived*	J	this study; Female = 260, Male = 389
E6. Net Energy per Successful Forage				
Net(W) = m(W) * K - Ecost				
m(W)	Crab wet mass	From E2	g	From E2
K	Effective digestible energy density	From E4	$J \cdot g^{-1}$	From E4
Ecost	Flight cost per capture	From E5	J	From E5; Female = 251, Male = 368
Net(W)	Net energy gain	*derived*	J	From E6

Figure A.1. Plot of number of Great-tailed Grackle foraging events (per hour) over floating sargassum during the period of observation (07 July – 21 August). Days without any recorded foraging events indicate a lack of sargassum because grackles generally forage whenever sargassum is present and suitable for foraging.

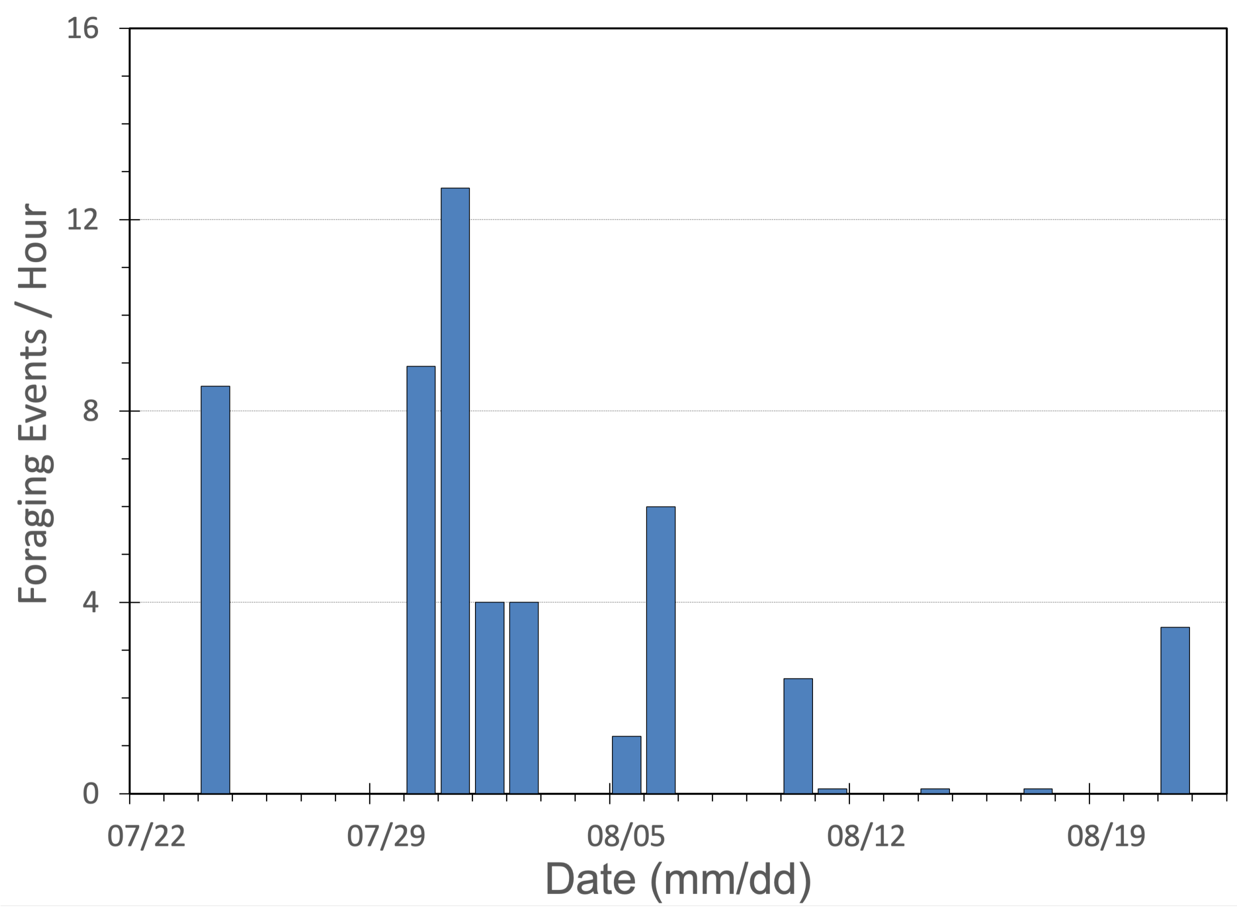
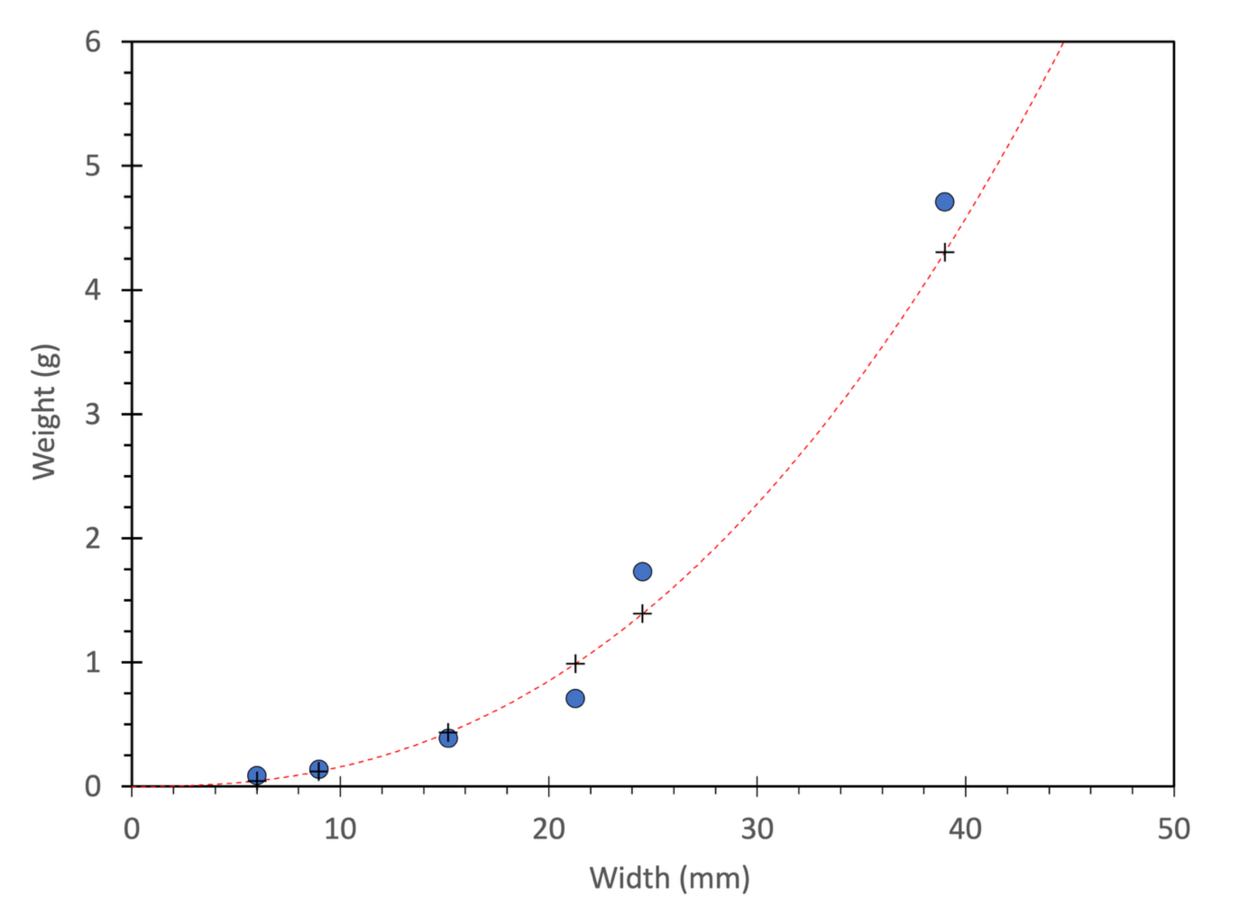


Figure A.2. Crab Width and weight data (filled blue circles) for sargassum swimming crabs from the literature (West and Brooks, 2018) and from V. Monroy Velazquez (unpublished data, 2025). The relationship between crab weight and carapace width is modeled as a power law function (red dashed line). Modeled weights of measured crabs are indicated with plus ('+') symbols.



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