Seafood menus reflect long-term ocean changes

Peer-reviewed letter

Global fisheries declines have alerted ecologists that long-term ecosystem assessments require diverse information sources (Jackson *et al.* 2001; Lotze and Worm 2009). Non-traditional sources of information on past marine ecosystems have included photographs (McClenachan 2009a), newspapers (McClenachan 2009b; Van Houtan *et al.* 2012), artwork (Guidetti and Micheli 2011), and living memory (Sáenz-Arroyo *et al.* 2005; Kittinger *et al.* 2013). To date, this information has been taken primarily from historical harvest records, but a secondary and largely untapped wealth of data exists on consumption. Archaeologists have long analyzed preserved midden deposits to understand resource use and its ecological impacts (eg Reitz 2004). Restaurant menus may provide a recent analog to middens, given that they document seafood consumption over time and potentially the availability and value of different species in the past. Menus have been used to evaluate historical changes in seafood popularity (Jones 2008; Hall and Camhi 2012), but published studies using menus to track wild population abundance are limited. Hawaii is perhaps an ideal location to use menus to analyze historical changes in the marine environment because its remote location meant most locally consumed seafood was locally sourced (Geslani *et al.* 2012).

We analyzed 376 menus from 154 different restaurants in Hawaii (Figure 1a), dated from 1928 to 1974, to supplement official fishery landing records and to infer changes in the availability of marine resources. The menus represent a range of eateries from local businesses to larger restaurants serving tourists (we excluded 60 cruise-ship menus because their pantries were not locally sourced).

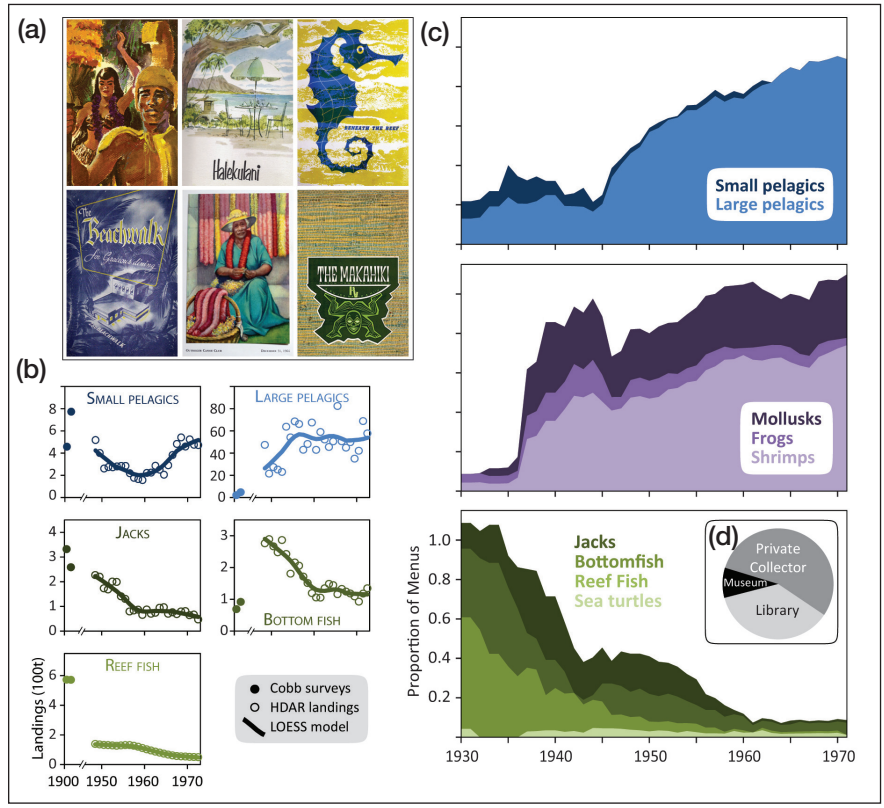

Figure 1. *Historical marine resource insights from restaurant menus. (a) Menu covers from six Honolulu restaurants circa 1960 (courtesy M Payne/Arkiva Tropika). (b) Commercial landings for five fish guilds in Hawaii from early US Government surveys (Cobb 1905) and the Hawaii Department of Aquatic Resources (HDAR); note the break in time on the x axis. LOESS = locally weighted regression. (c) Menu occurrence of fishery items follows the rise and fall of local fisheries: wild-caught offshore fish species (top panel), imported and aquaculture species (middle panel), and wild-caught inshore species (bottom panel). (d) More than half of the restaurant menus used in this study came from private archives.*

Importantly, these menus bridge a critical 45-year gap in early 20th-century fishery records. We compared landings from early market surveys (Cobb 1905) and later government fishery statistics for five historically important fish guilds (Figure 1b) against the presence of these guilds on restaurant menus (WebTable 1), calculating their proportion of occurrence in a 9-year moving window (Figure 1c).

The menus capture many of the marked shifts reflected in fishery landings, and perhaps additional changes in market supply and in public preference. Reef fish, jacks, and bottomfish were common on menus before 1940, but by Hawaii's statehood in 1959 these items appeared collectively on less than 10% of the menus sampled. This period marked a rapid growth in pelagic fisheries (Schug 2001) and concurrent declines in nearshore fishery stocks (Figure 1b). While nearshore resources sharply declined, restaurants shifted to serving large pelagic fish (Figure 1c). By 1970, 95% of our menus contained large pelagics. For nearshore guilds, changes in menu occurrence may reflect market availability (and by proxy wild abundance) rather than shifts in consumer preferences (Geslani *et al.* 2012). Not all local fishery dynamics are reflected in menus. Mollusks and shrimps were mostly imported from the mainland US, and frogs were obtained from local aquaculture farms. Sea turtles were harvested in a commercial fishery in Hawaii; turtle meat, however, was sold primarily at local fish markets, not in restaurants (Van Houtan and Kittinger in review). Although we did not evalu-

ate listed prices on menus, future attention here may reveal how consumer preference influenced these changes. Private collectors supplied most of our menus (Figure 1d), suggesting that traditional research archives in some cases may harbor only a fraction of such information.

Restaurant menus represent an intriguing data source with the potential to fill existing knowledge gaps and measure long-term ecosystem changes. Nevertheless, we caution that menus should be used selectively and in concert with relevant socioeconomic information on fishery operation and culture. Market dynamics, resource abundance, availability, and consumer preference can all influence menu trends. However, fish occurrence on menus may be a useful proxy of population changes when species are locally harvested and restaurants are the major market. In our research on Hawaiian fisheries, this was the case for small pelagics, large pelagics, bottomfish, jacks, and reef fish. Alternatively, local wild-caught species may primarily supply a non-restaurant market (as with sea turtles), or may come from local aquaculture (as with frogs) or be imported (as with mollusks and shrimps). These latter instances may still present important information, such as the market forces supporting wildlife harvests (Van Houtan and Kittinger in review). Our research also revealed that a wealth of restaurant menus exist in private collections in addition to traditional research archives (Jones 2008). When compiled and interpreted in the appropriate socioeconomic context, menus have great potential as a window to the past.

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WebTable 1. List of local Hawaiian menu seafood items, guilds, and scientific names

ID	*Guilds*	*Habitat*	*Menu name*	*Common name*	*Scientific name*
1	large pelagics	offshore	ahi	yellowfin tuna	*Thunnus albacares*
2	large pelagics	offshore	aku	skipjack tuna	*Katsuwonus pelamis*
3	large pelagics	offshore	mahi-mahi	mahi-mahi	*Coryphaena hippurus*
4	large pelagics	offshore	ono	wahoo	*Acanthocybium solandri*
5	large pelagics	offshore	swordfish	swordfish	*Xiphias gladius*
6	large pelagics	offshore	marlin	marlin	*Makaira* spp
7	small pelagics	offshore	akule	bigeye scad	*Selar crumenophthalmus*
8	small pelagics	offshore	opelu	mackerel scad	*Decapterus macarellus*
9	small pelagics	offshore	walu	escolar	*Lepidocybium flavobrunneum*
10	bottomfish	nearshore	hapaku	grouper	*Hyporthodus quernus*
11	bottomfish	nearshore	opakapaka	pink snapper	*Pristipomoides filamentosus*
12	bottomfish	nearshore	snapper	red snapper	*Etelis* spp
13	bottomfish	nearshore	uku	gray jobfish	*Aprion virescens*
14	jacks	nearshore	kahala	amberjack	*Seriola* spp
15	jacks	nearshore	omilu	bluefin trevally	*Caranx melampygus*
16	jacks	nearshore	ulua	giant trevally	*Caranx ignobilis*
17	reef fish	nearshore	kumu	goatfish	*Parupeneus porphyreus*
18	reef fish	nearshore	mullet	mullet	*Mugil cephalus*
19	reef fish	nearshore	pakii	flounder	Bothidae
20	reef fish	nearshore	weke	goatfish	Mullidae
21	sea turtles	nearshore	turtle	green turtle	*Chelonia mydas*