Proc. Estonian Acad. Sci. Biol. Ecol., 2007, **56**, 4, 278–289

https://doi.org/10.3176/eco.2007.4.05

Annual biomass loss of the loose-lying red algal community via macroalgal beach casts in the Väinameri area, NE Baltic Sea

Priit Kersen[a,b*] and Georg Martin[a]

[a] Estonian Marine Institute, University of Tartu, Mäealuse 10a, 12618 Tallinn, Estonia
[b] Department of Natural Sciences, Tallinn University, Narva mnt. 25, 10120 Tallinn, Estonia

Received 3 January 2007, in revised form 21 September 2007

Abstract. A unique, commercially exploited loose-lying red algal community in the Baltic Sea is situated in Kassari Bay, the Väinameri area (NE Baltic Sea). These macroalgae have been harvested since the 1960s, and continuous monitoring of biological characteristics of the community has been carried out to enable sustainable exploitation of this marine living resource. In this study the losses of the red algal community through beach casts were calculated from the estimates of the amounts of marine wrack on the NE shores of Saaremaa Island from April to November 2002. The community loss through beach casts was estimated at ~5000 tonnes wet weight per year. These annual losses via wrack deposition represent ~3% of the community standing stock in summer. Commercial exploitation in the form of bottom trawling of the loose algal community made up only 20% of the losses due to beach casts.

Key words: Kassari Bay, storm cast, *Furcellaria lumbricalis*, *Coccotylus truncatus*, loose-lying algal community, wrack deposition, commercial seaweed.

INTRODUCTION

The sea area of the West Estonian Archipelago (Väinameri) hosts the largest known mixed community of loose-lying *Furcellaria lumbricalis* (Huds.) Lamour and *Coccotylus truncatus* (Pall.) Wynne & Heine. The community covers up to 120 km^2 of sea bottom and forms more than 140 000 tonnes of biomass in Kassari Bay (Martin et al., 2006a). In this area the circular current and bottom morphology are preventing the community from drifting away, and promote the development

* Corresponding author, pkersen@ut.ee

of a specific drifting form of algal community (Martin et al., 1996). Commercial importance of the red alga *F. lumbricalis* is due to polysaccharides technologically extracted from the thallus (Bird et al., 1991; Truus et al., 1996; Tuvikene et al., 2006). The industrial exploitation of the community started in Saaremaa Island in 1966 (Kersen, 2005). The state of the drifting algal community has been monitored since the beginning of its industrial exploitation but investigations explaining the biomass formation and community fluctuation were initiated only recently. Nowadays a similar community is found only on the western coast of Canada (McLachlan et al., 1987; Sharp et al., 1993).

Previously, the marine wrack in the Väinameri area was studied by Trei (1965, 1968). More recent studies on the shores of Saaremaa Island were made in 1976–1985 (Kukk & Rosenberg, 1985; Martin et al., 1996). In these investigations wrack was described for industrial purposes. In the 1980s also aero-observations over Kassari Bay were made in order to discover new wracks deposited immediately on shores after storm events (H. Kukk, pers. comm.). However, these studies do not provide any quantitative information on the accumulation of wrack.

The present investigation was prompted by lack of relevant information about algal biomass losses by natural processes. The aims of this study are (1) to describe the wrack accumulation patterns and taxonomic composition, (2) to assess annual losses of the loose-lying macroalgal community through casts ashore, and (3) to compare these amounts with the commercially harvested biomass of the community.

MATERIAL AND METHODS

Study area

Kassari Bay (also Hiiu Strait) extends for more than 600 km^2 (Mardiste, 1974) and is relatively isolated from the Baltic Proper and other regions of the Väinameri (the inner sea of the West Estonian Archipelago). According to the archive of the Estonian Hydrological and Meteorological Institute (EMHI) for winters 1970/1971–2004/2005, ice cover lasts on average 100 days in Kassari Bay. Salinity is typically between 6.0 and 6.7 (Suursaar et al., 2000, 2001).

Based on Virtsu station data, there is a strong seasonality wind pattern on the West Estonian coast (Kull, 1999), where SW winds are prevailing. The annual average wind speed is up to 6–7 m s^{-1} in the Väinameri, but is higher in autumn and winter.

Two shore types dominate: till shore and gravel–pebble shore (Orviku, 1993). The bottom of the bay is relatively flat (Mardiste, 1970) as the 5 m isobath lies at 0.5–1 km from the studied shore sites in the NE of Saaremaa Island. Less than half of the sea area is under 5 m deep.

Circular currents and hollow bottom topography with prevailing depths of 7–10 m prevent the unattached red algae community from drifting the region. The community is found at the depth range of 5–9 m mainly on clay and sand bottoms.

Fieldwork

Data for the present study were collected at three sampling sites on the NE coast of Saaremaa Island from 21 April to 5 October 2002 (Fig. 1). These three sites were selected because they are adjacent to the 5 m isobath and considering also the historical aspect of wrack collection. The sites were visited monthly (seven times in all) during the ice-free season. In each study site three replicate shore sections were studied. The length of the sections ranged from 49 to 67 m. These replicate sections coincided with the location where visual observations were performed. The visual observations of the wrack were made to clarify whether new macroalgae have accumulated on the shore. In the case of fresh wrack (herein defined as stranded below driftline, *sensu* Orr et al., 2005) was present, algae were described (spatial distribution and macroscopic taxonomic composition) and measured (length, width, and thickness of the wrack ridge). Biomass samples were taken only when the unattached form of *F. lumbricalis* was found.

One sample was randomly taken within each replicate section (quadrate frame, 20 × 20 cm, $n = 32$). Thickness of each biomass sample was measured. The collected flora was packed, labelled, and then deep-frozen at −18 °C.

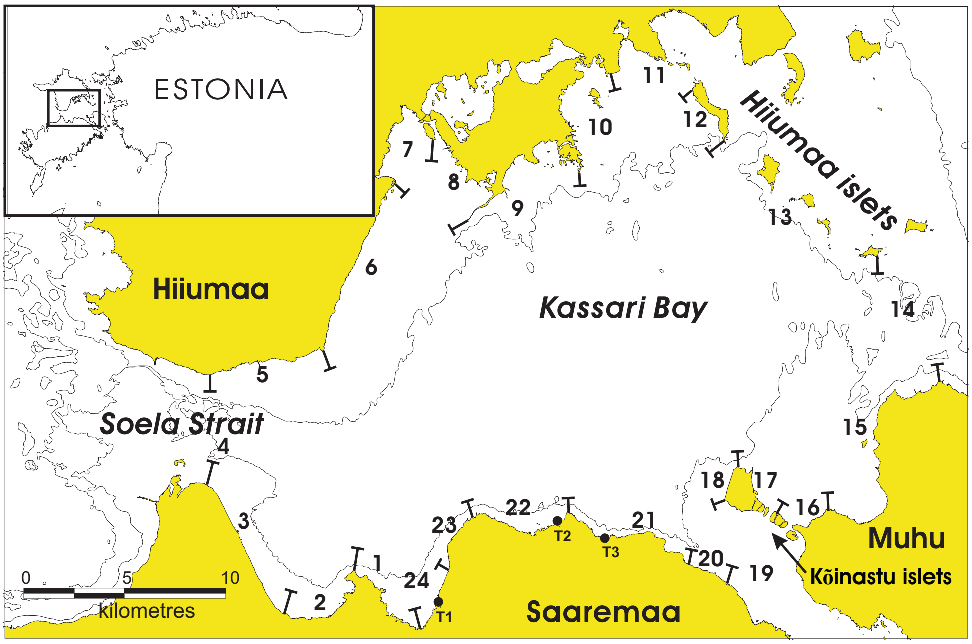

Fig. 1. Location of the study area. Study sites are indicated by filled circles (T1, T2, and T3). Bright fine lines mark the 5 m isobaths. T-shaped sticks indicate the borders of 24 shore sections (marked by numbers) of the Kassari Bay area.

Laboratory analyses

Three floristic components were separated for biomass determination: *F. lumbricalis*, *C. truncatus*, and other macrophytes. Other taxa in the samples were determined only qualitatively. Determination was made according to the keys of Trei (1991) and Leht (1999). The species list of macrophytobenthos followed the nomenclature presented in Nielsen et al. (1995). Specimens were dried at 60 °C for two weeks until constant dry weights (accuracy ±0.1 mg). The dry mass to volume ratio of the red algae *F. lumbricalis* and *C. truncatus* in the sampling frame (i.e. sample density) was used to calculate the biomass of the shore casts (g $m^{-1}_{shoreline}$). The volume of algal species was determined by multiplying the sample surface area by the sample height. As the intervals between observations were unequal the biomasses were divided by the number of days between data collection.

Data analyses

Wind data of Virtsu station (28.02.2002–08.12.2002) by EMHI were used. Wind velocities from favourable wind directions (according to shore site exposure azimuth) for each study site were selected. Significant wind velocity was defined as moderate and strong wind (≥5 m s^{-1}) when wind induces sufficient wave driven and near-bottom currents for algal redeposition (detailed wind–currents interactions see Raudsepp & Kõuts, 2001; Suursaar et al., 2001).

Shoreline bounding Kassari Bay (Fig. 1) was divided into 24 sections, wherein the average distances between the 5 m isobath and each section were measured. Several sections were located at Soela Strait, Hiiumaa islets, and Muhu Island and around Kõinastu islets (Fig. 1). The length of the shoreline was measured with a step of 500 m at the chart (Estonian Maritime Administration, 2001).

Stepwise linear regression analysis was used to describe the functional relationship between wrack accumulation, sum of significant wind velocities, distance of the 5 m isobath, and wave exposure (StatSoft Inc., 2006). The wave exposure for each site was calculated by measuring the radius (in degrees) of the site exposure to the sea using a nautical chart at a 1 : 50 000 scale (Wenberg & Thomsen, 2005). Data are presented in Table 1. Prior to analysis some variables were squared because of the occurrence of polynomial relations and/or multiplied if interactions were expected.

Based on the obtained regression equations the wrack accumulation of *F. lumbricalis* and *C. truncatus* for each period between sampling (6 in total) and shore section (24 in total) were calculated. Using spatial extrapolation, the dry weights of beach-cast macroalgae for each section were calculated by multiplying the wrack biomass (g $m^{-1}_{shoreline}$) by the length of the specific section (m). Total wrack biomass accumulated during the study period was obtained when the values of dry weights were summed and transformed to wet weight (by ratio of 1 : 5; according to our measurements and analogously to Greenwell et al., 1984). The same calculation procedures were applied for ante- and post-observation ice-free wrack accumulation periods (i.e. 28.02–21.04 and 06.11–08.12).

Table 1. Variables used in regression analysis to calculate wrack accumulation over the whole Kassari Bay area

Period	Site	* Avg. significant wind velocity, m s^{-1}	* Sum of significant wind velocities	* Avg. wind velocity, m s^{-1}	Distance of 5 m isobath, km	Wave exposure, deg	*F. lumbricalis* BM, g m^{-1}, dry	*C. truncatus* BM, g m^{-1}, dry
28.02–21.04	T1	6.3	146.0	3.8	1.6	52.0	1 133.9	0.0
	T2	6.1	207.0	3.8	0.7	127.0	891.4	18.9
	T3	6.1	190.0	3.9	0.5	94.0	36 775.1	26 944.0
22.04–23.05	T1	7.2	137.0	4.7	1.6	52.0	795.8	0.0
	T2	7.2	137.0	4.4	0.7	127.0	0.0	0.0
	T3	7.3	132.0	4.6	0.5	94.0	8.7	6.9
24.05–21.06	T1	6.0	127.0	3.9	1.6	52.0	634.0	12.0
	T2	6.0	132.0	3.7	0.7	127.0	0.0	0.0
	T3	6.1	109.0	3.9	0.5	94.0	55.0	13.2
22.06–21.07	T1	5.7	57.0	3.6	1.6	52.0	93.7	0.0
	T2	5.7	57.0	3.5	0.7	127.0	0.0	0.0
	T3	5.5	44.0	3.5	0.5	94.0	0.0	0.0
22.07–22.08	T1	5.7	34.0	3.1	1.6	52.0	0.0	0.0
	T2	5.4	54.0	3.2	0.7	127.0	0.0	0.0
	T3	5.4	54.0	3.3	0.5	94.0	0.0	0.0
23.08–17.09	T1	5.9	88.0	3.9	1.6	52.0	0.0	0.0
	T2	5.9	88.0	3.7	0.7	127.0	0.0	0.0
	T3	5.9	71.0	3.9	0.5	94.0	0.0	0.0
18.09–05.11	T1	6.1	194.0	4.3	1.6	52.0	0.0	0.0
	T2	6.0	254.0	4.0	0.7	127.0	1 226.9	214.0
	T3	6.1	237.0	4.0	0.5	94.0	2 676.1	1 779.1

* In Virtsu station, measured by EMHI.
BM, biomass.

In total 197 days were covered by observations and 168 days were not. According to ice charts (from EMHI archives) the dates of ice break-up and ice formation were 27 February 2002 and 9 December 2002, respectively. Thus, the ice-free period not covered by observations was 85 days in 2002. The beach casts were assumed to be negligible during the period of ice cover; therefore, annual wrack accumulations were defined as wrack accumulation during the ice-free period.

RESULTS AND DISCUSSION

Fresh wrack (beach cast macroalgae) was observed during every sampling occasion. The wrack included *F. lumbricalis* on five occasions (see Table 2). Storm casts in August and September did not contain *F. lumbricalis* because of unfavourable winds (mostly from southerly directions). The accumulation values varied strongly and were the highest in April. However, these values reflected the

Table 2. Wrack sampling data at the three study sites (T1, T2, and T3) on the NE coast of Saaremaa Island

Date	Location	Section length, m	Avg. width of ridge, m	Avg. thickness of ridge, m	Biomass sampling		Biomass of sample, g, dry		
					Replicate	Thick-ness, m	*Furcellaria lumbricalis*	*Coccotylus truncatus*	Total
21.04.02	T1	62.3	4.6	0.26	1	0.13	5.56	0	145.04
					2	0.12	5.05	0	106.01
					3	0.08	2.77	0	107.20
	T2	49.5	1.1	0.25	1	0.1	18.85	0.27	128.51
					2	0.05	26.39	0.30	93.40
					3	0.11	17.61	0.77	112.47
	T3	51.4	15.1	0.34	1	0.1	49.85	32.52	121.36
					2	0.09	51.25	41.71	124.34
					3	0.12	46.91	34.22	124.81
23.05.02	T1	49	15.5	0.02	1	0.02	*Furcellaria lumbricalis* absent		
					2	0.02	1.09	0	44.52
					3	0.02	0.97	0	43.04
	T2			*Furcellaria lumbricalis* absent					
	T3	51.4	0.45	0.01	1	0.01	0.46	0.57	22.37
					2	0.01	1.06	0.78	29.59
					3	0.01	0.80	0.50	26.82
21.06.02	T1		0.2		1		2.84	0.11	70.05
					2		2.35	0	68.60
					3		12.11	0.23	201.07
	T2			*Furcellaria lumbricalis* absent					
	T3		0.15		1		0.47	0.09	15.30
					2		0.08	0.06	14.14
					3		0.95	0.22	38.51
21.07.02	T1	57.7	3.9	0.04	1	0.02	1.14	0	71.35
					2	0.035	0.60	0	104.73
					3	0.03	0.40	0	113.08
	T2	49.5	0.125	0.015	1	0.015	0.04	0	13.36
					2	0.015	0.06	0	31.02
					3	0.015	0.33	0	86.97
	T3			*Furcellaria lumbricalis* absent					
22.08.02	T1			*Furcellaria lumbricalis* absent					
	T2			*Furcellaria lumbricalis* absent					
	T3			*Furcellaria lumbricalis* absent					
17.09.02	T1			*Furcellaria lumbricalis* absent					
	T2			*Furcellaria lumbricalis* absent					
	T3			*Furcellaria lumbricalis* absent					
05.11.02	T1			*Furcellaria lumbricalis* absent					
	T2	67	3.2	0.14	1	0.25	32.44	5.47	206.27
					2	0.13	8.33	1.10	86.56
					3	0.02	1.78	0.64	13.92
	T3	66	4.3	0.1	1	0.05	6.58	6.00	31.85
					2	0.06	11.74	8.28	40.79
					3	0.08	42.75	26.33	140.01

whole period between the break-up of ice (27.02) and the first sampling occasion (21.04). There is a possibility that these measurements included also beach casts since autumn 2001. The wrack of *F. lumbricalis* accumulated slightly or was missing between May and September, which resembles accumulation patterns elsewhere (e.g. Piriz et al., 2003).

The formation of wrack varied within wide ranges both by biomass and coverage. The wrack was found as regular and homogeneous ridges/mounds to fragmented single blotches. The width of wrack varied between 0.02 and 30 m and the thickness between 0.002 and 0.5 m. The average dimensions of the wrack at the sampling points are shown in Table 2.

A total of 32 macrophyte biomass samples were analysed. Altogether 14 taxa were recorded throughout the study period: 5 species of red, 2 species of brown,

Table 3. List of the macrobenthic species occurring in the observed wrack in 2002 on the NE coast of Saaremaa Island

Species	Recording level		
RHODOPHYTA			
Ceramium spp.	V	P	
Coccotylus truncatus		P	B
Furcellaria lumbricalis	V	P	B
Polysiphonia fucoides		P	
Rhodomela confervoides		P	
PHAEOPHYCEAE			
Fucus vesiculosus	V	P	
Pylaiella littoralis		P	
CHLOROPHYTA			
Cladophora glomerata	V	P	
Ulva intestinalis		P	
CHAROPHYTA			
Chara aspera	V	P	
MAGNOLIOPHYTA			
Myriophyllum spicatum	V	P	
Potamogeton sp.	V	P	
Ruppia maritima		P	
Zostera marina	V	P	
GASTROPODA			
Hydrobia sp.	V		
BIVALVIA			
Mytilus trossulus	V		
Macoma balthica	V		

V, recorded in wrack (by observation).
P, recorded in biomass samples (by laboratory determination).
B, biomass accumulation calculated.

and 2 species of green algae, 1 charophyte species, 5 species of flowering plants, and 3 macrozoobenthos taxa (Table 3). Most important taxonomic components of the wrack biomass samples are given in Fig. 2.

The proportion of the red algae *F. lumbricalis* and *C. truncatus* in the biomass samples was 0.3–39.9% and 0.1–29.2%, respectively. The highest percentage of both algae was found in April. The average taxonomic composition over 3 study sites of the wrack indicates that dominants were *C. truncatus* (6% of the wrack total biomass), *F. lumbricalis* (13%), and the rest of the macrophytes jointly (81%) during the observation period.

The red algae *F. lumbricalis* and *C. truncatus* accumulated on shores at a rate of 5.2 DWt km^{-1} yr^{-1} and 2.4 DWt km^{-1} yr^{-1}, respectively. The highest amounts of both species accumulated in the first (ante-observation) period. As the periods between sampling were not of equal duration, the accumulated wrack was divided by the number of days in each period in order to reveal seasonality in the wrack accumulation (see Fig. 3).

The following empirical relationships were obtained:

$$F = 0.04T^2 - 4.90(TI) - 9.15E + 943, \quad (1)$$

where F – wrack biomass accumulation of *F. lumbricalis* (DWg m^{-1}),
T – sum of significant wind velocities (m s^{-1}),
I – distance of the 5 m isobath (km),
E – wave exposure (deg)

$$C = 0.03T^2 - 4.34(TI) - 6.23E + 699, \quad (2)$$

where C – wrack biomass accumulation of *C. truncatus* (DWg m^{-1}).

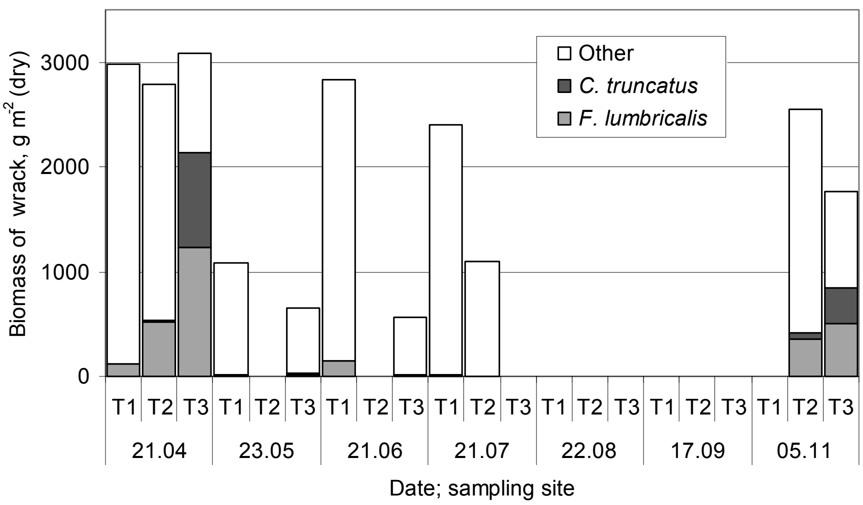

Fig. 2. The average biomass of the wrack by major macrofloristic components at three sampling sites in 2002.

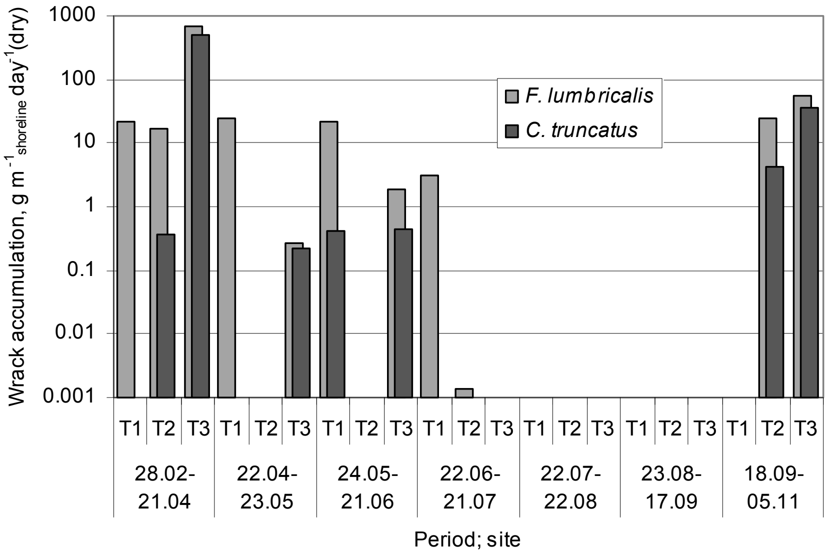

Fig. 3. The daily wrack accumulation rate of the dominant species at three sites during the study period (in logarithmic scale).

These two empirical models were relatively good ($R^2 = 0.65$ for *F. lumbricalis* and $R^2 = 0.53$ for *C. truncatus*; $P < 0.005$), although the sample size was rather poor ($n = 18$) and the biomass varied in a wide range.

The loose-lying algae *F. lumbricalis* and *C. truncatus* were cast ashore at the same times and rates. A very strong linear correlation between the biomasses of these taxa in the wrack ($R^2 = 0.85$) suggests that the algae responded similarly to hydrodynamic conditions. The biomass ratio of *F. lumbricalis* to *C. truncatus* in the wrack was similar to that in the natural habitat (Martin et al., 2006b).

According to our statistical model, the red alga *F. lumbricalis* was mainly cast ashore in autumn (see Fig. 4) when N- and NE-winds were prevailing. Relatively large amounts of wrack were sporadically recorded in summer. In general this wrack did not consist of *F. lumbricalis*, but mainly of *Zostera marina* L. (formerly also the dominant wrack taxa (Trei, 1965)), *Fucus vesiculosus* L., and *Potamogeton pectinatus* L.

The wrack formation of *F. lumbricalis* and *C. truncatus* during the period from April to November was estimated at 1026 tonnes and 402 tonnes in wet weight, respectively (Fig. 4). During the remaining ice-free season (85 days) the algal biomass amounted to 434 and 163 tonnes, including the first sampling occasion on 21 April.

Thus, the total annual losses of the red algal community through storm casts were estimated at 4779 tonnes in wet weight. As the amounts of wrack collected on Kassari Bay shores have decreased during the last 15 years and have been

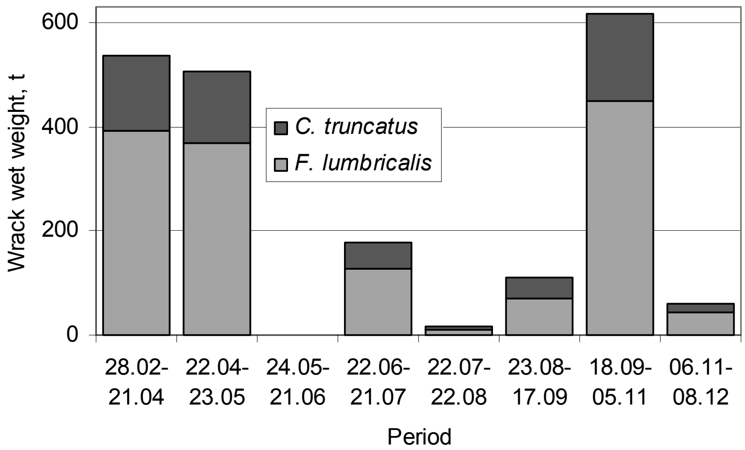

Fig. 4. Natural losses of the red algae through the beach-casts calculated by regression equations in the ice-free season separately for both dominant taxa in 2002.

negligible since 2001 (by EstAgar data) it is commercially advisable to harvest storm casts from the shores of the area in addition to traditional harvesting of red algal stocks.

The calculated annual losses via wrack deposition represent ~3% of the community standing stock in summer 2002 (Martin et al., 2006b). Based on the recent production estimates (Martin et al., 2006a) the losses due to beach cast made up approximately 20% of the potential annual production of the algal community. The commercial exploitation in the form of bottom trawling of the loose algal community made up only 1/5 of the losses due to beach cast (Kersen & Martin, 2005).

The wrack accumulations during the study period were strongly related to the inner-annual meteorological and hydrological conditions in the sea area (according to empirical models 1 and 2). The results show that coastal slope, wind velocity, and wave exposure describe a large part of the variability of macro-algal beach casts. It is likely that bottom and surface currents and wave activity are behind the relationships.

ACKNOWLEDGEMENTS

This study was financed by the Estonian Ministry of Environment, Target Financing Programme No. 0182578s03, and Estonian Science Foundation grant No. 6750. The authors are thankful to Kristjan Herkül for his assistance in field and laboratory.

REFERENCES

Bird, C. J., Saunders, G. W. & McLachlan, J. 1991. Biology of *Furcellaria lumbricalis* (Hudson) Lamouroux (Rhodophyta: Gigartinales), a commercial carrageenophyte. *J. Appl. Phycol.*, **3**, 61–81.

Estonian Maritime Administration. 2001. Soela Strait to Väike Strait [1 : 100 000]. In *Charts of Estonia. Vol. 2. Väinameri (West-Estonian Archipelago): From Osmussaar to Saaremaa*, p. 10. Tallinn.

Greenwell, M., Bird, C. J. & McLachlan, J. 1984. Depth-related variation in gross chemical composition of several seaweeds. *Aquat. Bot.*, **20**, 297–305.

Kersen, P. 2005. Kassari lahe töönduslikult kasutatav punavetikakooslus: varude hindamine ja prognoos. *Keskkonnatehnika*, 7, 20–23.

Kersen, P. & Martin, G. 2005. Preliminary assessment of natural losses in loose-lying red algal community through beach-cast macroalgae accumulation in the area of Kassari Bay (NE Baltic Sea). In *Book of Abstracts.* "*The Baltic Sea – changing ecosystem*" *5th BSSC, Sopot, Poland 20–24 June 2005*, 264.

Kukk, H. & Rosenberg, T. (eds) 1985. *Töönduslike vetikavarude olukorrast ENSV rannikumeres ja 1986. aasta limiit*. Läänemere Kalamajanduse TUI, Tallinn. Manuscript.

Kull, A. 1999. Eesti tuule kliima. *Publ. Inst. Geogr. Univ. Tartu.*, **85**, 86–93.

Leht, M. (ed.) 1999. *Eesti taimede määraja*. Eesti Loodusfoto, Tartu.

McLachlan, J., Greenwell, M., Bird, C. J. & Holmsgaard, J. E. 1987. Standing stocks of seaweeds of commercial importance on the north shore of Prince Edward Island, Canada. *Bot. Mar.*, **30**, 277–289.

Mardiste, H. 1970. Väinameri. In *Lääne-Eesti rannikualade loodus* (Kumari, E., ed.), pp. 7–16. Loodusuurijate Selts ENSV TA juures, Valgus, Tallinn.

Mardiste, H. 1974. Kassari lahe hüdroloogilisest režiimist. In *Eesti Geograafia Seltsi aastaraamat 1973* (Merikalju, L., ed.), pp. 91–102. Valgus, Tallinn.

Martin, G., Paalme, T. & Kukk, H. 1996. Long-term dynamics of the commercially useable *Furcellaria lumbricalis–Coccotylus truncatus* community in Kassari Bay, West Estonian Archipelago, the Baltic Sea. In *Proc. Polish–Swedish Symposium on Baltic Coastal Fisheries: Resources and Management*, pp. 121–129. Sea Fisheries Institute, Gdynia.

Martin, G., Paalme, T. & Torn, K. 2006a. Growth and production rates of the loose-lying and attached forms of the red algae *Furcellaria lumbricalis* and *Coccotylus truncatus* in Kassari Bay, the West Estonian Archipelago Sea. *Hydrobiologia*, **554**, 107–115.

Martin, G., Paalme, T. & Torn, K. 2006b. Seasonality pattern of biomass accumulation in drifting *Furcellaria lumbricalis* community in waters of the West Estonian Archipelago, Baltic Sea. *J. Appl. Phycol.*, **18**, 557–563.

Nielsen, R., Kristiansen, A., Mathiesen, L. & Mathiesen, H. (eds) 1995. Distributional index of the benthic macroalgae of the Baltic Sea area. *Acta Bot. Fenn.*, **155**, 1–51.

Orr, M., Zimmer, M., Jelinski, D. E. & Mews, M. 2005. Wrack deposition on different beach types: spatial and temporal variation in the pattern of subsidy. *Ecology*, **86**, 1496–1507.

Orviku, K. 1993. Contemporary coasts. In *Geology of the Estonian Shelf* (Luts, J. & Raukas, A., eds), pp. 29–39. Estonian Geological Society, Tallinn.

Piriz, M. L., Eyras, M. C. & Rostagno, C. M. 2003. Changes in biomass and botanical composition of beach-cast seaweeds in a disturbed coastal area from Argentine Patagonia. *J. Appl. Phycol.*, **15**(1), 67–74.

Raudsepp, U. & Kõuts, T. 2001. Observations of near-bottom currents in the Gulf of Riga, Baltic Sea. *Aquat. Sci.*, **63**, 385–405.

Sharp, G. J., Tetu, C., Semple, R. & Jones, D. 1993. Recent changes in the seaweed community of western Prince Edward Island: implications for the seaweed industry. *Hydrobiologia*, **260/261**, 292–296.

StatSoft, Inc. 2006. *Electronic Statistics Textbook*. StatSoft, Tulsa, OK. WEB: http://www.statsoft.com/textbook/stathome.html
Suursaar, Ü., Otsmann, M. & Kullas, T. 2000. Exchange processes in the Väike Strait (Baltic Sea): present, past, future. *Proc. Estonian Acad. Sci. Biol. Ecol.*, **49**, 235–252.
Suursaar, Ü., Kullas, T. & Otsmann, M. 2001. The influence of current and waves on ecological conditions of the Väinameri. *Proc. Estonian Acad. Sci. Biol. Ecol.*, **50**, 231–247.
Trei, T. 1965. Materjale Väinamere põhjataimestiku ja tööndusl ike punavetikate kasutamise võimaluste kohta. *Eesti NSV TA Toim. Biol.*, **14**, 180–196.
Trei, T. 1968. Tööndusl ike vetikate kasutamisest ja uurimisest. *Abiks Kalurile*, 1(46), 22–24.
Trei, T. 1991. *Taimed Läänemere põhjal*. Valgus, Tallinn.
Truus, K., Vaher, M., Kukk, H., Pehk, T. & Kollist, A. 1996. Läänemere punavetikate geelistuvad galaktaanid. *Eesti TA Toim. Keemia*, **45**, 15–29.
Tuvikene, R., Truus, K., Vaher, M., Kailas, T., Martin, G. & Kersen, P. 2006. Extraction and quantification of hybrid carrageenans from the biomass of the red algae *Furcellaria lumbricalis* and *Coccotylus truncatus*. *Proc. Estonian Acad. Sci. Chem.*, **55**, 40–53.
Wenberg, T. & Thomsen, M. S. 2005. The effect of wave exposure on the morphology of *Eclonia radiata*. *Aquat. Bot.*, **85**, 61–70.

Kinnitumata punavetikakoosluse aastane biomassi kadu Väinameres läbi mereheidiste akumulatsiooni

Priit Kersen ja Georg Martin

Läänemere ainus teadaolev tööndusl ikult tarbitav kinnitumata punavetikakooslus asub Kassari lahes Väinameres. Sealseid vetikavarusid on välja püütud alates 1960. aastatest. Koosluses kasvav punavetikas agarik (*Furcellaria lumbricalis*) on väärtuslik tooraine geelistuvate polüsahhariidide tootmises. Taolised varem esinenud kooslused on mujal Läänemeres tugevalt kahjustunud või koguni hävinud. Selliseid varusid esineb tööndusl ikes kogustes veel vaid Kanada rannikuvetes.

Käesolevas töös on uuritud punavetikakoosluses esinevaid biomassi kadusid mereheidiste akumulatsiooni tulemusena. Looduslikke kadusid on arvutatud kooslusest väljauhtumise kaudu Saaremaa kirderanniku vaatlusjaamade ja empiiriliste statistiliste mudelite põhjal 2002. aastal. Mereheidiste akumulatsiooniks on hinnatud ~5000 t/a märgkaalus, mis sõltub oluliselt vaatluspiirkonnas valitsevatest aastaajalistest meteoroloogilistest ja hüdroloogilistest tingimustest. Aastased randa uhutud biomassi kaod moodustavad koosluse suvisest biomassi varust ~3%, ületavad väljatraalitava vetikasegu koguse *ca* 5 korda ja on ühtlasi koosluse aastasest potentsiaalsest produktsioonist ligikaudu 20%. Seega on otstarbekas taastada Kassari lahe piirkonnas – lisaks praegusele väljapüügile – mereheidiste randadest kogumine, mis on olnud viimase 15 aasta jooksul pea olematu.